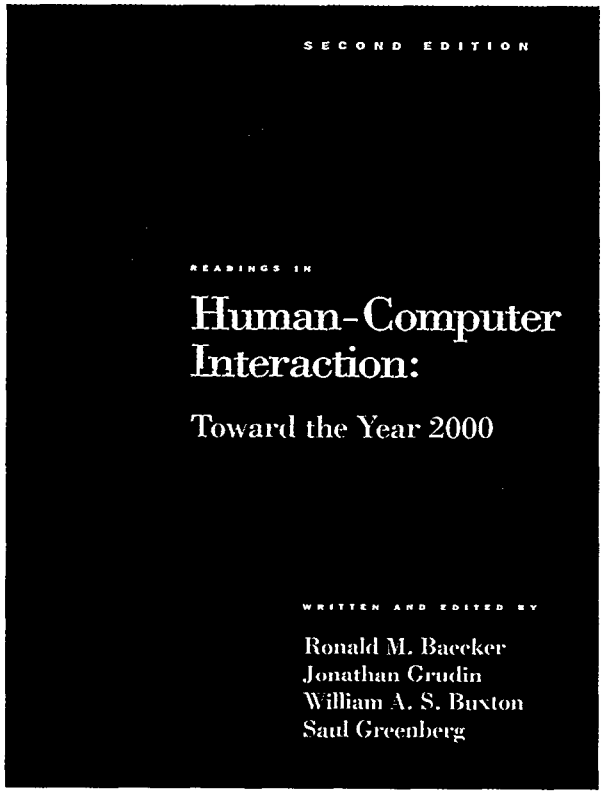
book preview

Readings in Human-Computer Interaction: Toward the Year 2000 Ronald Baecker, Jonathan Grudin, William Buxton, and Saul Greenberg. The man sitting next to me owned a transmission repair shop in Texas. He handed me his card and asked what I did. I told him. "Computers," he replied, "they're everywhere. When I hire a new guy, the first thing I do is send him to computer school for two weeks. The days when a kid learned to fix cars in the backyard under the apple tree are gone."



Computer systems are found throughout our society. School children, scholars, secretaries, bank tellers, middle managers, executives, nurses, factory workers, animators, printers, architects, and planners are all discovering that computers are changing roles and expectations, enhancing some careers, trivializing or eliminating others.

Some computer systems run with little or no intervention, but most are interactive–they have human users who are engaged in computer-assisted tasks. The human-computer interface, usually called the user interface, is often the single most important factor in the success or failure of an interactive system or application.

Narrowly defined, this interface comprises the input and output devices and the software that services them; broadly defined, the interface includes everything that shapes users' experiences with computers, including docu-

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mentation, training, and human support.

The human-computer interface has become a very expensive part of software development. Sutton and Sprague (1978) gathered data on 22 interactive business applications in 10 large organizations from a variety of industries and found that the code required to support the human-computer interface averaged 59 percent of the total application code. Smith and Mosier (1984) surveyed 201 people concerned with information systems design, many involved in human factors engineering. The 83 who replied to the survey estimated that the interface took on average 30 to 35 percent of the software. Bobrow, Mittal, and Stefik (1986) report that the interface often constitutes one third to one half of the code of typical expert or knowledge-based systems. A broadly-distributed survey by Myers and Rosson (1992) drew 74 responses from developers who estimated that 48% of application code and a comparable amount of development time is devoted to the interface today.

Yet, despite its importance, the human-computer interface is one of the most poorly understood aspects of most systems. The success or failure of the interface is determined by complex, subtly interrelated issues: For example, is it responsive or sluggish, forgiving or intolerant of human error, easy or difficult to learn, easy or difficult to use? Even whether or not it is attractive and fun to use makes a significant difference.

The capabilities and disciplines required to balance these and other factors are diverse. Interface design and development require software engineering and programming skills, of course, but can also benefit from the skills of graphic and industrial designers; human factors engineers and psychologists who understand human cognitive, perceptual, and motor skills; technical writers and training specialists; people knowledgeable in group and organizational dynamics; and those with expertise in input devices, display technologies, interaction techniques, dialogue design, and design methodologies. Individuals with an aptitude for elegance in system design play a crucial role. The growing use of sound, voice, video, animation, and three-dimensional display draw upon still other specialties. As computation now mostly supports activity in non-technical domains, those with knowledge of such domains or with the skills to acquire such knowledge become valuable contributors to the development process.

Effective interface development is thus a multidisciplinary process. A holistic view is required in approaching any design problem. More skills are required than any single individual is likely to possess.

Yet even if assembling a team of experts in all of these areas were always possible, it does not guarantee success. Graphic design for computer displays, for example, is very different from the design taught in most art and design schools. The same is true of the other disciplines involved. What we need are new specialists, trained to understand and improve the ways in which humans interact with computers, and broad enough in their outlook to work successfully on multidisciplinary teams.

The Purpose of The Book

What materials are available to help a person become a user interface specialist? Over a thousand papers relevant to the field are published annually, but these are typically written for the expert, cover relatively specialized topics, and are located in journals or conference proceedings which are not widely available. Edited volumes on specific topics have proliferated enormously and more monographs are appearing. There is an excellent although now somewhat dated handbook of human-computer interaction containing over 50 comprehensive and scholarly review papers (Helander, 1988). There are also an increasing number of excellent elementary books summarizing basic principles of human-computer interaction (e.g., Rubinstein and Hersh, 1984; Nickerson, 1986; Booth, 1989; Perlman, 1989; Thimbleby, 1990; Laurel, 1990; Heckel, 1991; Shneiderman, 1992; Mayhew, 1992; Lewis and Rieman, 1993; Dix, Finlay, Abowd, and Beale, 1993; Preece, Rogers, Sharp, Benyon, Holland, and Carey, 1994).

Yet these do not, in our view, sufficiently meet the needs of students, researchers, and practitioners interested in an overview of the significant concepts and results in the field and an introduction and guide to the research literature. That is the niche we sought to fill.

Why a Second Edition?

The first edition of this book (Baecker and Buxton, 1987) was published in 1987. We saw a need for appropriate teaching and learning materials that integrated, at an advanced level, relevant results from the research community, professional practice, and real applications. We therefore gathered, integrated, edited, and annotated with lengthy and scholarly introductions a source book of outstanding papers in human-computer interaction (HCI).

We feel that we were successful. The book was well received and has attracted high ratings from researchers, developers, and instructors. It continues to draw readers. However, seven years have passed. Seven years represents a significant fraction of this young field's existence. The volume of work has increased rapidly. More has probably been published on human-computer interaction in the past three or four years than all that came before. Thus a new edition was clearly needed.

Organization and Contents of the Book

This volume is organized into five parts, consisting of fourteen chapters and three case studies analyzing specific systems and applications as follows:

Part I. Introduction to Human-Computer Interaction
- *Case A. Iterative Design of an Information Kiosk*
- Ch. 1. A Historical and Intellectual Perspective
- *Case B. Emergence of Graphical User Interfaces*

Part II. The Process of Developing Interactive Systems
- Ch. 2. Design and Evaluation
- Ch. 3. Design and Evaluation in a Work Context
- Ch. 4. Development Methods and Contexts
- Ch. 5. Development Tools

Part III. Interacting with Computers
- Ch. 6. Vision, Graphic Design, and Visual Display
- Ch. 7. Touch, Marking, and Gesture
- Ch. 8. Audition, Speech, and Language

Part IV. Psychology and Human Factors
- Ch. 9. Human Information Processing
- Ch. 10. Designing to Fit Human Capabilities

Part V. Research Frontiers in HCI
- Ch. 11. Computer-Supported Cooperative Work
- *Case C. A Multimedia Communication System*
- Ch. 12. Tailorable and Adaptive Systems
- Ch. 13. Hypertext and Information Retrieval
- Ch. 14. Computers and Environments

Part I introduces human-computer interaction by presenting an illustrative case study of a real design problem, discussing user interface design in the context of the design of "everyday things," and describing the historical roots and intellectual development of the field.

In Part II we look at the process of developing interactive systems. We examine in depth the many approaches to design and evaluation. We also look at the social and organizational work contexts in which computers ultimately function, and consider their implications for the design process. We discuss how interface design is influenced by the systems development process of which it is a part and by the nature of the organizations in which it takes place. Finally, we consider the tools and techniques that facilitate implementation of interactive systems and their interfaces.

Part III focuses on the sensori-motor modalities through which users interact–visual, haptic, and audio–and on the interaction styles and techniques that computers support, ranging from direct manipulation in graphical interfaces to the use of speech and natural language.

Part IV focuses on users and usage of interactive computer systems, on the underlying cognitive processes, and on methods of modeling users and systems. Ways in which design can be responsive to human capabilities are then examined, including error handling, documentation, training, and workplace ergonomics.

Finally, Part V looks at research frontiers that are becoming increasingly important as we approach the year 2000: computer-supported cooperative work and groupware; end-user programming; hypertext and information retrieval; and two complementary visions of the future –ubiquitous computing and virtual reality.

Each chapter and case study consists of an original introduction followed by key articles selected and reprinted from the literature. The introductions explain why each paper was selected, what in it is of key importance, and how it relates to the other papers in the volume. Excerpts are included from some important papers that could not be reprinted in their entirety. Shorter quotations appear in the introductions, longer passages are included as readings.

In choosing these readings, we have tried to include papers which:

- maintain a balance between the abstract and the concrete, between the universal and the application-specific, between theory and practice. Theoretical papers appear alongside case studies of real systems and applications.
- describe both the possibilities and constraints of technology and the capabilities and limitations of humans.
- show the importance of the insights required for design and synthesis, as well as those needed in the more rigorous–or at least different–processes of analysis and evaluation.
- deal with individual users of computer systems, and others that deal with communities of users. Some articles focus on a user's dialogue with the computer, others on the context surrounding human-computer dialogues.
- examine the past, the present, and the future of human-computer interaction; and show approaches that are evolutionary as well as those that are revolutionary.

Despite the length of the volume, the sizeable number of readings, and the number of additional excerpts, we do not claim to have included every desirable paper or to have made the best selection of papers in any absolute sense. We labored under constraints of space and time, the need to provide balance, and the ever-expanding volume of relevant literature. The more we read and study, the more we find there is to know. Yet we feel that this volume fills a gap in the literature and addresses the real needs cited above; later editions, or similar volumes by others, will carry this effort further and improve upon the result.

Although the volume is intended as a sourcebook which brings together timely information, there is no central bibliography. We felt it best to list additional readings at the end of each chapter introduction, in closer proximity to the relevant material. Again, we had to be very selective. To help readers initiate literature searches, we biased our choices towards papers that are recent. Our bibliography also includes references to available video tapes, since a video tape record is often more effective in documenting, presenting, and explaining an interactive system than is a written record. Excellent bibliographies are also included.

One happy development is the creation of bibliographic data bases, central repositories of information relevant to the field that are available across the Internet or in other formats. (see Perlman, 1991, hcibib@cis.ohio-state.edu; Shackel et al., 1992, p.reid@lut.ac.uk).

We hope that this volume serves both as a valuable free-standing collection and as a set of pointers and a guide to the rich and rapidly evolving literature of human-computer interaction.

What's New in the Second Edition?

What did we keep, what did we change? The simple answer is that this is closer to a new book than a second edition. Almost all of the readings are new, and there are 20% more pages than in the first edition. The first edition is thus still valuable as a companion volume. The overall structure of the book has been largely preserved, but significantly reordered.

Readers may be surprised, for example, to find design and evaluation collapsed into one (long) chapter. Relatively pure cases of design exist, but the emphasis on prototyping and iterative development are eroding the barriers between design and evaluation. Good design practice often includes the evaluation of current practice, existing systems, and the use of prototypes. We did, however, include a few papers which focus exclusively on design or evaluation.

Over the years, we have seen this book often being used in courses which include a student project consisting of the design or evaluation of an interface. To assist students in carrying out such projects, we moved the chapters on development, design, and evaluation forward. Material on the emerging psychology of human-computer interaction thus appears later, a change we made reluctantly.

A few other changes are noteworthy. Two burgeoning fields, computer-supported cooperative work and hypertext, warranted significant attention and received chapters of their own. The same is true of tailorable systems and end-user programming, and virtual reality and ubiquitous computing. We also included more papers focusing on the work environments,

Ron Baecker is Professor of Computer Science, Electrical Engineering, and Management, and Director of the Collaborative Multimedia Research Group of the Dynamic Graphics Project of the Computer Systems Research Institute, University of Toronto, Canada. email: rmb@dgp.toronto.edu

Jonathan Grudin is Associate Professor of Information and Computer Science, University of California, Irvine, where he is in the Computers, Organizations, Policy and Society (CORPS) group. email: grudin@ics.uci.edu

In 1992 the ACM SIGCHI (Special Interest Group on Human-Computer Interaction) published a report of its Curriculum Development Group entitled "ACM SIGCHI Curricula for Human-Computer Interaction" (ACM, 1992). See also ACM SIGCHI Curricula for Human-Computer Interaction in this issue. Section 2.3 of the report is called "The Content of Human-Computer Interaction." It attempts to inventory "the current state of research results in the field of HCI" as follows (p. 15):

N The Nature of HCI
- N1 (Meta-)Models of HCI

U Use and Context of Computers
- U1 Human Social Organization and Work
- U2 Application Areas
- U3 Human-Machine Fit and Adaptation

H Human Characteristics
- H1 Human Information Processing
- H2 Language, Communication, Interaction
- H3 Ergonomics

C Computer System and Interface Architecture
- C1 Input and Output Devices
- C2 Dialogue Techniques
- C3 Dialogue Genre
- C4 Computer Graphics
- C5 Dialogue Architecture

D Development Process
- D1 Design Approaches
- D2 Implementation Techniques
- D3 Evaluation Techniques
- D4 Example Systems and Case Studies

P Project Presentations and Examinations

Instructors, students, and researchers wishing to review the field according to the inventory presented on pages 13-28 of the Report [CDG] can find in this volume [BGBG] most of the topics described in the inventory, albeit organized in a different way:

[CDG]N1:	[BGBG] Ch. 1
[CDG]U1:	[BGBG] Chs. 3, 4, 11
[CDG]U2:	[BGBG] Cases A-C, Chs. 11-14
[CDG]U3:	[BGBG] Chs. 10, 12
[CDG]H1:	[BGBG] Chs. 9, 10
[CDG]H2:	[BGBG] Chs. 6-8
[CDG]H3:	[BGBG] Ch. 10
[CDG]C1:	[BGBG] Chs. 6-8
[CDG]C2:	[BGBG] Chs. 6-8
[CDG]C3:	[BGBG] Chs. 2, 6
[CDG]C4:	[BGBG] Ch. 6
[CDG]C5:	[BGBG] Chs. 5, 6
[CDG]D1:	[BGBG] Chs. 2, 6
[CDG]D2:	[BGBG] Chs. 2, 4, 5
[CDG]D3:	[BGBG] Chs. 2,3
[CDG]D4:	[BGBG] Cases A-C, Chs. 11-14

The only [CDG] content area that we barely cover is C4: Computer Graphics, which is almost always taught and studied as a separate subject. A comprehensive text is Foley, van Dam, Feiner, and Hughes (1990). On the other hand, our Chapter 3: Design and Evaluation in a Work Context and Chapter 4: Development Methods and Contexts goes significantly beyond what was proposed in the CDG report

Bill Buxton is an Associate Professor in the Department of Computer Science at the University of Toronto, Canada, where he is the scientific director of the Ontario Telepresence Project and the Input Research Group. He is also a consulting research scientist at Xerox's Palo Alto Research Center (PARC).
email: willy@dgp.toronto.edu

Saul Greenberg is Assistant Professor of Computer Science, University of Calgary, Alberta, Canada.
email: saul@cpsc.ucalgary.ca

development organizations, and software engineering practices that constitute the context for most applications of human-computer interaction. On the other hand, we reduced the emphasis on studies of text editing and word processing, although there remain lessons to be learned from these mature application areas.

One Disclaimer

The field of human-computer interaction has in the past fifteen years focused on the needs of individual computer users, people who are often discretionary users working with personal computers, workstations, and minicomputer terminals. The field has been heavily influenced by cognitive psychologists and human factors engineers interested in problems arising in these contexts, and by vendor companies that are developing for these markets. The overwhelming mood among those involved in the development and delivery of these technologies has been optimism, ranging from mild pleasure at tangible advance to euphoria and a belief in the liberating and enhancing effects of appropriate technology.

There is another field, with much older roots in the mainframe computer era, that also focuses on the interaction of people and computers. Variously called Data Processing (DP), Management Information Systems (MIS), and Information Technology (IT), this field has been heavily influenced by social and organizational psychologists, management theorists, and by large customer organizations, such as banks, hospitals, and government agencies. Researchers and practitioners in this field and many others coming from computer science, sociology, philosophy, and law are more evenly divided between optimistic and pessimistic outlooks. Questions they raise include: What is appropriate technology? How should it be applied? Of what use is it to enhance the human-computer interface if the purpose and the application are not ennobling and enriching?

The field of human-computer interaction has not usually dealt with these issues–social implications of computing–in any depth. The human-computer interaction focus is typically development and refinement, as opposed to critique and analysis of fundamental change in society brought about by technology. The two fields are no longer entirely isolated, as they have come together in forums such as the study of computer-supported cooperative work, but differences in emphasis remain.

The effect of computers on employment, personal privacy, safety from an accidental nuclear disaster, the distribution of power and control in our society, and on our self image, to identify some of the serious issues raised by such scholars, are critical to the wise and humane use of computers and should be pondered and debated by all those active in the so-called "computer revolution."

Despite the importance of these issues, this volume is intended to represent, insofar as is possible in 900 pages, the major results and research contributions in the field of human-computer interaction as it is conventionally constituted today. Fortunately, we can recommend several excellent books devoted to the study of the social impact of computerization. For example, Dunlop and Kling (1991) draws on the MIS/IT literature to provide valuable perspectives on many of these issues. Other good introductions are Erman, Williams, and Gutierrez (1990), Forester and Morrison (1990), Rosenberg (1992), and BBC (1992).

Using this Book in Teaching

The first edition of this book has been widely used in courses at the advanced undergraduate and graduate levels. One explicit goal of the second edition was to enable its use both for one semester graduate courses and for one or two semester undergraduate courses. To a large extent this has been successfully tested with draft manuscripts in the 1993-94 academic year.

Another way of discussing the use in courses is that adopted in the Curriculum Development Group report, which describes four prototypical courses as follows (p. 30): "The proposed courses can be broadly characterized as either technology oriented (CS1: User Interface Design and Development and CS2: Phenomena and Theories of Human-Computer Interaction) or human-oriented (PSY1: Psychology of Human-Computer Interaction and MIS1: Human Aspects of Information Systems), and as moving from a

general professional/practical orientation (CS1 and MIS1) to one that is more specialized and research oriented (CS2 and PSY1)."

The first term of a two-semester computer science HCI course (CS1) would draw most heavily from Part I, Chapters 2 and 5 in Part II, and selected topics from Part III and Part V, with one or two lectures dealing with material in Part IV. The second semester (CS2) would pick up additional topics from Parts II, III, and V, with significant emphasis on material in Part IV. A one-semester course in psychology (PSY1) would begin with Part I, and choose in a balanced way material from Chapters 2 and 5, Parts III, and IV, using some material in Part V for motivation and illustration. The same is true for a one-semester course in management information systems (MIS1), except more emphasis would be given to material in Chapters 3 and 4, with a corresponding de-emphasis on Part IV. ■

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