SHNEIDERMAN • PLAISANT • COHEN • JACOBS • ELMQVIST

SIXTH EDITION
GLOBAL EDITION

DESIGNING THE USER INTERFACE

STRATEGIES FOR EFFECTIVE HUMAN-COMPUTER INTERACTION

Pearson

Boston Columbus Indianapolis New York San Francisco Hoboken
Amsterdam Cape Town Dubai London Madrid Milan Munich Paris Montréal Toronto
Delhi Mexico City São Paulo Sydney Hong Kong Seoul Singapore Taipei Tokyo

CHAPTER 1

Usability of Interactive Systems

> “Designing an object to be simple and clear takes at least twice as long as the usual way. It requires concentration at the outset on how a clear and simple system would work, followed by the steps required to make it come out that way—steps which are often much harder and more complex than the ordinary ones. It also requires relentless pursuit of that simplicity even when obstacles appear which would seem to stand in the way of that simplicity.”

T. H. Nelson
The Home Computer Revolution, 1977

CHAPTER OUTLINE

1.1 Introduction

User-interface designers are the heroes of a profound transformation. Their work turned personal computers into today's wildly successful mobile devices, enabling users to communicate and collaborate in remarkable ways. The desktop applications that once served the needs of professionals have increasingly given way to powerful social tools that deliver compelling user experiences to global communities. These invigorated communities conduct business, communicate with family, get medical advice, and create user-generated content that can be shared with billions of connected users.

These life-changing shifts were made possible because researchers and user-interface designers harnessed technology to serve human needs. Researchers created the interdisciplinary design science of *human-computer interaction* by applying the methods of experimental psychology to the powerful tools of computer science. Then they integrated lessons from educational and industrial psychologists, instructional and graphic designers, technical writers, experts in human factors or ergonomics, and growing teams of anthropologists and sociologists. As the impact of these mobile social tools and services spreads, researchers and designers are gathering still fresher insights from sustainability activists, consumer advocates, citizen scientists, and humanitarian disaster response teams.

User experience designers produce business success stories, Hollywood heroes, and Wall Street sensations. They also produce intense competition, copyright-infringement suits, intellectual-property battles, mega-mergers, and international partnerships. Crusading Internet visionaries, like Google's Eric Schmidt, promote a world with free access to information and entertainment, while equally devoted protectors of creative artists, like singer Taylor Swift, argue for fair payments. User interfaces are also controversial because of their central role in personal identification, national defense, crime fighting, electronic health records, and so on.

At an individual level, effective user experiences change people's lives: Doctors can make more accurate diagnoses, and pilots can fly airplanes more safely; at the same time, children can learn more effectively, users with disabilities can lead more productive lives, and graphic artists can explore more creative possibilities. Some changes, however, are disruptive, reducing the need for telephone operators, typesetters, and travel agents. Too often, users must cope with frustration, fear, and failure when they encounter excessively complex menus, incomprehensible terminology, or chaotic navigation paths.

At a societal level, connected communities open up new forms of collective action and policy engagement. Having more informed citizens may lead to better decisions, more transparent governance, and greater equity when facing

legal, health, or civic challenges. But there may be increased dangers from extreme groups who promote terrorism, oppressive social policies, or racial hatred. The increased power of social media and collaboration technologies means that there must be a new balance of legal protections, police powers, and privacy.

The steadily growing interest in human-computer interaction stems from the designers' desire to improve the users' experience (Figs. 1.1 to 1.3 show some popular applications). In business settings, better decision-support and document-sharing tools support entrepreneurs, while in-home settings, digital photo libraries, and internet conferencing enhance family and personal relationships. Millions of people take advantage of the World Wide Web's extraordinary educational and cultural heritage resources, which provide access to everything from outstanding art objects from China to music from Indonesia, sports from Brazil, and entertainment from Hollywood or Bollywood

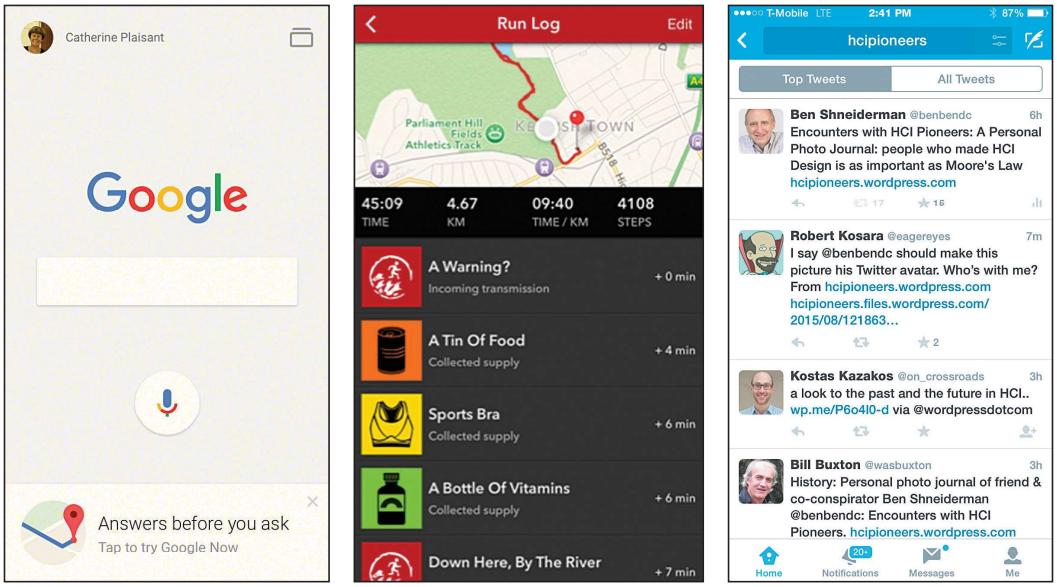

FIGURE 1.1

Smartphones have high-quality displays, provide fast Internet connections, include many sensors, and support a huge variety of applications.
Left: Google Now for searching, reviewing notification cards, and speaking commands.
Center: Zombies, Run! is an immersive running game and audio adventure which encourages runners to run as if pursued by zoombies, and to collect goods to help their community survive.
Right: A Twitter feed lists the top tweets after Ben Shneiderman announced the release of the HCI Pioneers website.

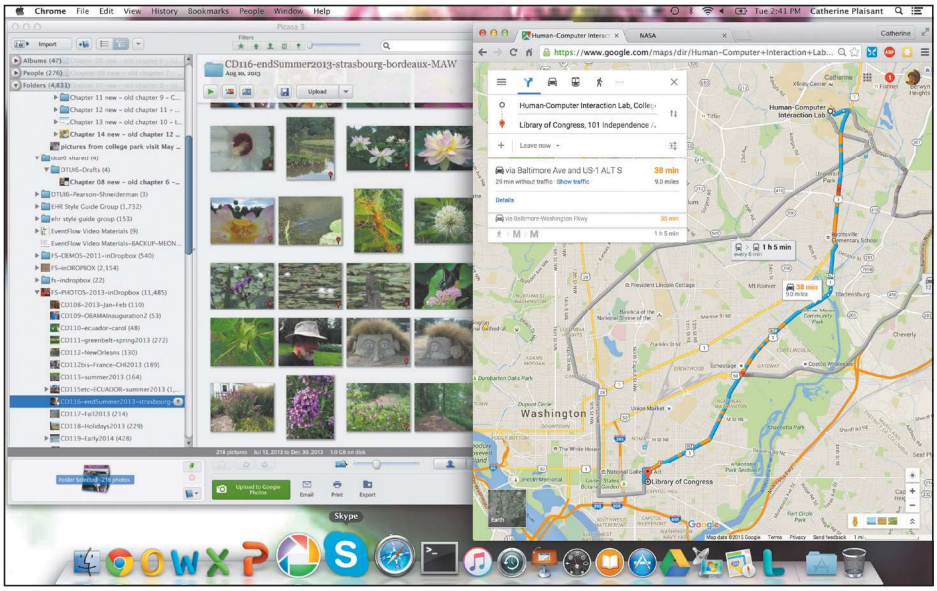

FIGURE 1.2

Apple® Mac OS X®. showing Picasa for photo browsing and Google Maps in a web browser. The bottom of the screen also shows the Dock, a menu of frequently accessed items whose icons grow larger on mouse-over.

(Figs. 1.4 to 1.5 show examples of popular websites). Mobile devices enrich daily life for many users, including those with disabilities, limited literacy, and low incomes. On a worldwide scale, promoters and opponents of globalization debate the role of technology in international development, while activists work to attain the United Nations Sustainable Development Goals.

The remarkably rapid and widespread adoption of mobile devices (including smartphones, tablets, game devices, fitness trackers, etc.) supports personal communication, collaboration, and content creation. The proliferation of such devices in developed as well as developing

FIGURE 1.3

Ben Shneiderman at a standing desk with two high-resolution screens. We can see a MS Word document (with six pages visible), two web browsers, and the Outlook e-mail application in a Windows environment.

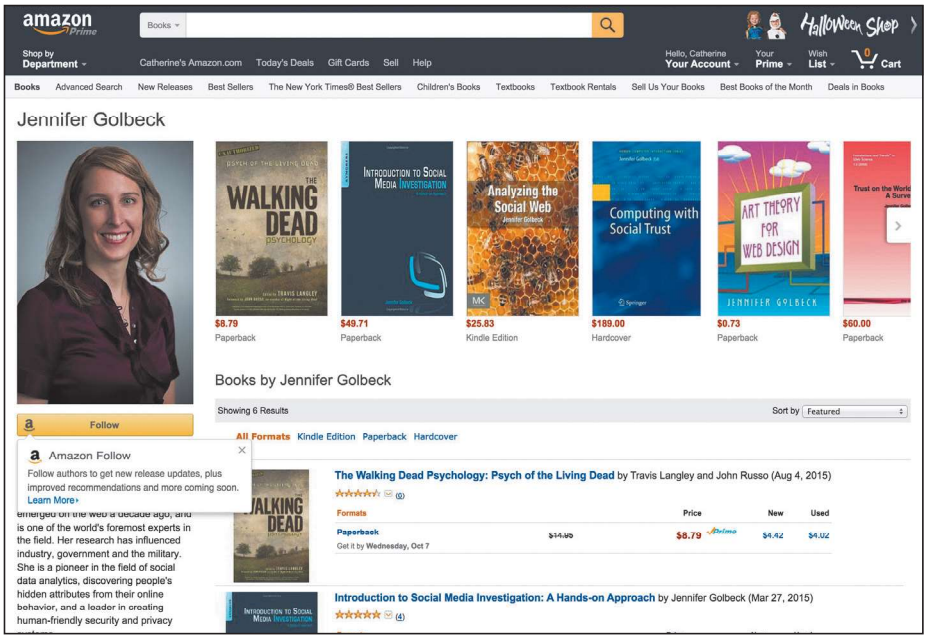

FIGURE 1.4

The Amazon.com website (http://www.amazon.com/) showing the books published by Jen Golbeck. Facebook will make book and product recommendations based on a user's personal history with the site.

nations has been astonishing. Economists see a direct linkage between cell-phone dissemination and economic growth since communications facilitate e-commerce and stimulate entrepreneurial ventures. Mobile devices also promote wellness, enable timely medical care, and provide life-saving disaster response services.

Similarly, explosive growth is the appropriate description for what's happening in the realms of social networking and user-generated content. Older media, such as newspapers and television, have lost audiences in favor of social media such as Facebook, Twitter, YouTube, and Wikipedia (all of which are among the top 10 most visited services). These leading websites are just a taste of what is to come, as entrepreneurs trigger ever more social media involvement accessible through web-based applications and small mobile devices.

Designers enable users to create, edit, and distribute 3-D printed objects, immersive virtual reality games, interactive animations, and increasingly high-definition music, voice, and videos. The result is ever-richer experiences and a creative outpouring of user-generated content available, even on mobile devices.

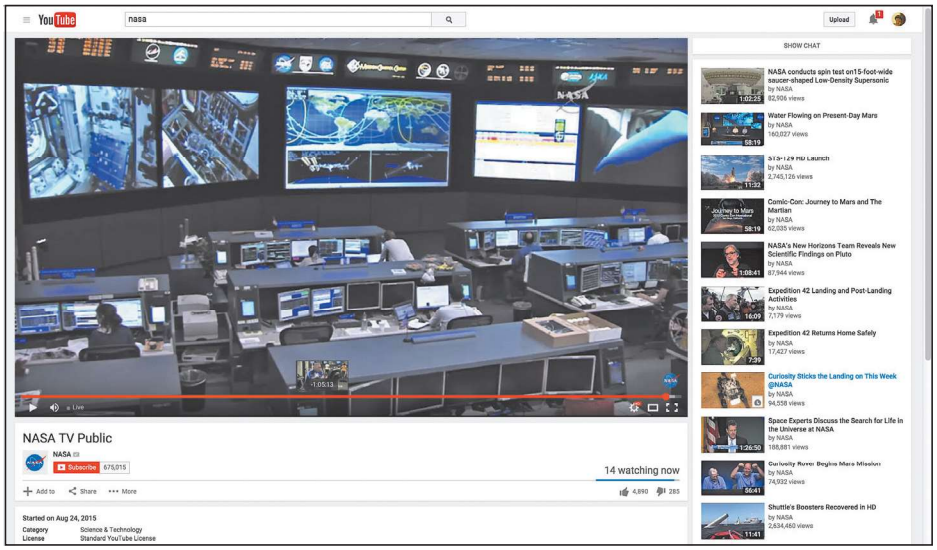

FIGURE 1.5

YouTube showing a video showing NASA TV and other available related videos on the side. The NASA video shows an example of a control center with multiple large wall displays and workstations.

Sociologists, anthropologists, policymakers, and managers are studying how social media are changing education, family life, shopping, and services such as medical care, financial advice, and political organizations. They are also dealing with issues of organizational impact, job redesign, distributed teamwork, work-at-home scenarios, and long-term societal changes. As face-to-face interaction gives way to screen-to-screen, how can personal trust and organizational loyalty be preserved? How can empathy be conveyed and civic participation be enhanced?

Designers face the challenge of providing services on small-, wall-, and mall-sized displays, ranging from jewelry, clothing (Fig. 1.6), smartphones, and tablets (Fig. 1.7) to large panels, projected displays, and illuminated buildings. When the *plasticity* of their designs provides smooth conversion across different display sizes, consumers take pleasure; when conversions are difficult, consumers take notice. But the malleability of user interfaces has to extend to translation into multiple languages, accessibility support for users with disabilities, and accommodation for varying network bandwidths.

Some innovators promise that desktop computers and their user interfaces will disappear, as new interfaces become ubiquitous, pervasive, invisible, and embedded in the surrounding environment. They believe that novel devices will be context-aware, attentive, and perceptive, sensing users' needs and providing feedback through ambient displays that glow, hum, change shape, or blow air.

FIGURE 1.6

Two children learn about the human body using a wearable, e-textile shirt displaying real-time visualizations of how the body works via "organs" with embedded LED lights and sound (Norooz et al., 2015).

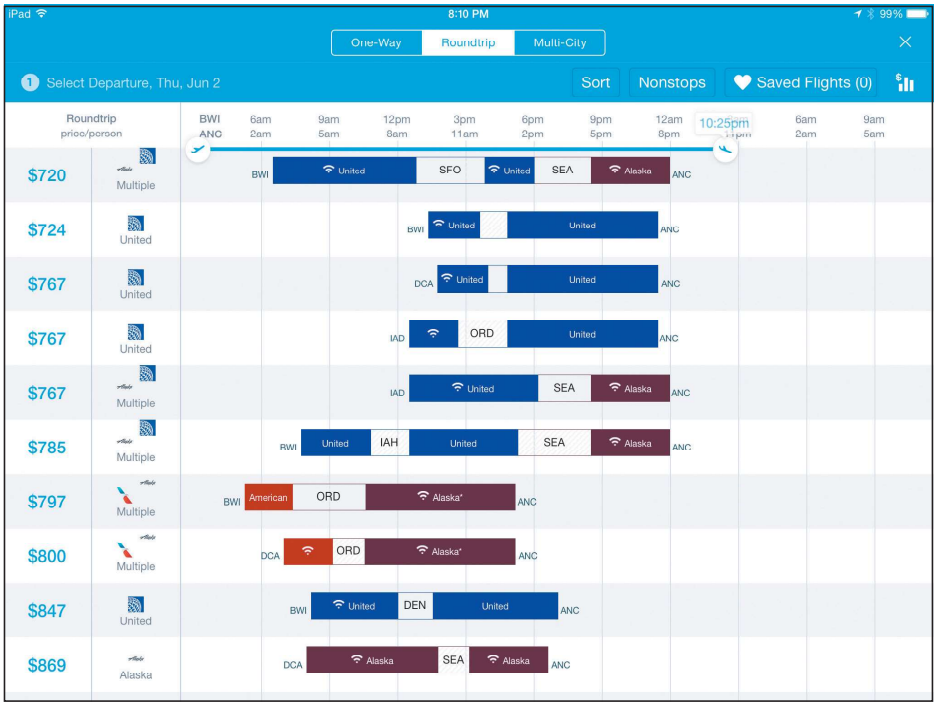

FIGURE 1.7

The HIPMUNK travel search shows available flights visually as seen on a Apple iPad tablet. The slider at the top allows users to narrow down the results. Here we see only the flights landing before 10:25 P.M.

Designers are already offering interfaces that are wearable or control implanted (under-the-skin) devices, such as pacemakers, insulin pumps, and varied biomonitors. Other kinds of sensors already track FedEx packages, users entering buildings, or cars at tollbooths, but they will expand into elaborate sensor nets that follow crowds, epidemics, and pollution.

Other designers promote persuasive technologies that change users' behavior, multi-modal or gestural interfaces that facilitate use, and affective interfaces that respond to the user's emotional state.

We are living in an exciting time for designers of user interfaces. The inspirational pronouncements from technology prophets can be thrilling, but rapid progress is more likely to come from those who do the hard work of tuning designs to genuine human needs. These designers will rigorously evaluate actual use with eager early adopters, as well as reluctant late adopters, and seriously study the resistant non-users. This book's authors believe that the next phase of human-computer interaction will be strongly influenced by those who are devoted to broadening the community of users by promoting universal usability and facilitating many forms of social media participation. User interfaces that deliver excellent user experiences will be a key component in improving healthcare, creating sustainable economies, protecting natural resources, and resolving conflicts (Froehlich et al., 2010; Friedman et al., 2014).

This first chapter gives a broad overview of human-computer interaction from practitioners' and researchers' perspectives. It lays out usability goals, measures, and motivations in Sections 1.2 and 1.3 and closes with a statement of goals for our profession. Specific references cited in the chapter appear at the end, followed by a set of general references. Lists of relevant books, guidelines documents, journals, professional organizations, and video collections give readers starting points for further study.

The second chapter takes on universal usability, reminding readers of the opportunities to reach diverse users with tailored materials that serve the needs of young and old, high and low literacy users, diverse international users, and users with varying disabilities.

The third chapter reviews the guidelines, principles, and theories that will be drawn on and refined throughout the book. Chapters 4–6 introduce design processes and evaluation methods, with case study examples to demonstrate the processes and methods. Chapters 7–9 cover interaction styles that range from graphical direct manipulation to speech control and their implementation using common interaction devices. Collaboration is included in this part to emphasize the need for every designer to go beyond the personal computer and consider the many forms of social computing. Chapters 10–16 address the critical design decisions that often determine the success or failure of products and that may lead to breakthroughs that open the way to new possibilities. The Afterword reflects on the societal and individual impacts of technology.

1.2 Usability Goals and Measures

Every designer wants to develop high-quality user experiences that are admired by colleagues, celebrated by users, and imitated by competitors. But getting such attention takes more than flamboyant promises and stylish advertising; it's earned by providing quality features such as usability, universality, and usefulness. These goals are achieved by thoughtful planning, sensitivity to user needs, devotion to requirements analysis, and diligent testing, all while keeping within budget and on schedule.

Managers who pursue user-interface excellence first select experienced designers and then prepare realistic schedules that include time for requirements gathering, guidelines preparation, and repeated testing. The designers begin by determining user needs, generating multiple design alternatives, and conducting extensive evaluations (Chapters 4–6). Modern user-interface-building tools then enable implementers to quickly build working systems for further testing.

Successful designers go beyond vague notions of "user friendliness," "intuitive," and "natural," doing more than simply making checklists of subjective guidelines. They have a thorough understanding of the diverse community of users and the tasks that must be accomplished. They study evidence-based guidelines and pursue the research literature when necessary. Great designers are deeply committed to enhancing the user experience, which strengthens their resolve when they face difficult choices, time pressures, and tight budgets. Great designers are also aware of the importance of eliciting emotional responses, attracting attention with animations, and playfully surprising users.

When managers and designers have done their jobs well, their interfaces generate positive feelings of success, competence, and mastery among users. The users have a clear mental model of the interface that enables them to confidently predict what will happen in response to their actions. In the best cases, the interface almost disappears, enabling users to concentrate on their work, exploration, or pleasure. This kind of calming environment gives users the feeling that they are "in the flow," operating at their peak, while attaining their goals.

Close interaction with the user community leads to a well-chosen set of benchmark tasks that is the basis for usability goals and measures. For each user type and each task, precise measurable objectives guide the designer through the testing process. The ISO 9241 standard *Ergonomics of Human-System Interaction* (ISO, 2013) focuses on admirable goals—*effectiveness*, *efficiency*, and *satisfaction*—but the following usability measures, which focus on the latter two goals, lead more directly to practical evaluation:

1. *Time to learn.* How long does it take for typical members of the user community to learn how to use the actions relevant to a set of tasks?

2. *Speed of performance.* How long does it take to carry out the benchmark tasks?
3. *Rate of errors by users.* How many and what kinds of errors do people make in carrying out the benchmark tasks? Although time to make and correct errors might be incorporated into the speed of performance, error handling is such a critical component of interface usage that it deserves extensive study.
4. *Retention over time.* How well do users maintain their knowledge after an hour, a day, or a week? Retention may be linked closely to time to learn, and frequency of use plays an important role.
5. *Subjective satisfaction.* How much did users like using various aspects of the interface? The answer can be ascertained by interviews or by written surveys that include satisfaction scales and space for free-form comments.

Every designer would like to succeed in every measure, but there are often forced tradeoffs. If lengthy learning is permitted, task-performance times may be reduced by use of abbreviations, hidden shortcuts, and compact designs that minimize scrolling. If the rate of errors is to be kept extremely low, speed of performance may have to be sacrificed. In some applications, subjective satisfaction may be the key determinant of success; in others, short learning times or rapid performance may be paramount. Project managers and designers who are aware of the tradeoffs can be more effective if they make their choices explicit and public. Requirements documents and marketing brochures that make clear which goals are primary are more likely to be valued.

After multiple design alternatives have been raised, the leading possibilities should be reviewed by designers and users. Low-fidelity paper mockups are useful, but high-fidelity interactive prototypes create a more realistic environment for expert reviews and usability testing. The user training and supporting materials such as online help can be produced before the implementation to provide another review and a new perspective on the design. Next, the implementation can be carried out with proper software tools; this task should be a modest one if the design is complete and precise. Then, acceptance testing certifies that the delivered interface meets the goals of the designers and customers. Finally, continuous evaluation and improvement have become common practices. These design processes, evaluation procedures, and software tools are described more fully in Chapters 4–6.

The business case for usability is strong and has been made repeatedly (Bias and Mayhew, 2005; Tullis and Albert, 2013). User-interface design success stories can also be managerial success stories for projects that are on budget and on schedule. A thoroughly documented set of user needs clarifies the design process, and a carefully tested prototype generates fewer changes during implementation while avoiding costly updates after release. Thorough acceptance testing of the implementation produces robust interfaces that are aligned

with user needs. Then continuous evaluation based on usage logs and user comments guide evolutionary refinements.

1.3 Usability Motivations

The enormous interest in interface usability arises from the demonstration of the benefits that come from well-designed user interfaces. This increased motivation emanates from designers and managers of consumer electronics who produce mobile devices, e-commerce websites, and social media where excellent user experiences are necessary to succeed in large, highly competitive markets. Usability has gone from desirable to necessary for survival. Similarly, the huge interest in games and entertainment has raised the performance of devices, networks, and user interfaces. The goals are to ensure that game playing is fluid and vivid; that photo, music, and video streaming is fast; and that sharing is graceful and simple. Strong motivations for usability quality come from high-functioning professionals who demand excellence in environments such as life-critical systems, industrial plants, legal offices, and police agencies. The spirit of usability excellence is also expected by users of exploratory, creative, and collaborative interfaces as well as diverse sociotechnical systems.

1.3.1 Consumer electronics, e-commerce, and social media

User experience designers have played a key role in the dramatic growth of consumer electronics by providing effective and satisfying designs that have become widely adopted for personal communications, education, healthcare, and much more. The annual Consumer Electronics Show, now replicated in many locations around the world, brings tens of thousands of exhibitors and hundreds of thousands of attendees who are eager to try the latest products from leading vendors.

Product announcements trigger worldwide media coverage, with Hollywood or sports personalities celebrating the newest products. Similarly, famed musicians, supermodels, and other luminaries contribute to the media hype while making everyone aware of the latest designs, appealing features, and must-have capabilities. Heroes such as Apple's Chief Design Officer Jony Ive have become celebrities who are knighted by the Queen of England and pestered by interviewers to reveal the secrets of the next product release.

The transformative power of consumer electronics has been celebrated by those who see improved family communication, better healthcare, thriving businesses, and wider access to education. The social media applications, dominated by Facebook, and user-generated content such as online restaurant, film, or product reviews have become part of daily life for many users. For these

interfaces, ease of learning, low error rates, and subjective satisfaction are paramount because use is discretionary and competition is fierce. If the users cannot succeed quickly, they will give up or try a competing supplier. Critics raise concerns about reduced privacy, dangers in distracted driving, and declining quality of interpersonal relationships.

1.3.2 Games and entertainment

The rapid expansion of home and entertainment applications is a further source of interest in usability. Personal-computing applications include e-mail clients, search engines, cellphones, digital cameras, and music players. Entertainment applications have flourished, making computer games a larger industry than Hollywood, while game input devices like the Nintendo® Wii™ and *the Microsoft Kinect's*™ controller-free gameplay (Fig. 1.8) open up entirely new possibilities in areas ranging from sports to education to rehabilitation.

Choosing the right functionality while keeping costs low is difficult. Novices are best served by a constrained, simple set of actions, but as users' experience increases, so does their desire for more extensive functionality and rapid performance. A layered or level-structured design is one approach to facilitating graceful evolution from novice to expert usage: Users can move up to higher layers when they need additional features or have time to learn them. A simple

FIGURE 1.8

Dance Central, a highly successful dance-playing franchise of games in which users dance to popular songs and earn points for how well they keep up. The Dance Central website allows users to purchase additional songs and also hosts livestream events and community forums.

example is the design of search engines, which almost always have basic and advanced interfaces (Chapter 15). Another approach to winning novice users is to carefully trim the features to make a simple device or application so users can get started easily.

1.3.3 Professional environments

Most consumer electronics users also benefit from interfaces in professional environments from supermarkets to space stations. Life-critical systems include those that control air traffic, nuclear reactors, power utilities, police or fire dispatch, military operations, and clinical care (Fig. 1.9). In these applications, high costs are expected, but they should yield high reliability and effectiveness. Lengthy training periods are acceptable to obtain rapid, error-free performance, even when the users are under stress. Subjective satisfaction is less of an issue because the users are well-motivated professionals. Retention is obtained by frequent use of common functions and practice sessions for emergency actions.

Typical industrial and commercial uses include interfaces for banking, insurance, production management, airline and hotel reservations, utility billing, and point-of-sale terminals. In these cases, costs shape many judgments. Operator training time is expensive, so ease of learning is important. Since many businesses are international, translation to multiple languages and adaptations to local cultures are necessary. The tradeoffs between speed of performance and error rates are governed by the total cost over the system's lifetime (Chapter 12). Subjective satisfaction is of modest importance; retention is obtained by frequent use. Speed of performance is central for most of these applications because of the high volume of transactions, but operator fatigue, stress, and burnout are legitimate concerns. Trimming 10% off the mean transaction time could mean 10% fewer operators, 10% fewer workstations, and a 10% reduction in hardware costs.

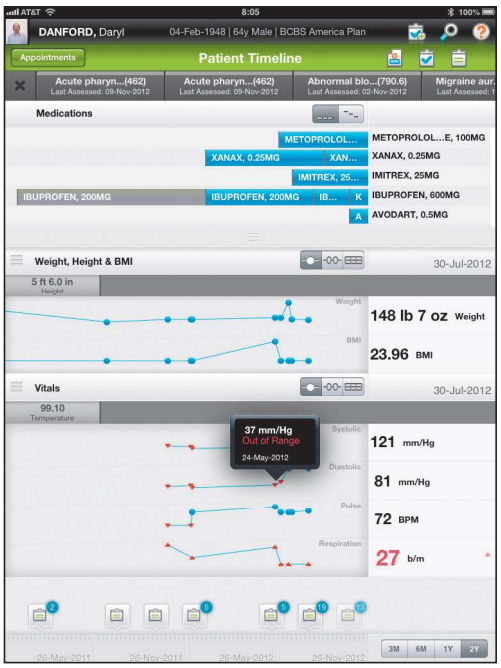

FIGURE 1.9
The Wand timeline view of a patient record in Allscript's ambulatory Electronic Health Record iPad application.

1.3.4 Exploratory, creative, and collaborative interfaces

An increasing fraction of computer use is dedicated to supporting open-ended exploration that promotes human creativity while lowering barriers to collaboration. Exploratory applications include web browsers, search engines, data visualization, and team collaboration support. Creative applications include design environments (Fig. 1.10), music-composition tools, animation builders, and video-editing systems. Collaborative interfaces enable two or more people to work together (even if the users are separated by time and space) through use of text, voice, and video; through systems that facilitate face-to-face meetings; through large audience participation in webinars; or through sharing tools that enable remote collaborators to work concurrently on a document, map, calendar, or image.

In these exploratory, creative, and collaborative environments, the users may be knowledgeable in the task domains but novices in the underlying computer concepts. Their motivation is often high, but so are their expectations. Benchmark tasks are more difficult to describe because of the exploratory nature of these applications, and usage can range from occasional to frequent. In short, it is difficult to design and evaluate these systems. Designers can pursue the goal of having the

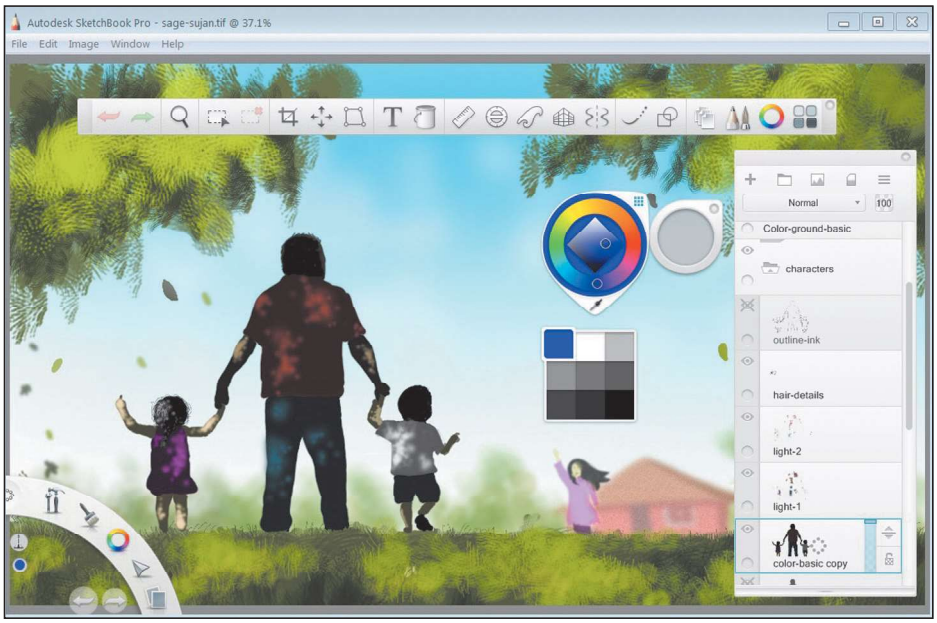

FIGURE 1.10

Sketchbook™, a design tool for digital artists, from Autodesk™. A large number of tools and options are available through a rich set of menus and tool palettes (http://www.sketchbook.com).

computer "vanish" as users become completely absorbed in their task domains. This goal seems to be met most effectively when the computer provides a direct-manipulation representation of the world of action (Chapter 7), supplemented by keyboard shortcuts. Then tasks are carried out by rapid familiar selections or gestures with immediate feedback and new sets of choices. Users can keep their focus on the task with minimal distraction caused by operating the interface.

1.3.5 Sociotechnical systems

A growing domain for usability is in social systems that involve many people over long time periods, such as healthcare, citizen science, disaster response, and community crime reporting. Interfaces for these systems, often created by governmental organizations, have to deal with trust, privacy, and responsibility as well as limiting the harmful effects of malicious tampering, deception, and incorrect information. Users will want to know whom to turn to when things go wrong—and maybe whom to thank when things go right (Whitworth and de Moor, 2009).

For example, in electronic voting systems (Jones and Simons, 2012), citizens need to have reassuring feedback that their votes are correctly recorded, possibly by having a printed receipt. In addition, government officials and professional observers from opposing parties need to have ways of verifying that the votes from each district and regional aggregations are correctly reported (Fig. 1.11). If complaints are registered, investigators need tools to review procedures at every stage.

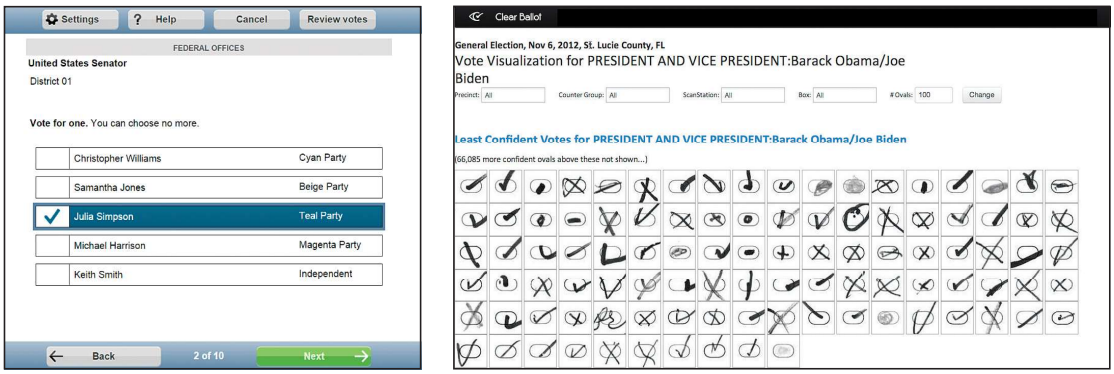

FIGURE 1.11

On the left we see an example of a touchscreen voting kiosk interface (Summers et al., 2014). We see contest number 2 out of 10 and the five candidates. The selected candidate is clearly marked. Some voting jurisdictions use paper ballots that are then digitized. The interface on the right allows rapid review of all the handwritten marks. Courtesy of Clear Ballot (http://www.clearballot.com).

Designers of sociotechnical systems have to take into consideration the diverse levels of expertise of users with different roles. Successful designs for the large number of novice and first-time users emphasize ease of learning and provide the feedback that builds trust. Designs for professional administrators and seasoned investigators enable rapid performance of complex procedures, perhaps with visualization tools to spot unusual patterns or detect fraud in usage logs.

1.4 Goals for Our Profession

Clear goals are useful not only for interface design but also for educational and professional enterprises. Three broad goals seem attainable: (1) influencing academic and business researchers; (2) providing tools, techniques, and knowledge for commercial designers; and (3) raising the user-interface consciousness of the general public.

1.4.1 Influencing academic and business researchers

Researchers in human-computer interaction are prolific as they produce more than 10,000 papers per year. Their research include traditional controlled experimentation in laboratory settings, but increasingly researchers conduct online testing with real users, ethnographic observations in users' homes or workplaces, and long-term, in-depth case studies of users (Chapter 5).

Newer research methods include crowd-sourced user studies that invite thousands of users to participate or pay users through systems such as Amazon's Mechanical Turk. Another innovation is the use of user log data, observations, and interviews to provide complementary strategies that reveal actual performance in live settings. The combination of methods often leads to a deeper understanding of the fundamental principles of human interaction with computers.

The classic scientific method for interface research, which is based on controlled experimentation, has this basic outline:

- Understanding of a practical problem and related theory
- Lucid statement of a testable hypothesis
- Manipulation of a small number of independent variables
- Measurement of specific dependent variables
- Careful selection and assignment of subjects
- Control for bias in subjects, procedures, and materials
- Application of statistical tests
- Interpretation of results, refinement of theory, and guidance for experimenters

When experimental materials and methods are tested by pilot studies and results validated by replication in various situations, then the recommendations are more likely to be reliable.

Of course, the scientific method based on controlled experimentation has its weaknesses. It may be difficult or expensive to find adequate subjects, and laboratory conditions may distort the situation so much that the conclusions have little value. Controlled experiments typically deal with short-term usage, so understanding long-term consumer behavior or experienced user strategies is difficult. Since controlled experiments emphasize statistical aggregation, extremely good or poor performance by individuals may be overlooked. Furthermore, anecdotal evidence or researcher insights may be given too little emphasis because of the authoritative influence of statistics.

Because of these concerns, researchers balance controlled experimentation with ethnographic observation methods and long-term, in-depth case studies. Anecdotal experiences and subjective reactions are recorded, think-aloud approaches are employed, and field or case studies can be carried out. Other research methods include crowd-sourced user studies, analysis of user logs, surveys, focus groups, and interviews.

Within computer science and information studies, there is a growing awareness of the need for greater attention to usability issues. Courses on human-computer interaction are required for some undergraduate degrees, and interface design issues are being added to many curricula. Researchers who propose new programming languages, privacy-protection schemes, or network services are more aware of the need to align with human cognitive skills and preferences. Designers of advanced graphics systems, 3-D printing tools, or consumer products increasingly recognize that their success depends on the construction of effective user interfaces and creation of appealing user experiences.

There is a grand opportunity to apply the knowledge and techniques of traditional psychology (and of subfields such as cognitive and social psychology) to the study of human-computer interaction. Psychologists are investigating human problem solving and creativity with user interfaces to gain an understanding of cognitive processes and social dynamics. The benefit to psychology is great, but psychologists also have a golden opportunity to dramatically influence an important and widely used technology. Similarly, sociologists and communications theorists are now actively participating in human-computer interaction research.

Researchers in business, management, education, sociology, anthropology, and other disciplines are benefiting from and contributing to the study of human-computer interaction. There are many fruitful directions for research, but here are a few:

- *Reduced anxiety and fear of computer usage.* Although computers are widely used, some otherwise competent people resist using e-mail and engaging in e-commerce because they are anxious about—or even fearful of—breaking

the device, making an embarrassing mistake, or having their privacy violated. Fear of scams and frustration with e-mail spam could also be reduced by improved designs that promote security and privacy while increasing the users' control over their experiences.

- *Graceful evolution.* Although novices may begin their interactions with a computer by using just a few features, they may later wish to move up to more powerful facilities. Refined multi-layer interface designs, preference settings, and training materials are needed to smooth the transition from novice to knowledgeable user to expert. The differing requirements of novices and experts in terms of prompting, error messages, online assistance, display complexity, pacing, and informative feedback all need investigation. Users may be allowed to customize their interfaces far beyond changing backgrounds, font sizes, and ring tones, but methods for guiding users through such processes are an open topic.
- *Social media.* The remarkable spread of social media is an indicator of larger changes to come. Enabling sharing of user-generated content, especially from mobile devices, is widespread; much work remains to be done in raising the quality of what is produced, enabling effective annotations, making these materials accessible, and facilitating reuse in ways that protect users' desires for privacy or profit.
- *Input devices.* The plethora of input devices presents opportunities and challenges to interface designers (Chapter 10). There are heated discussions about the relative merits of multi-touch screens, voice, gestures, and haptic feedback. Such conflicts could be resolved through experimentation with multiple tasks and users. Underlying issues include speed, accuracy, fatigue, error correction, and subjective satisfaction.
- *Information exploration.* As navigation, browsing, and searching in multimedia digital libraries and the World Wide Web become more common, the pressure for more effective strategies and tools has increased (Chapter 15). Users will want to filter, select, and restructure their information rapidly with minimum effort and without fear of getting lost or finding misleading information. Large databases of text, images, graphics, sound, video, and scientific data, commonly called *big data*, are becoming easier to explore with information visualization and visual analytic tools.

1.4.2 Providing tools, techniques, and knowledge for commercial designers

User-interface design and development are hot topics, and international competition is lively. Employers who used to see usability as a secondary topic are increasingly hiring user experience designers, information architects, mobile app implementers, and usability testers. These employers recognize the

competitive advantage from high-quality consumer interfaces and from improving the performance of their employees. There is a great thirst for knowledge about software tools, design guidelines, and testing techniques. User-interface–building tools provide support for rapid prototyping and interface development while aiding design consistency, supporting universal usability, and simplifying evolutionary refinement.

Guidelines documents have been written for general and specific audiences (see the list at end of this chapter). Most projects take the productive route of writing their own guidelines, which are tied to the problems of their application environments and users. These guidelines are constructed from experience with existing interfaces, research results, and knowledgeable guesswork.

Iterative usability testing and expert reviews are appropriate during interface design. Once the initial interface is available, continuous refinements can be made on the basis of observations, surveys, interviews, usage log analysis, or more controlled empirical tests of novel strategies (Chapter 5). Agile processes emphasize lively design studio critiques of proposals and rapid trials of multiple alternatives to guide designers.

Feedback from users during the design process and for continuous refinement can provide useful insights and guidance. E-mail, web-based tools, and text messaging allow users to send comments directly to the designers, while logs of user behaviors provide designers with further evidence of what needs fixing. While searchable databases of user questions can often resolve problems and guide designers, online user consultants and fellow users can provide assistance and supportive encouragement.

1.4.3 Raising the user-interface consciousness of the general public

The media are so filled with stories about user interfaces that raising public consciousness of these tools may seem unnecessary. However, many people are still uncomfortable with the technologies they use. When they use a bank machine, a cell phone, or e-mail, they may feel fearful of making mistakes, anxious about damaging the equipment, worried about feeling incompetent, or threatened by the computer "being smarter than I am." These fears are generated, in part, by poor designs that have complex features, inconsistent terminology, confusing error messages, and tortuous sequences of actions.

One of our goals is to encourage users to translate their internal fears into outraged action. Instead of feeling guilty when they get a message such as DATA ERROR, users should express their anger at the user-interface designer who was so inconsiderate and thoughtless. Instead of feeling inadequate or foolish because they cannot remember a complex sequence of actions, they should complain to the designer who did not provide a more convenient mechanism or should seek another product that does.

Usability ultimately becomes a question of national priorities. Advocates of electronic voting and other services and promoters of e-healthcare and e-learning increasingly recognize the need to influence allocation of government resources and commercial research agendas. Policymakers and industry leaders become heroes when they facilitate access and promote quality, but they become villains when failures threaten children, disrupt travel, or menace consumers.

As examples of successful and satisfying interfaces become more visible, the crude designs appear archaic and will become commercial failures. As designers improve the user experience, some users' fears will recede, and the positive experiences of their competence, mastery, and satisfaction will flow in.

Practitioner's Summary

When designers of interactive systems conduct thorough user and task analyses, they are more likely to gain insights that will lead them to a proper functional design. They are more likely to have positive outcomes if they pay attention to reliability, availability, security, integrity, standardization, portability, integration, and the administrative issues of schedules and budgets. As design alternatives are proposed, evaluations can lead to shorter learning times, more rapid task performance, lower error rates, easier retention, and higher user satisfaction. Designers who accommodate the needs of children, older adults, and users with disabilities can improve the quality for all users. As designs are refined and implemented, evaluation by pilot studies, expert reviews, usability tests, user observations, user log analysis, and acceptance tests can accelerate improvement. Success in product design is measured in terms of evidence that universal usability is being attained (rather than testimonials from a few enthusiastic users). The proliferating literature and evidence-based guidelines will be of assistance in designing projects while accommodating the increasingly diverse and growing community of users.

Researcher's Agenda

The criteria for success in research favor innovations that work for broad communities of users performing useful tasks over longer time periods. At the same time, researchers are struggling to understand what kinds of imaginative consumer products will attract, engage, and satisfy diverse populations. The opportunities for researchers are unlimited. There are so many interesting, important, and doable projects that it may be hard to choose a direction. The goal of

universal usability through plasticity of interface designs will keep researchers busy for years. Getting past vague promises and measuring user performance with alternate interfaces will be central to rapid progress. Each study has two parents: the practical problems facing designers and the fundamental theories based on principles of human behavior and interface design. Begin by proposing a lucid, testable hypothesis. Then consider the appropriate research methodology, conduct the study, collect the data, and analyze the results. Each study also has three children: specific recommendations for the practical problem, refinements of theories, and guidance for future researchers.

WORLD WIDE WEB RESOURCES

www.pearsonglobaleditions.com/shneiderman

This book is accompanied by a website (www.pearsonglobaleditions.com/shneiderman) that includes pointers to additional resources tied to the contents of each chapter. In addition, this website contains information for instructors, students, practitioners, and researchers. The links for Chapter 1 include pointers to general resources on human-computer interaction, such as professional societies, government agencies, companies, bibliographies, and guidelines documents.

Readers seeking references to scientific journals and conferences can consult the online searchable bibliography for human-computer interaction (http://www.hcibib.org/). Maintained since 1989, under the heroic leadership of Gary Perlman, the HCI Bibliography makes available more than 120,000 journal, conference, and book abstracts plus link collections on many topics, including consulting companies, education, history, and international development.

Some wonderful World Wide Web resources are:

- Resource on usability methods and guidelines from the U.S. government: http://www.usability.gov/
- IBM's extensive guide to user-centered design methods: http://www.ibm.com/design/
- Interaction Design Foundation's free online educational materials: https://www.interaction-design.org/
- Diamond Bullet Design: http://www.usabilityfirst.com/

E-mail lists for announcements and discussion lists are maintained by ACM SIGCHI (http://www.acm.org/sigchi/) and by the British HCI Group (http://www.bcs-hci.org.uk/), which also sponsors the frequently updated Usability News (http://usabilitynews.bcs.org/).

Discussion Questions

1. Devise an outline, consistent with the scientific method, which interface researchers should follow to validate their designs.
2. List some characteristics of successful user-interface designers with respect to their approach to solving UI problems.
3. As noted in this chapter, some skeptics feel that accommodating diversity requires dumbing-down or lowest-common-denominator strategies. However, the authors claim that in their experience, rethinking interface designs to accommodate these diversity situations will result in a better product for all users. Give an example of a product that meets the specific needs of a certain group of people, yet gives all users a better experience.
4. How can designers encourage novice users to use a system?
5. Suggest three usability measures that can be directly used to produce a practical evaluation of a system. Keep the goals of efficiency and satisfaction in mind with these measures.

References

Specialized references for this chapter appear here; general information resources are listed in the following section.

Bias, Randolph and Mayhew, Deborah (Editors), *Cost-Justifying Usability: An Update for the Internet Age,* 2nd Edition, Morgan Kaufmann, San Francisco, CA (2005).

Center for Information Technology Accommodation, Section 508: The road to accessibility, General Services Administration, Washington, DC (2015). Available at http://www.section508.gov.

Friedman, C., Rubin, J., Brown, J., Buntin, M., Corn, M., Etheredge, L., Gunter, C., Musen, M., Platt, R., Stead, W., Sullivan, K., and Van Houweling, D., Toward a science of learning systems: A research agenda for the high-functioning learning health system, *Journal of the American Medical Informatics Association* (2014), 1–6.

Froehlich, Jon, Findlater, Leah, and Landay, James, The design of eco-feedback technology, *Proceedings CHI 2010 Conference: on Human Factors in Computing Systems,* ACM Press, New York (2010), 1999–2008.

Jones, Douglas W., and Simons, Barbara, *Broken Ballots: Will Your Vote Count?* Center for the Study of Language and Information (2012).

Norooz, L., Mauriello, M., McNally, B., Jorgenson, A., and Froehlich, J., BodyVis: A new approach to body learning through wearable sensing and visualization, *Proceedings CHI 2015 Conference: Human Factors in Computing Systems, ACM Press, New York* (2015), 1025–1034.

Summers, K., Chisnell, D., Davies, D., Alton, N., and McKeever, M., Making voting accessible: Designing digital ballot marking for people with low literacy and mild cognitive disabilities. *USENIX Journal of Election Technology and Systems (JETS)* 2, 2 (2014).

Tullis, Thomas, and Albert, William, *Measuring the User Experience: Collecting, Analyzing, and Presenting Usability Metrics*, 2nd Edition, Morgan Kaufmann (2013).

Whitworth, Brian and De Moor, Aldo (Editors), *Handbook of Research on Socio-Technical Design and Social Networking Systems*, IGI Global, Hershey, PA(2009).

General information resources

Primary journals include the following:

ACM Interactions: A Magazine for User Interface Designers, ACM Press

ACM Transactions on Accessible Computing, ACM Press

ACM Transactions on Computer-Human Interaction (TOCHI), ACM Press

AIS Transactions on Human-Computer Interaction, AIS

Behaviour & Information Technology (BIT), Taylor & Francis Ltd.

Computer Supported Cooperative Work, Springer

Human-Computer Interaction, Taylor & Francis Ltd.

Information Visualization, Sage

Interacting with Computers, Oxford University Press

International Journal of Human-Computer Interaction, Taylor & Francis Ltd.

International Journal of Human-Computer Studies, Elsevier

Journal of Usability Studies, User Experience Professionals Association

Universal Access in the Information Society, Springer

Other journals that regularly carry articles of interest include:

ACM: Communications of the ACM (CACM)

ACM Transactions on Graphics

ACM Transactions on Information Systems

ACM Transactions on Interactive Intelligent Systems

ACM Transactions on the Web

Cognitive Science

Computers in Human Behavior

Ergonomics

Human Factors

IEEE Computer

IEEE Computer Graphics and Applications

IEEE Transactions on Human-Machine Systems

IEEE Transactions on Visualization and Computer Graphics

Journal of Computer-Mediated Communication

Journal of Visual Languages and Computing

Personal and Ubiquitous Computing
Presence
Psychology
Technical Communication
User Modeling and User-Adapted Interaction
Virtual Reality

The Association for Computing Machinery (ACM) has a Special Interest Group on Computer-Human Interaction (SIGCHI), which holds regularly scheduled conferences. ACM also publishes the highly regarded *Transactions on Human-Computer Interaction* and the lively magazine *Interactions*. Other ACM Special Interest Groups, such as Graphics and Interactive Techniques (SIGGRAPH), Accessible Computing (SIGACCESS), Multimedia (SIGMM), and Hypertext and the Web (SIGWEB), also produce conferences and newsletters. Other relevant ACM groups are Computers and Society (SIGCAS), Design of Communication (SIGDOC), Groupware (SIGGROUP), Information Retrieval (SIGIR), and Mobility of Systems, Users, Data, and Computing (SIGMOBILE).

The IEEE Computer Society, through its many conferences, transactions, and magazines, covers user-interface issues. Similarly, the business-oriented Association for Information Systems (AIS) has a SIGHCI that publishes a journal and runs sessions at several conferences. The long-established Human Factors & Ergonomics Society also runs annual conferences and has a Computer Systems Technical Group with a newsletter. Additionally, the Society for Technical Communications (STC), the American Institute of Graphic Arts (AIGA), the International Ergonomics Association, and the Ergonomics Society increasingly focus on user interfaces. The influential business-oriented User Experience Professionals Association (UXPA) publishes the *UX—User Experience* magazine and the online *Journal of Usability Studies*. The UXPA also spawned the annual World Usability Day with hundreds of events around the world each November.

The International Federation for Information Processing has a Technical Committee (TC.13) and Working Groups on Human-Computer Interaction. The British Computer Society Human-Computer Interaction Group has held an international conference since 1985. The French Association Francophone pour l'Interaction Homme-Machine (AFIHM), the Spanish Asociación Interacción Persona-Ordenador (AIPO), and other associations promote HCI within their language communities. Other groups conduct important events in South Africa, Australia/New Zealand, Scandinavia, Asia, Latin America, and elsewhere.

Conferences—such as the ones held by the ACM (especially SIGCHI), IEEE, Human Factors & Ergonomics Society, and IFIP—often have relevant papers presented and published in the proceedings. INTERACT, Human-Computer Interaction International, and Work with Computing Systems are conference series that cover user-interface issues broadly. Many specialized conferences may also be of interest: for example, User Interfaces Software and Technology, Hypertext, Computer-Supported Cooperative Work, Intelligent User Interfaces, Computers and Accessibility, Ubiquitous Computing, Computers and Cognition, Designing Interactive Systems, and more.

Brad Myers's brief history of HCI (*ACM Interactions*, March 1998) is one starting point for those who want to study the emergence and evolution of this field. James Martin provided a thoughtful and useful survey of interactive systems in his 1973 book *Design of Man-Computer Dialogues*. Ben Shneiderman's 1980 book *Software Psychology: Human Factors in Computer and Information Systems* promoted the use of controlled experimental

techniques and scientific research methods. Rubinstein and Hersh's *The Human Factor: Designing Computer Systems for People* (1984) offered an appealing introduction to computer-system design and many useful guidelines. The first edition of this book, published in 1987, reviewed critical issues, offered guidelines for designers, and suggested research directions.

A steady flow of influential books has stimulated widespread media and public attention about usability issues, including Nielsen's *Usability Engineering* (1993), Landauer's *The Trouble with Computers* (1995), and Nielsen's *Designing Web Usability* (1999). Don Norman's 1988 book *The Psychology of Everyday Things* (reprinted and revised in 2013 as *The Design of Everyday Things*) is a refreshing look at the psychological issues involved in the design of the everyday technology that surrounds us.

As the field matured, subgroups and publications centered around specialized topics emerged; this happened with mobile computing, web design, online communities, information visualization, virtual environments, and so on. The following list of guidelines documents and books is a starting point to an exploration of the large and growing literature.

Guidelines documents

Apple Computer, Inc., *Human Interface Guidelines, Version for the Mac OS X, iPhone, iPad, and Apple Watch,* Apple, Cupertino, CA (April 2015). Available at http://developer.apple.com/.

—Explains how to design consistent visual and behavioral properties for Apple products.

International Organization for Standardization, *ISO 9241 Ergonomics of Human-System Interaction*, Geneva, Switzerland (updated 2013). Available at http://www.iso.org/.

—Thorough general introduction, covering dialog principles, guidance on usability, presentation of information, user guidance, menu dialogs, command dialogs, direct-manipulation dialogs, form-filling dialogs, and much more. This is an important source for many countries and companies.

Microsoft, Inc., *The Microsoft Windows User Experience Interaction Guidelines*, Redmond, WA (2015). Available at https://msdn.microsoft.com/.

—Describes design principles, controls, text, interaction, windows, and aesthetics.

United Kingdom Health & Social Care Information Centre, *User Interface Guidance* (June 2015). Available at http://systems.hscic.gov.uk/data/cui/uig.

—Detailed guidelines oriented to medical systems.

United Kingdom Ministry of Defence, *Human Factors for Designers of Systems*, Defence Standard 00-250 (June 2013). Available at http://www.dstan.mod.uk/data/00/250/00000100.pdf.

—Describes human factors, integration processes, requirements, and acceptance testing.

U.S. Dept. of Defense, *Human Engineering Design Criteria Standard*, Military Standard MIL-STD–1472G, U.S. Government Printing Office, Washington, DC (2012).

—Covers traditional ergonomic and anthropometric issues. Later editions pay increasing attention to user-computer interfaces. Interesting and thought-provoking reminder of many human-factors issues.

U.S. Federal Aviation Administration, *The Human Factors Design Standard*, Atlantic City, NJ (updated May 2012). Available at http://hf.tc.faa.gov/hfds/.

—Extensive compilation of human-factors standards for contractors to follow, especially relevant to aircraft and air-traffic control.

U. S. National Cancer Institute, *Research-based Web Design and Usability Guidelines*, Dept. of Health & Human Services, National Institutes of Health (2006, updated on the web 2015). Available at http://guidelines.usability.gov/.

—Authoritative and packed with numerous full-color examples of information-oriented websites.

World Wide Web Consortium's Web Accessibility Initiative, *Web Content Accessibility Guidelines 2.0* (2008). Available at http://www.w3.org/WAI/.

—Practical, implementable three-level prioritization of web design guidelines for users with disabilities. The Web Accessibility Initiative (WAI) develops strategies, guidelines, and resources to help make the web accessible to people with disabilities. Four principles are offered: Perceivable, Operable, Understandable, and Robust.

World Wide Web Consortium, *Web Accessibility Evaluation Tools* (2014). Available at http://www.w3.org/WAI/ER/tools/.

—An occasionally updated list of software tools related to accessibility; demonstrates lively activity.

Books

Allen, J., and Chudley, J., *Smashing UX Design: Foundations for Designing Online User Experiences*, Wiley, Chichester (2012).

Anderson, S., *Seductive Interaction Design: Creating Playful, Fun, and Effective User Experiences,* New Riders (2011).

Barnum, Carol M., *Usability Testing Essentials: Ready, Set… Test!* Morgan Kaufmann (2011).

Baxter, Kathy, and Courage, Catherine, *Understanding Your Users: A Practical Guide to User Requirements Methods, Tools, and Techniques*, 2nd Edition, Morgan Kaufmann (2015).

Bell, Genevieve, and Dourish, Paul, *Divining a Digital Future: Mess and Mythology in Ubiquitous Computing*, MIT Press (2011).

Berkman, Eric, and Hoober, Steven, *Designing Mobile Interfaces,* O'Reilly, Sebastopol, CA (2011).

Boy, Guy, *Handbook of Human-Machine Interaction*, Ashgate (2011).

Boy, Guy, *Orchestrating Human-Centered Design*, Springer (2013).

boyd, danah, *It's Complicated: The Social Lives of Networked Teens*, Yale University Press (2014).

Buley, Leah, *The User Experience Team of One: A Research and Design Survival Guide*, Rosenfeld Media (2013).

Cairns, P., and Cox, A. L. (Editors), *Research Methods for Human-Computer Interaction*, Cambridge University Press (2008, reprinted 2011).

Calvo, Rafael A., and Peters, Dorian, *Positive Computing: Technology for Wellbeing and Human Potential*, MIT Press (2014).

Carroll, J. (Editor), *Creativity and Rationale: Enhancing Human Experience by Design*, Springer (2013).

Chandler, C., and Unger, R., *A Project Design to UX Design: For User Experience Designers in the Field or in the Making*, 2nd Edition, New Riders (2012).

Chandler, C., and van Slee, A., *Adventures in Experience Design*, New Riders (2014)

Chapman, C., *The Smashing Idea Book: From Inspiration to Application*, Wiley (2011).

Colborne, Giles, *Simple and Usable Web, Mobile, and Interaction Design (Voices That Matter)*, New Riders, Berkeley, CA (2011).

Cooper, A., Reimann, R., Cronin, D., and Noessel, C., *About Face: The Essentials of Interface Design*, 4th Edition, John Wiley & Sons (2104).

Crabtree, Andrew, Rouncefield, Mark, and Tolmie, Peter, *Doing Design Ethnography*, Springer, London (2012).

Craig, Alan B., *Understanding Augmented Reality: Concepts and Applications*, Morgan Kaufmann, San Francisco, CA (2013).

Cunningham, Katie, *Accessibility Handbook*, O'Reilly Publishing (2012).

Dannen, Chris, *iPhone Design Award-Winning Projects (The Definitive Guide)*, Apress, Berkeley, CA (2010).

Ferster, Bill, *Interactive Visualization: Insight through Inquiry*, MIT Press (2012).

Garrett, J. J., *The Elements of User Experience: User-centered Design for the Web and Beyond*, 2nd Edition, New Riders Press (2010).

Goodman, E., Kuniavsky, M., and Moed, A., *Observing the User Experience*, 2nd Edition, Morgan Kaufmann (2012).

Gothelf, J., and Seiden, J. (Editors), *Lean UX: Applying Lean Principles to Improve User Experience*, O'Reilly Media (2013).

Greenberg, S., Carpendale, S., Marquardt, N., and Buxton, B., *Sketching User Experiences: The Workbook*, Morgan Kaufmann (2012).

Harris, D., *Writing Human Factors Research Papers: A Guidebook*. Ashgate Publishing (2012).

Hartson, R., and Pyla, P., *The UX Book: Process and Guidelines for Ensuring a Quality User Experience*, Morgan Kaufmann (2012).

Hearst, Marti A., *Search User Interfaces*, Cambridge University Press, New York, NY (2009).

Hinman, Rachel, *The Mobile Frontier: A Guide for Designing Mobile Experiences*, Rosenfeld Media, Brooklyn, NY (2012).

Holtzblatt, Karen and Beyer, Hugh, *Contextual Design Evolved*, Morgan & Claypool (2014).

Horton, Sarah and Quesenbery, Whitney, *A Web for Everyone: Designing Accessible User Experiences*, Rosenfeld Media (2015).

Johnson, Jeff, *Designing with the Mind in Mind: Simple Guide to Understanding User Interface Design Rules*, 2nd Edition, Morgan Kaufmann, San Francisco, CA (2014).

Jones, P., *Design for Care: Innovating the Healthcare Experience*, Rosenfeld Media (2013).

Katz, J., *Designing Information: Human Factors and Common Sense in Information Design*. John Wiley (2012).

Kim, Gerard Jounghyun, *Human-Computer Interaction: Fundamentals and Practice,* CRC Press (2015).

Kipper, Greg, and Rampolla Joseph, *Augmented Reality: An Emerging Technologies Guide to AR,* Syngress (2012).

Klimczak, E., *Design for Software,* Wiley (2013).

Kolko, J., *Thoughts on Interaction Design*, 2nd Edition, Morgan Kaufmann (2011).

Koskinen, I., Zimmerman, J., Binder, T., Redstrom, J., and Wensveen, S., *Design Research through Practice from the Lab, Field, and Showroom,* Morgan Kaufmann (2011).

Kraft, C., *User Experience Innovation: User Centered Design That Works*, Apress (2012).

Krug, Steve, *Rocket Surgery Made Easy*: *The Do-it-yourself Guide to Finding and Fixing Usability Problems*, New Riders (2010).

Krug, Steve, *Don't Make Me Think, Revisited: A Common Sense Approach to Web Usability*: 3rd Edition *(Voices That Matter),* New Riders, Berkeley, CA (2014).

Lazar, J., Feng, J. H., and Hochheiser, H., *Research Methods in Human-Computer Interaction*, Wiley (2010).

Lazar, Jonathan, Goldstein, Daniel F., and Taylor, Anne, *Ensuring Digital Accessibility through Process and Policy*, Morgan Kaufmann (2015).

Levin, Michal, *Designing Multi-Device Experiences: An Ecosystem Approach to User Experiences across Devices,* O'Reilly Media, Sebastopol, CA (2014).

Lund, A., *User Experience Management: Essential Skills for Leading Effective UX Teams,* Morgan Kaufmann (2011).

MacKenzie, I. Scott, *Human-Computer Interaction: An Empirical Research Perspective,* Morgan Kaufmann, San Francisco, CA (2013).

Mariani, Joseph, Rosset, Sophie, Garnier-Rizet, and Devillers, Laurence (Editors), *Natural Interaction with Robots, Knowbots and Smartphones: Putting Spoken Dialog Systems into Practice*, Springer (2014).

McKay, E., *UI Is Communication: How to Design Intuitive, User-centered Interfaces by Focusing on Effective Communication*, Morgan Kaufmann (2013).

Moffett, Jack, *Bridging UX and Web Development*, Morgan Kaufmann (2014).

Monk, Andrew (Editor), *Fundamentals of Human-Computer Interaction*, Morgan Kaufmann/Academic Press (2014).

Nagel, Wolfram, *Multiscreen UX Design: Developing for a Multitude of Devices,* Morgan Kaufmann (2015).

Nakano, Y., Conati, C., Bader, T. (Editors), *Eye Gaze in Intelligent User Interfaces: Gaze-based Analyses, Models, and Applications*, Springer (2013).

Neil, Theresa, *Mobile Design Pattern Gallery: UI Patterns for Smartphone Apps*, 2nd Edition, O'Reilly (2014).

Nielsen, Jakob, and Pernice, Kara, *Eyetracking Web Usability,* New Riders, Berkeley, CA (2010).

Nielsen, Jakob, and Budiu, Raluca, *Mobile Usability,* New Riders, Berkeley, CA (2012).

Nielsen, Lene, *Personas: User Focused Design,* Springer, London (2013).

Norman, D., *The Design of Everyday Things: Revised and Expanded Edition,* Basic Books (2013).

Nudelman, G., *Android Design Patterns*, John Wiley (2013). Available at http://www.androiddesignbook.com.

Olson, J. S., and Kellogg, W. A. (Editors), *Ways of Knowing in HCI*, Springer (2014).

Oviatt, Sharon, and Cohen, Philip, *The Paradigm Shift to Multimodality in Contemporary Computer Interfaces*, Morgan & Claypool (2015).

Parush, Avi, *Conceptual Design for Interactive Systems: Designing for Performance and User Experience,* Elsevier/Morgan Kaufmann (2015).

Pratt, A., and Nunes, J., *Interactive Design: An Introduction to the Theory and Application of User-Centered Design*, Rockport Publishers (2012).

Preece, J., Rogers, Y., and Sharp, H., *Interaction Design: Beyond Human-Computer Interaction*, 4th Edition, Wiley, New York, NY (2015).

Purchase, Helen, *Experimental Human-Computer Interaction: A Practical Guide with Visual Examples*, Cambridge University Press (2012*).*

Quesenbery, Whitney, and Szuc, Daniel, *Global UX: Design and Research in a Connected World*, Morgan Kaufmann (2011).

Redish, Janice, *Letting Go of the Words: Writing Web Content That Works (Interactive Technologies),* 2nd Edition, Morgan Kaufmann, San Francisco, CA (2012).

Reiss, E., *Usable Usability: Simple Steps for Making Stuff Better,* Wiley (2012).

Ritter, Frank E., Baxter, Gordon D., and Churchill, Elizabeth F., *Foundations for Designing User-Centered Systems: What System Designers Need to Know about People,* Springer, London (2014).

Robinson, Simon, Jones, Matt, and Marsden, Gary, *There's Not an App for That: Mobile User Experience Design for Life*, Morgan Kaufmann (2015).

Salgado, L. C. C., Leitão, C. F., and de Souza, C. S., *A Journey through Cultures: Metaphors for Guiding the Design of Cross-Cultural Interactive Systems*, Springer (2012).

Sauro, J., and Lewis, J., *Quantifying the User Experience: Practical Statistics for User Research,* Morgan Kaufmann (2012).

Schlatter, T., and Levinson, D., *Visual Usability: Principles and Practices for Designing Digital Applications*, Morgan Kaufmann (2013).

Sharon, Tomer, *It's Our Research: Getting Stakeholder Buy-in for User Experience Research Projects*, Morgan Kaufmann (2012).

Stephanidis, Constantine, *The Universal Access Handbook (Human Factors and Ergonomics),* CRC Press, Boca Raton, FL (2009).

Tullis, Thomas, and Albert, William, *Measuring the User Experience: Collecting, Analyzing, and Presenting Usability Metrics,* 2nd Edition, Morgan Kaufmann (2013).

Weinschenk, S., *100 Things Every Designer Needs to Know about People*, New Riders (2011).

Wigdor, Daniel, and Wixon, Dennis, *Brave NUI World: Designing Natural User Interfaces for Touch and Gesture*, Morgan Kaufmann, San Francisco, CA (2011).

Wilson, Chauncey, *Brainstorming and Beyond: A User-Centered Design Method,* Elsevier/Morgan Kaufmann, Burlington (2013).

Wilson, Chauncey, *Interview Techniques for UX Practitioners: A User-Centered Design Method*, Elsevier/Morgan Kaufmann, Burlington (2013).

Wilson, Chauncey, *User Interface Inspection Methods,* Elsevier/Morgan Kaufmann, Amsterdam (2014).

Wilson, C. (Editor), *User Experience Re-Mastered: Your Guide to Getting the Right Design*, Morgan Kaufmann (2010).

Wilson, Max L., *Search User Interface Design (Synthesis Lectures on Information Concepts, Retrieval, and Services),* Morgan & Claypool Publishers, San Rafael, CA (2011).

Videos

Video is an effective medium for presenting the dynamic, graphical, and interactive nature of modern user interfaces. A wonderful set of lectures from Stanford University's CS547 Human-Computer Interaction Seminar can be found at http://hci.stanford.edu/courses/cs547/.

Inspirational videos from the annual Technology, Entertainment & Design (TED) Conference, which covers a wide range of topics including visionary user-interface themes, are found at http://www.ted.com/index.php/talks/. Another exceptional resource is YouTube (http://www.youtube.com/), where a search on "user interfaces" produces a list of hundreds of recent product demonstrations, research reports, and some clever and funny technology demonstrations.