1. Introduction to Human-Computer Interaction

From fishing nets to drilling machines, tools are vital to human ability. They amplify our physical abilities and are central to many intellectual activities, such as writing, mathematics, and accounting. It is hardly surprising that great efforts have been invested throughout history in innovating and refining them. However, in the long history of tools, the birth of the computer marks a watershed. The invention of transistors in the 20th century, together with the theory of computation and the architecture of the digital computer, pushed humanity to transform itself.

At the core of this revolution was the ability to flexibly define and execute *computer programs*—sequences of logical operations executed on a computer. Transistors enable energy-efficient and noise-resilient logic gates, which in turn enable implementation of Boolean operations, such as `nand` and `nor`. These logic gates are organized as logic circuits to implement the necessary functions of a computer, such as arithmetic logic units and registers, all the way up to a complete microprocessor. A computing system integrates a microprocessor with the memory and peripherals needed to execute programs. An important enabler is an operating system, a special computer program that manages the hardware and software resources of a computer, such as access to memory and displays, and allocates such resources to programs. It also provides common services to programs, such as access to networks.

Programmability lends computers their power as a tool. Computer programs can decompose complex activities into sequences of much simpler operations. When input is provided to a program, it is executed according to the program. For example, the task of sending a message to a contact is broken down to subtasks, such as sensing user's input, committing letters, updating the display, selecting a recipient from a menu, or sending a message over a network. Each of these subtasks is implemented via numerous simpler operations carried out by a computer. Computer programs also permit computation using different formalisms, from algebra to probability theory. They can be used to flexibly represent the types of input that are important. An input can represent virtually anything that—ultimately—can be defined using a binary system, such as images, text, and sound. This has been central to the wider appropriation of computing as a tool. Thus, the remarkable efficiency, flexibility, and scalability of computers as tools boil down to the concept of a programmable machine capable of interpreting computer programs.

However, computers would be useless as a tool if they did not offer some way for people to control them. A special part of a computing system is the *user interface*. It is the part that the user can see and act on to command the computer. Through a user interface, users can provide input and instructions to a computer and receive feedback from it. In short, a user interface enables *interaction* with a computer. The user interface simplifies the underlying technical system for the user: it allows users to command a computer without bothering with what it exactly does under the hood. Instead of defining a long and incomprehensible binary code that commands a microprocessor to delete a file, which would be unreachable for most users, the command can be provided with a few mouse movements and clicks. When a user drags an icon representing a file to the trash bin to delete it, this instruction is propagated through many layers of instructions, trickling down from the file system managed by the operating system to low-level disk management handled by the actual physical storage device. At the end, the computer updates the display to communicate back to the user what it did.

The development of technology for *interactive computing systems* has been an important driver behind the massive adoption of computing that we have witnessed in the last 50 years. Figure 1.1 shows a few snapshots of the transformation of computing from being machines used exclusively by trained professionals to tools for everybody. The speed of this development has been mind-boggling. The authors of this book have experienced the adoption of the personal computer, the world wide web, the mobile phone, intelligent interactive systems, and virtual and augmented reality. These and many other technologies have impacted practically all areas of life during their lifetimes. Computing has had a pervasive impact on what we do, how we think, what we value, how we play—and even how we build and maintain social relationships, including romantic relationships. Computers have shaped our economies, leisure, transportation patterns, social networks, and even elections and wars.

Although computing systems can be autonomous, most systems are intended to be used by humans and specifically to assist them. The realization that this is not a trivial challenge has given raise to the field of research called *human-computer interaction*, or HCI for short. HCI emerged gradually through early efforts in other fields, including psychology, computer science, and electrical engineering. What we now know as the field of HCI was launched around the late 1970s. The birth of the field coincided with the revolution of the personal computer, which saw the transition of computers from expensive mainframes kept at organizations into computing technology adopted to homes and workplaces. Interest in HCI was fueled by the belief that such technology will fail unless it is designed with serious consideration of its users.

Two foundational questions characterized early research: *how* should all this computing power be used and *for what*? Around the emergence of the personal computer in the late 1970s, it became clear that software needs to be designed for end-users and not just for specialists, such as programmers. These and other observations started a search for both new visions of computing and for fundamental knowledge about the nature of human use of computers. Over the years, the focus of HCI evolved to the question we now see drive HCI research:

> how can people with different goals and capabilities, and in different contexts, be able to use computing productively, enjoyably, and safely?

In short, the noble goal of HCI is to help create computing for the betterment of humankind.

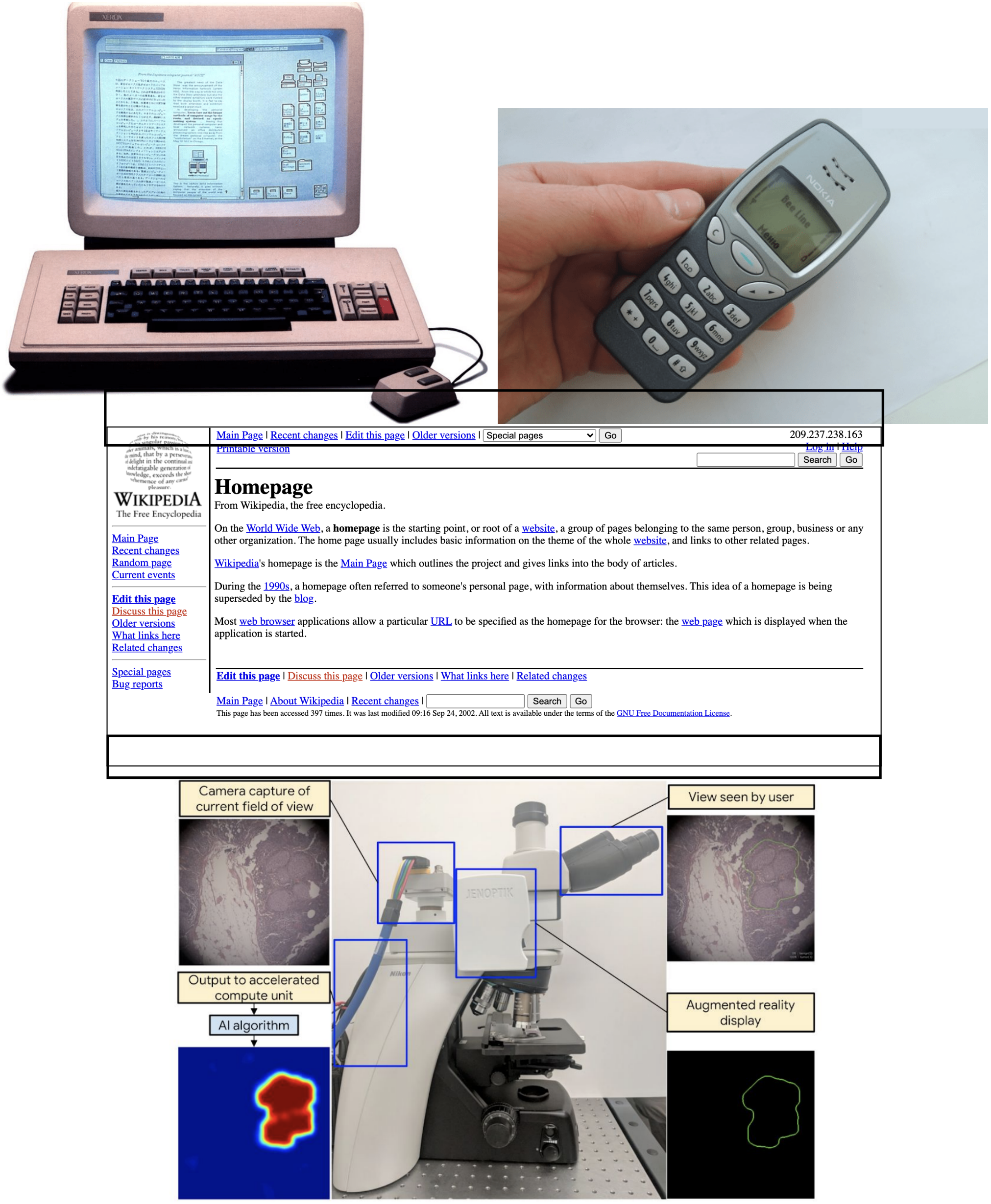

Figure 1.1.: The evolution of interactive computing, from top-left and clockwise. The emergence of *personal computing*, exemplified with the Xerox Star from 1981 [390]. The emergence of *mobile computing*, as with the popular Nokia 3210, around 1999. The emergence of *social computing*, as with the collaborative encyclopedia Wikipedia, created in 2001. The emergence of *AI-enhanced computing*, as in this AI-assisted microscope from 2019 [145].

The book provides an introduction to the field of human-computer interaction. HCI is primarily a research-driven field. However, it focuses not only on scientific principles of interaction, but also on the very concrete goal of designing better computing systems. For this reason, while the starting point in this book is theoretical research that helps us understand interaction, we do not let design off the hook. The pragmatic aims of HCI cannot be overstated. Therefore, the chapters in this book acknowledge the many challenges that practitioners face and identify the solution principles that can be used to tackle them.

Since HCI is not typically taught in basic education, most HCI researchers to-date have discovered the field during university studies. Everybody has a unique story to tell on how they fell in love with the area. We, the authors of the book, discovered HCI in very different ways: Kasper found HCI via scientific curiosity. As a student of computer science, Kasper realized during his third undergraduate year that HCI, and not lambda calculus as he thought at the time, unified his interests in technology, psychology, and philosophy. Another co-author, Per Ola, was educated in cognitive science, and early on got interested in applying it to the practical problem of how to help people enter text, a pursuit which eventually led to the invention of the gesture keyboard, a text-entry technique you can find installed on many mobile devices today. Finally, Antti, was motivated by frustration while studying cognitive psychology for a Master's degree. He felt that human-computer interaction is too complex for verbally expressed theories. Over the years, he has developed a view that scientific knowledge about users' behavior and thinking can be encapsulated into computational models, similar as in other areas of applied science, which can then be used – with the help of algorithms – to explain and enhance interaction. We hope that this book can plant the seeds of new stories that will change the field in the future!

In the rest of this chapter, we will expand on the defining characteristics of HCI. In particular, we will explain why HCI is a challenging field and why it needs to combine science, design, and engineering. We will also give a brief historical account of how HCI emerged as a field and became what it is now: a multidisciplinary melting pot. We also strongly believe that HCI is of pivotal importance to society, which is why we will give some space to the key arguments on why this is the case. Finally, we will explain our approach to HCI and the structure of this book.

1.1. Why is HCI Challenging?

So what makes HCI worth studying, and why is a separate research field needed? First, humans are complex biological and social organisms. A human being is capable of conscious thought and has developed language abilities, capabilities for fine motor movements, and generally excellent abilities to learn to develop, use, and adapt tools to achieve goals. Several of such fundamental abilities are sufficiently well-understood to apply them in HCI, such as central aspects of human motor control. However, many open questions remain, such as those related to experience and language. Furthermore, HCI must account for individual differences. What may work for one user may be a failure for another.

Individual differences in computer use are whopping, not only in terms of performance, but in terms of what is considered interesting or culturally appropriate. For example, an expert on HCI4D (HCI for development) described the challenges faced in non-Western contexts as follows [183, p. 2228]:

> We need to address the everyday problems of people. Most people don't know how to scroll, navigate. We need to do basic HCI work to make text larger. Also, time of day is the most prominent thing on [a phone's] screen. Let's replace that with the amount of airtime you have left. We need to improve upon what we built yesterday rather than doing novel interventions or focusing on the future.

Second, the computer is the most complex tool humans have devised. A modern computer relies on an elaborate stack ranging from transistors, logic gates, microcontrollers, and memory chips to operating systems, software drivers, software libraries and toolkits, applications, and ultimately user interfaces. Modern computers typically rely on multiple cores to perform computations in parallel and retrieve data from sources with indeterminate delays, such as information from networks. Designing systems with this level of complexity is inherently challenging.

Third, HCI involves people interacting with computers in complex contexts where they attempting to carry out a variety of goals. Thus, HCI requires some systems thinking. This means taking the full socio-technical context into account that the specific HCI activities are situated in. In HCI, even if we often focus on a subsystem (e.g., interaction with a graphical user interface), successful deployment relies on the ability to understand and relate observations to their wider, system-level context.

Fourth, design is hard. The purpose of HCI is, ultimately, to impact the design of applications, interaction techniques, systems, or services so that users can achieve their goals in an effective, efficient, safe, and satisfactory manner. Why is doing such designing hard? One reason is that is no perfect design—design is about identifying tradeoffs and generating suitable solutions that each trade off certain characteristics in exchange for others, such as a user's speed for accuracy. Moreover, design requires creating new ideas. In *design fixation*, a designer maintains an early identified solution despite being inferior to other possible designs. It is hard to let get of old ideas and generate new ideas that are also valuable. Even experienced designers suffer from design fixation. Finally, to arrive at a design is a complex process where it is easy to introduce mistakes early in the process, such as accidentally injecting faulty user requirements based on misunderstandings, which later are exceedingly difficult to correct.

These reasons explain why HCI is hard. They mean that HCI requires a unique combination of skills that almost no student receives from basic education. The skills cover software development, such as understanding software architectures and programming user interfaces; analytical skills, such as formal modeling of a user's performance; design practice, for example, interaction design, service design, or product design; and user research skills, such as carrying out and analyzing experiments, conducting interviews, and engaging in field studies. This book covers these basic skills.

1.2. Human-Computer Interaction as a Field

The term *human-computer interaction* has been in use since mid-1970s [e.g., 131]. Before then, the terms *man-computer interaction* and *man-machine interaction* were in use since the early 1960s [e.g., 469, 575]. Until the 1970s, real-time interaction with a computer was impossible, mostly due to the limited capabilities in processing power and displays. Requests for computers were given in batches, sometimes in the clumsy form of punch cards. Further, the time it took to get an answer from the computer was often in the order of hours. With the advent of interactive terminals and later graphical displays, the term *interaction* suddenly became relevant. While computer users of that time were professionals—managers, developers, and operators—researchers of that era started to ask how to allow more people better access to computing. Consequently, the next decades saw the birth of a new scientific community with research groups, publication venues, and shared interests.

In the early 1990s, the international computer-science organization—the Association for Computing Machinery (ACM)—set up a task force on education that provided a definition of HCI [339]. This has become the most widely used definition for characterizing the field. It reads as follows:

> Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them.

There are three noteworthy parts in the definition. First, HCI is about building interactive systems. It is concerned with design and engineering, including implementation, as highlighted in the quote. Ultimately, the goal of the field is to improve the interactive systems we use and invent new ones. For example, if you visit an academic HCI conference, one presentation might concern making super-resolution touchscreens [784], a second on how to design technologies for tracking the periods of adolescents [768], and a third on how to place content at the most comfortable places in mixed reality technology [232].

Second, people are the point of departure for HCI. Ultimately, they also define what makes computing technology good. Therefore, researchers and practitioners study people's needs and wants in depth and evaluate if people can use systems. Its uncompromised focus on human aspects distinguishes HCI from areas within computer science, which mostly focus on computation and algorithms, and other areas in other disciplines, which start with technology in mind. In such areas, it is commonplace to make assumptions about users without always grounding them in empirical observations or theory. In contrast, HCI centers on justifiable and explicit knowledge about people, their abilities, needs, and wants. HCI goes beyond wishful thinking: it is about discovering solutions that *actually* make computer use more effective, efficient, and safe.

Third, HCI is concerned with investigating all phenomena relevant to interaction. In other words, its focus extends beyond technology to work and leisure and, more generally, to social, organizational, psychological, and many other factors. Wright and McCarthy [899] noted that "HCI is concerned with understanding the influence technology has on how people think, value, feel, and relate" and in turn "using this understanding to inform technology design" (p. 644). Understanding people is a means to develop better technology is not a detour—it is necessary to create technology that brings value to the world.

1.2.1. Research in HCI

According to the definition of HCI quoted above, research problems in HCI concern the human use of computing and how we might improve it. However, what does this mean in practice? What research problems are relevant to this goal?

Three main types of research problem can be distinguished in HCI [611]:

Empirical problems These concern developing accounts of phenomena in interaction grounded on empirical data. An empirical research problem is generally motivated by a lack of understanding of some aspect of interaction. For example, an empirical problem is to understand how people discover and learn to use features in an interface, or to understand the consequences of social media on relationships. As mentioned earlier, empirical problems may be about "all major phenomena surrounding interaction".

Conceptual problems These are about explaining previously unconnected phenomena occurring in interaction by reference to theoretical constructs. Conceptual problems involve hypotheses, explanations, theories, and models. For example, conceptual problems may concern reconciling different views of what privacy is, or to build a theory of what it means for users to feel immersed in virtual reality.

Constructive problems These tackle the knowledge needed for constructing interactive systems for some stated purpose in human use of computing. This understanding does not need to be expressed formally in terms of models. Constructive problems may just as well concern visions for building brain-computer interfaces or guidelines that help designers create accessible user interfaces.

The three types complement each other. Addressing empirical problems will illuminate new phenomena that HCI theory will need to be able to explain. The solution of conceptual problems may help identify ideas for how to more effectively construct interactive systems. Engaging in the construction of user interfaces may create new styles of interaction that represent an empirical research problem. In this way, the three types of research problem go hand in hand in HCI. Empirical data are linked to knowledge, knowledge is linked to design, and so on.

Throughout this book, we will provide numerous examples of classic and contemporary research in HCI and there will be many examples of each research contribution type. Good venues to find other examples of ongoing research are conferences supported by the professional society of the ACM Special Interest Group on Computer-Human Interaction (SIGCHI), for example, the flagship *ACM Conference on Human Factors in Computer Systems (CHI)*, and academic journals, such as *ACM Transactions on Computer-Human Interaction*, *Human-Computer Interaction*, or *International Journal on Human-Computer Studies*.

1.2.2. The Practice of HCI

In addition to research, human-computer interaction is also a practice. Hundreds of thousands of professionals around the world engage daily in designing, implementing, and evaluating interactive systems. Many of those systems are already used or will be used in the near future. HCI practitioners hold different and continually evolving professional titles, such as *interaction designer*, *usability specialist*, *HCI specialist*, *user interface engineer*, *user researcher*, *behavioral analyst*, and *user experience designer*, among others.

What practitioners actually do has itself been a topic of research in HCI. Multiple studies have attempted to characterize their work and views. A key takeaway from such studies is that practitioners' work spans four main activities:

- Many HCI practitioners work to create an understanding of users and their activities. For instance, this may involve the analysis of the tasks that users do or the collection of empirical data that focuses on the activities and work of users [846]. To inform practical decisions, they perform requirements gathering, benchmarking against competitors, task analysis, and user studies in the real world [44]. Empirical research (Part III) forms the basis of their methodology.

- Most actively contribute and often drive constructive activities. That is, they design and prototype interactive systems, for instance, using mockups or sketches [371]. A user interface designer, for example, may use digital tools to sketch wireframes of graphical user interfaces. The design of those tools has a significant impact on their work and, thereby, the world. Here they use methods from design and engineering, including those for wireframing, sketching, and prototyping (Part VI).

- HCI practitioners also evaluate interactive systems from the user's perspective, for instance, by testing the systems with users or by doing expert reviews [846, 44]. Many of these methods have roots in behavioral and social sciences, especially psychology and sociology. We discuss evaluation methods in Part VIII

- Finally, HCI practitioners engage with other professionals, for example in marketing professionals and software developers, as well as other stakeholders including representatives of clients and end-users [599]. Occasionally the structure of such engagements is systematized into a process model, which we discuss in Part VI. Often success in such engagements is outside any process, however, and defined by one's ability to communicate and persuade. Such soft skills are important to influence decision makers and opinion leaders in relevant organizations. They can be decisive for the success of a project.

What is the relationship between academics and practitioners? Obviously, practitioners have been trained with HCI methods and theories, such as the ones in this book. To be able to apply such methods effectively in a situationally appropriate manner, it is desirable to know how these methods and theories have evolved, the explanatory mechanisms they rely on, the scientific and practical assumptions they make, and their positive and negative qualities. This determines their suitability for different tasks and contexts.

However, the relationship between research and practice is more complex than that [163]. Researchers and practitioners continuously debate the relevance of research on practice and the other way around. The intertwining of research and practice in HCI has been conceptualized as a three-stage process [752]. In the first step, thousands of researchers study a phenomenon. These results are eventually packaged into guidelines, demonstrations, software tools, and much more. In the second step, millions of developers actively producing HCI applications are influenced by those outcomes. In the third and final step, these applications are used by billions of people. More generally, ideas and methods propagate through undergraduate and graduate students studying and researching HCI and post-docs and academic staff actively contributing to work in industry.

This book does not cover tools and issues specifically tailored for practitioners. We refer the reader to the fast-moving frontier of practitioner books. Instead, in this book, we focus on the more time-enduring principles and skills.

1.2.3. Relation to Other Fields and Disciplines

HCI is a field that brings together researchers and practitioners from different disciplines. As will become evident throughout this book, HCI also draws on methods and insights from other fields, including those from psychology, sociology, cognitive science, anthropology, computer science, design, art, economics, health science, media studies, organizational studies, and many more.

Let us give a more in-depth example. Suchman [788] drew on methods from anthropology and sociology to critique early attempts to design interactive systems based on an assumption about people that was then prominent in cognitive science. Design guidelines for user interfaces suggested that users interact based on *plans*; that is, sequences of action they imagine before actually doing something with a computer. Her studies of photocopies showed that plans often fail and need to be changed. Users need to improvise actions and recover from errors and unplanned events. Moreover, often no plans are construed in advance. Observations like this called for research on users' actual practices and a change in the way user interfaces are designed, providing more room for different structures of action and, importantly, for improvisation. Throughout the book, we will encounter many such results from other fields.

Sometimes, other phrases are used in place of Human-Computer Interaction. They include *usability*, which emphasizes whether users can use systems to carry out goals as effectively, efficiently and safely as possible; *user experience*, which emphasizes the felt experience and motivation of users; *interaction design*, which emphasizes the design of user interfaces and conceptualization of novel interactions; or *human factors and ergonomics*, which emphasized human capabilities as the basis of interaction. In this book, we prefer the term HCI when describing this field.

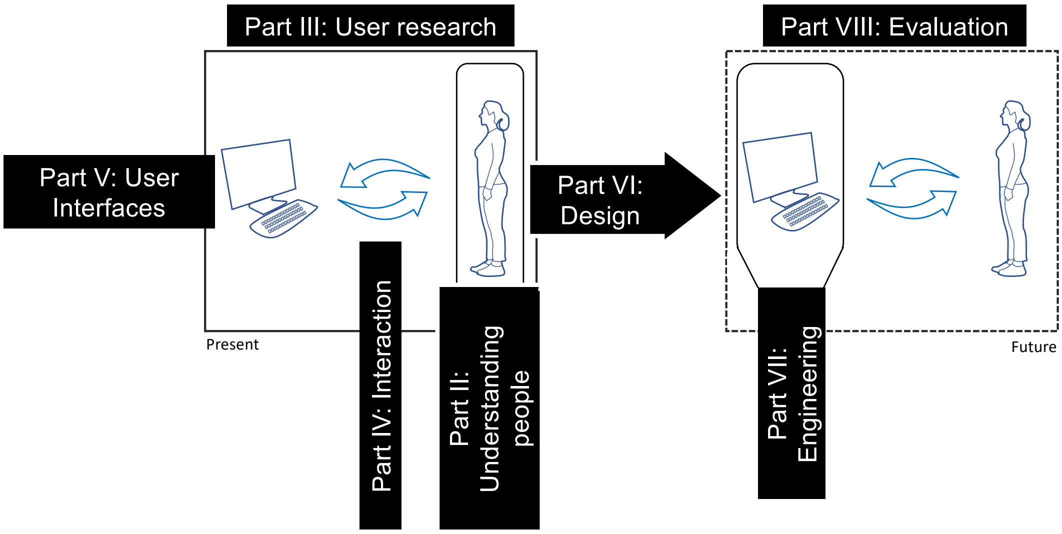

Figure 1.2.: An overview of the central areas of concern in HCI. The left-hand side of the figure is about the present; the right-hand side of the figure is about the future as envisaged through design, realized through engineering, and assessed through evaluation. Each dark area maps to the parts of the book.

1.3. Fundamental Concepts

The book is centered on a few fundamental concepts. Next, we will briefly outline them, explain why they are important, and highlight how they contribute to HCI. Figure 1.2 show these concepts.

1.3.1. Human-Centered

HCI focuses on the people who use an interactive system or are affected by its use. This focus is often called being *user-centered* or *human-centered* to contrast it with a focus primarily on the technology itself [420, 590]. Human-centeredness distinguishes HCI from many other technical disciplines.

Being human-centered has three immediate and deep implications: (1) a requirement to understand users, including their needs and motivations; (2) a requirement to engage with people as part of research and design; and (3) a requirement for an ethical consideration of how an interactive system may directly or indirectly affect people.

First, being human-centered means that you seek to understand the people who will be using the interactive system. This understanding concerns everything that is dependent on computer use, from basic theories of human perception to how people organize work and communicate with each other. Part II of the book summarizes key theories for understanding people. This knowledge has implications for how we design the system as

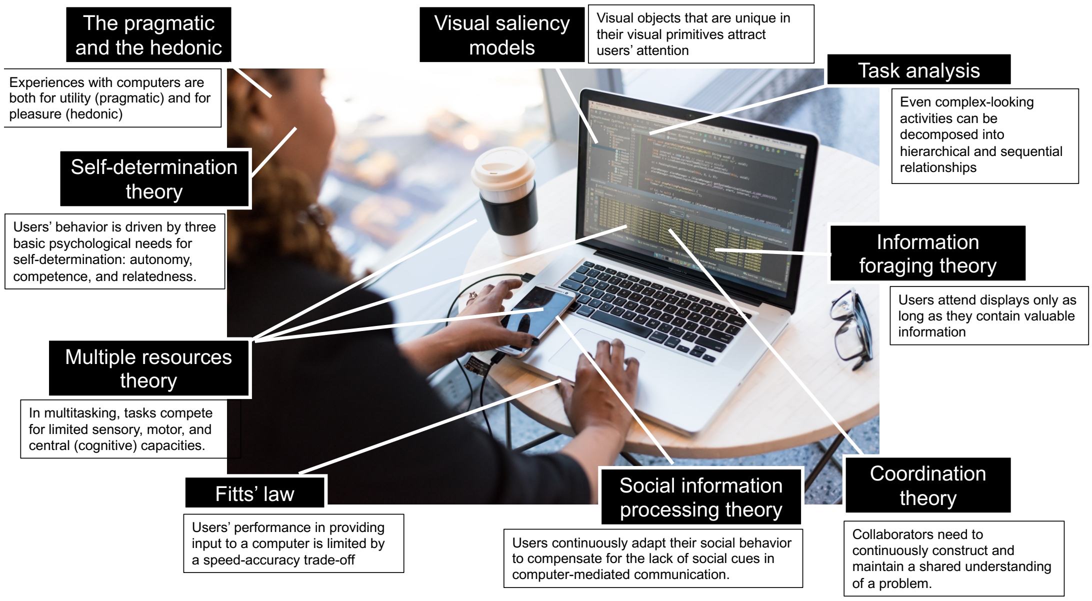

Figure 1.3.: Theories of HCI shed light on what happens in interaction: how people perceive, experience, and behave. This gallery shows a few core theories covered in this book.

we want it to *match people* – rather than requiring people to match the system. Being human-centered also means striving for the best possible understanding of people. In this book, we cover vastly different points of view, ranging from theories of how humans process information (Chapter 5) over theories of their motivation (Chapter 6) to theories of collaboration (Chapter 8). A rich set of theories can be brought to bear on any use situation. Figure 1.3 shows an example.

Second, being human-centered means engaging with people as part of any research and design, with the goal of understanding their *specific* concerns and practices. In 1985, Gould and Lewis [285, p.300] noted that

> designers must understand who the users will be. This understanding is arrived at in part by directly studying their cognitive, behavioral, anthropometric, and attitudinal characteristics, and in part by studying the nature of the work expected to be accomplished.

This advice is still as true now as it was then. HCI researchers and practitioners aim to create interactive systems that support humans and their goals, and therefore they need to start from those goals. Part III of the book present methods for empirically studying users, what they want, what they do, and what they value.

Third, being human-centered implies a particular ethical stance towards people. This stance means that the primary rationale for any practical decision should be rooted on understanding of the people using or affected by the system. There is a responsibility, even if it is not often said aloud, to avoid harm and try to find the best possible solution for people. For instance, the ACM code of ethics observes that "a computing professional should contribute to society and human well-being, acknowledging that all people are stakeholders in computing"[1]. Thus, being human-centered means to ensure users' privacy, security, fair treatment, good work conditions, and much more. This is a theme we will revisit throughout this book.

1.3.2. Interaction

Interaction is a concept that is fundamental for HCI and specific to this field [356]. Intuitively, it refers to the reciprocal influence between people and an interactive system that takes place through the user interface. Interaction is, in other words, not a property of the system design nor that of the user, but something that emerges when they influence each other. Therefore, we need to understand the interaction to understand how users can be supported in their tasks. Interactive systems are tools that help users achieve their goals. Interaction also concerns how users operate or manage the user interface, how they perceive messages, and what to do next.

The interactive relationship between human and computer can be complex, because it is not singularly defined by the user nor the computer. However, interaction is often more complicated than this because it is also affected by specific activities and the context of use. This is a pervasive aspect of HCI that even concerns the most mundane considerations. For instance, our expectations about the response time of a game may affect how we experience the game; it might be fundamentally changed when there is also lag in the game's response time. However, those expectations may differ depending on our location (on the move, at home) and in so far as they concern lags. They may be fully different for other types of application and depend on social norms, or what is being held as an acceptance lag.

Finally, interaction often involves co-adaptation between people and computers [632], meaning that both the user and the system learn and adapt during use. Such co-adaption can happen without hands-on contact, through changing work practices, or by fundamentally changing values or habits. Part IV outlines the concept of interaction and the distinct ways of thinking about computer use it affords.

1.3.3. User Interfaces

A key technical construct for HCI is the user interface. It refers to those parts of an interactive system that the user comes into contact with or that in other ways shape the users' perception of the system. Because the system behavior that the user experiences is affected by the system and the interface, design is almost invariably concerned not only about the user interface but also the broader system. Interactive systems include digital products, online services, appliances, websites, smartphones, and so on. These are the primary objects of design, and what practitioners and researchers try to envision differently.

[1] https://ethics.acm.org

The user interfaces that HCI studies are continuously changing (see Figure 1.4). The 1970s and the early 1980s saw a lot of work on command-line interfaces, for example, research on the naming of commands and the syntax of command-line arguments. The 1980s show pioneering work on the Xerox Star, a personal desktop computer.

Despite continuous developments, research on user interfaces can draw lessons from previous work. Many insights gained from studies with earlier systems remain relevant. For example, spoken-dialogue systems build on work on command-line interfaces, augmented reality interfaces contain menus that are similar to those of graphical user interfaces, and so on. Part V covers the varieties of user interfaces and current understanding of what makes them work and how to design them.

1.3.4. Design

HCI aims to change the world by designing human-centered systems. Designing is a process of arriving at a plan, specification, prototype, system, or service—a *design*. In HCI, this often means designing a user interface and relevant parts of the underlying interactive system. However, it can also be about designing, for example, services.

In general, design is about envisioning things as they could be. Although design processes have always been present in HCI, since the mid-1990s, they have been intensively developed and reflected upon [883, 540]. The book edited by [883] entitled "Bringing Design to Software" reflected this ethos. A key sentiment of the book read as follows.

> The education of computer professionals has often concentrated on the understanding of computational mechanisms, and on engineering methods that are intended to ensure that the mechanisms behave as the programmer intends. The focus is on the objects being designed: the hardware and software. The primary concern is to implement a specified functionality efficiently. When software engineers or programmers say that a piece of software works, they typically mean that it is robust, is reliable, and meets its functional specification. These concerns are indeed important. Any designer who ignores them does so at the risk of disaster.
>
> But this inward-looking perspective, with its focus on function and construction, is one-sided. To design software that really works, we need to move from a constructor's-eye view to a designer's-eye view, taking the system, the users, and the context all together as a starting point. When a designer says that something works (for example, a layout for a book cover or a design for a housing complex), the term reflects a broader meaning. Good design produces an object that works for people in a context of values and needs, to produce quality results and a satisfying experience.

The bottom line is that all interactive systems are designed. This gives HCI practitioners and researchers immense importance, but also immense responsibility. Design is discussed in Part VI of the book.

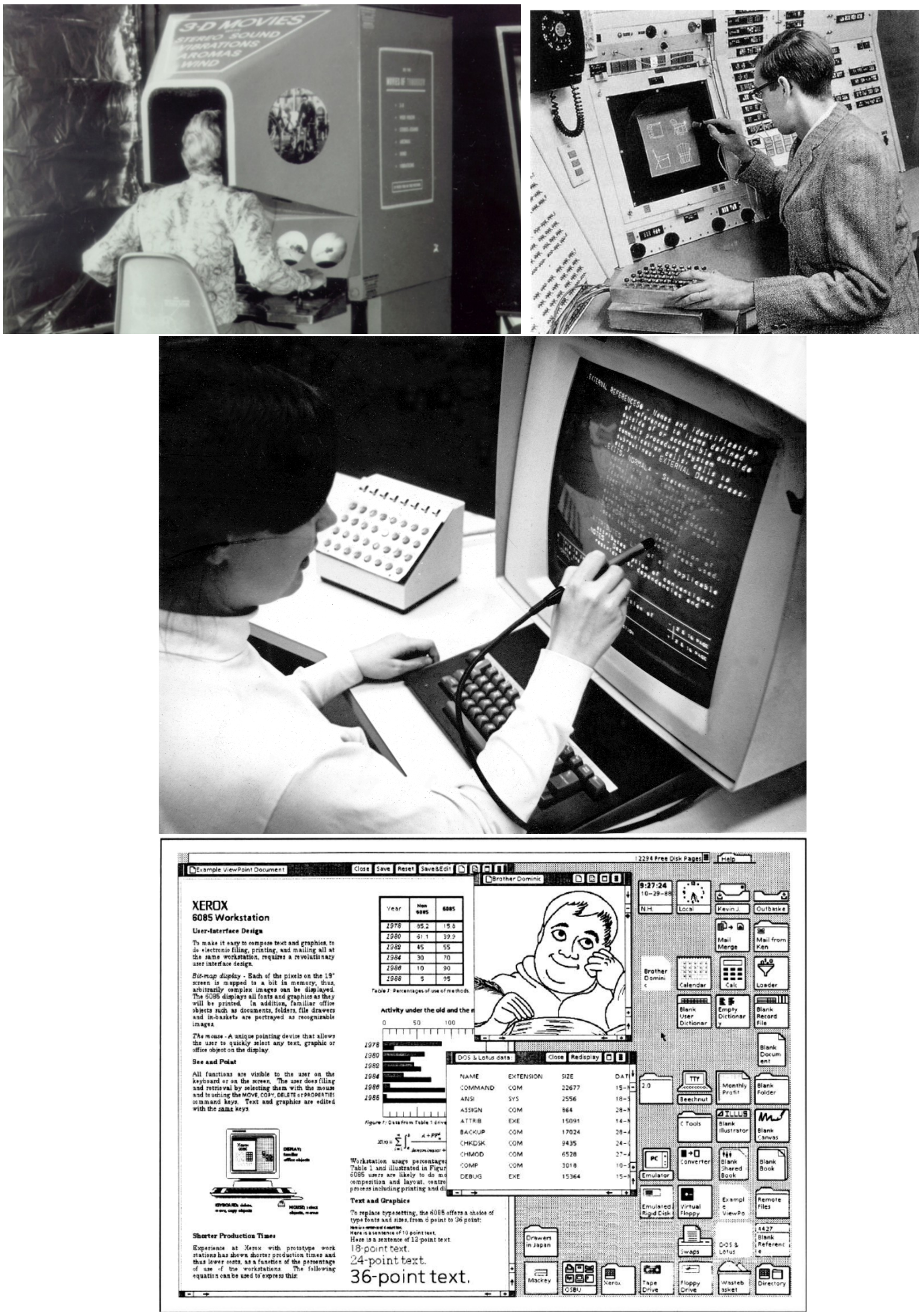

Figure 1.4.: Four revolutionary user interfaces. Top left: Sensorama was an experimental multisensory VR system patented in 1962 [328]. Top right: Sketchpad was an interactive system published in 1964 [793]. Bottom left: The Hypertext Editing System was developed around 1969 [827] and provided hypertext links that the user could follow by selecting them with a pen. Bottom right: The Xerox Star pioneered the graphical user interface around 1981.

1.3.5. Engineering

Engineering refers to using technical principles, such as mathematics, science, and technical know-how, to realize a design that best meets a given set of expectations, which are often captured in a requirements specification. Several emergent qualities of an implementation are important to users, including the performance, safety, robustness, and explainability of a system. When HCI researchers are engaged with such engineering problems, they need to integrate their understanding with the theory and practice of engineering and computer sciences. Engineering is discussed in Part VII of the book.

While there are many engineering and technical challenges in creating interactive systems, HCI focuses on those challenges that matter to people. A well-engineered interactive system has tackled throughout the development process. As a consequence, HCI 'spills' over into many areas that are not traditionally associated with it. In particular, HCI intersects many areas of computer science. For example, computer graphics, considers questions on people's perception of graphical displays, scenes, and objects. In machine learning and natural language processing research, many of their outputs are relevant only when implemented in interacting computers, such as speech recognition, automatic text summaries, recommendations, and search. HCI has always been central to software engineering. Early HCI research discovered that software design that assumes that users will make errors tends to work more reliably [583]. This had deep implications on the design of software architectures. For example, allowing users to reverse their actions—providing an *undo* feature—can be surprisingly difficult to implement well, demonstrating that such concerns are not simply features to be added later on. Instead, they should be considered at a more formative stage of the software architecture [505, 65]. HCI also has relevance in research on computing networks and systems, for instance, there are efforts to understand how people perceive network latency in networked applications, such as games [396].

In summary, HCI is not merely about the surface properties of interactive systems, but has deep implications also for other fields on how to develop interactive systems.

1.3.6. Evaluation

In HCI, *evaluation* refers to an application of some systematic methodology to attribute some human-related value to an artifact, prototype, system, or process. Examples of such attributes include performance, experience, and safety or ethical aspects, such as an avoidance of bias or harm. HCI research has a relatively strong emphasis on carrying out evaluations with users, which contrasts with some technically-oriented disciplines measuring technical properties without the involvement of people.

Verification, validation, and testing are variants of evaluation. *Verification* means ensuring that the design meets all requirements and constraints imposed for the design task. For example, in Part VII we review requirements specifications. *Validation* means ensuring the design is fit for its intended purpose. As such, a design can succeed in verification, but fail in validation, for example, if the design is used in some way that was unanticipated at design time. In this sense, HCI is no different from other design fields.

This book emphasizes the need to evaluate both assumptions and designs. Finally, *testing* (e.g., usability testing) refers to carrying out evaluation by means of trying out (testing) it in realistic conditions. For example, in usability testing (Chapter 43), evaluation is carried out by asking users to perform the tasks assigned to them. Several usability metrics are used to gauge how well they succeeded.

HCI's evaluations almost always use multiple methods. In HCI, we need to arrive at robust, generalizable, and reproducible findings that practical decisions can be based on. It is often naïve to expect a single or just a few evaluation methods to be sufficient, because these methods, despite certain overlaps, complement each other. As a result, practitioners deploy a plurality of evaluation methods ranging from ethnographic studies and interviews to studying log files, conducting controlled experiments, and analyzing computational models.

In HCI practice, evaluation is closely coupled with iterative design. Most design processes incorporate evaluation as an ongoing activity throughout all design, build, and deployment activities. The early pioneers of HCI [285] argued that "design must be iterative: There must be a cycle of design, test and measure, and redesign, repeated as often as necessary" (p. 300).

In Part VIII we discuss principles and methods for evaluating user interfaces.

1.4. Why HCI Matters

Understanding HCI is crucial when creating interactive systems for human use, when ensuring that such systems have a positive impact on the world and their users. This understanding is not trivial and cannot be achieved by "amateurs" despite popular belief. It requires discipline. Next, we outline the main justifications behind this argument. The intention is to make clear *why* research, practice, and education in HCI matter.

1.4.1. Interactive Systems are Difficult to Use

HCI was born out of the realization that interactive systems are difficult to use. As interactive systems begun to be used by non-computer experts, it became increasingly clear that many users had difficulties in understanding how to provide input and how to interpret output. We have all used interactive systems that exhibited unexpected behavior and difficult-to-understand instructions, requiring us to work around stumbling blocks or give up using the system altogether. The paper example below explains how even door handles may be difficult—throughout the book many other examples of papers will appear.

Paper Example 1.4.1 : The design of everyday things

The Design of Everyday Things is a book written by one of the pioneers of HCI, Donald Norman. The book changed the general perception of why everyday things need to be designed with their users in mind [586]. Consider the doors and how to open them. The three doors below are all difficult for users (search the world wide web for "Norman doors" to find many other examples).

The door to the left signals to push due to the flat handlebar; however, the door to the left actually needs to be pulled. The door in the middle does not offer any hint of how it can be opened. The door to the right is actually a sliding door, but it is so unclear to people that some friendly person has added an explanation. Whenever you see explanations or labels that have been added to things, think: Why was this not designed to make the explanation/label unnecessary?

The example makes three points. First, even simple things are hard to design right; for interactive systems, the challenge to match users' abilities is magnitudes harder. Second, all objects, including interactive systems, have been designed; sometimes, however, designers have not paid attention to the people who will use their designs. Third, designers have the opportunity and even a responsibility to improve the world through their design. Does that responsibility also apply to you?

Norman's book introduced ideas from cognitive psychology to bear on the design of everyday things and interactive systems.

Data suggest that this frustration is a common experience. A study found that frustrating episodes with computers occur frequently due to error messages, faulty network connections, long download times, and hard-to-find features [140]. Shockingly, about half of the time spent on the computer was lost to such incidents. These challenges may seem minor, but over time, they compound and can have unexpected and unfortunate downstream consequences. For example, consider how poorly some user interfaces support aging users, some of whom may struggle to use computers for even basic tasks. Such struggles are known to affect users' willingness to use computers, and, thereby, also their ability to benefit from computers, with negative effects on their ability to participate in society. Thus, as computing spreads to new groups of users and new contexts of use, HCI is needed to make interactive systems useful and usable.

1.4.2. The Egocentric Fallacy

People are complex, beyond intuition, and not all people are alike. It is an *egocentric fallacy* to assume that others are like us—to attempt to explain other people by reference to one's own experience. You are often NOT the user [448]. As a consequence, intuition can only go so far and is often misleading.

A good example is HCI research on mental models. People have vastly different beliefs about how calculators work [584] and these beliefs can explain errors and issues they have when using calculators. For instance, many people think that they need to press "clear" (or the equivalent) multiple times when using a calculator. More generally, many constructs that we use in HCI help us go beyond our everyday observations and avoid the egocentric fallacy. The implication is that we must use time and energy to understand users.

1.4.3. HCI is Right

As we have argued above, being human-centered is a value of its own. We have a responsibility to take the needs and abilities of other people seriously when designing technology. In the words of designer Dieter Rams, “Indifference towards people and the reality they live in is the one and only cardinal sin in design.” HCI has the potential to have a positive impact on the world, and HCI research can cause less bias, less frustration, and greater well-being [635].

In a classic book, Landauer [450] argued that computers are difficult to use and that this is the reason, at the time of writing, they failed to improve the productivity of the companies that invest in them. Landauer argued that a duty of HCI was to improve computers. We find that the argument is still valid.

1.4.4. HCI Pays Off

HCI also has financial value when done correctly, as it can help open up and conquer new markets, increase productivity, and lower costs. Investments in HCI pay off. Analysis of investment return has found several-fold returns for every investment that a company make in HCI [72].

Moreover, user interfaces and interaction design constitute a significant part of nearly all technology projects. In 1992, Myers and Rosson [559] found that 48% of the software code was related to the user interface. This means that getting anything relating to the user interface right early is important and that fixes to the user interface that are only discovered when the interactive system is deployed are very costly. In summary, instead of asking if HCI pays off, it is better to ask if one can afford to do without.

1.4.5. HCI Invents the Future

HCI is well-positioned to invent the future; see some examples in Figure 1.5 of how that has been done in the past. Systems, products, and services go through constant life cycles of market introduction, growth, maturity, and decline. Competition and changing demand create a need for existing systems, products, and services to evolve or be replaced with new alternatives. As user interfaces are integral parts of people's experiences when using mobile phones, apps, websites, and so on. HCI is critical to discovering ways to use new products, enjoy new services, and manage new systems. Figure 1.5 shows a selection of early visions created in HCI.

Two essential strategies for bringing something new to the market are *market pull* and *technology push*. Market pull means sensing there is market demand for a new offering. HCI with its rich plurality of human-centered research methods is eminently suitable for capturing users' needs and wants and framing such findings as actionable design know-how. In addition, HCI is also exceptional at *technology push*. Technology push means new technology is injected into the market and thus generates new demand for something that was previously unavailable. There are many visions and research discoveries in HCI that have changed how we view computer use, such as ubiquitous computing, tangible interfaces, and virtual and augmented reality.

1.5. Our Approach to HCI

The approach we follow in this book differs from that of many other textbooks. In this section, we explain the key tenets and outline the philosophy that has shaped the book.

1.5.1. The Title of this Book

The book is called *Introduction to Human-Computer Interaction* to emphasize that wherever feasible we focus on *basic principles and skills*. By 'principle' we refer to a foundational idea or rule that explains or controls how something happens or works in human-computer interaction. For example, *Direct Manipulation* is a principle for organizing the interaction with graphical user interfaces (Chapter 28). The principle states that computational objects must be presented on display and acted on by the user through direct, reversible, and incremental actions with immediate feedback. There is substantive empirical evidence for benefits that are rooted in the use of visual recognition. Throughout the chapters, we introduce several principles and summarize them in a table in Chapter 46.

1.5.2. Pluralism in Methods and Theories

All methods are limited [523]. Consequently, we will cover a range of different research approaches and methodologies, and carefully account for their strengths and weaknesses. We will cover the views of science, design, and engineering as ways of knowing in HCI. For instance, we will explain the principles of design thinking alongside concepts of validity for experimental studies. We consider them all useful, even if they are rarely introduced together. The value of some viewpoint does not lie in the authority of who said it, but in its value in helping us do better HCI.

At the same time, we believe that HCI phenomena can be studied from a variety of levels, all of which are relevant. This is a form of theoretical pluralism [697]. It means

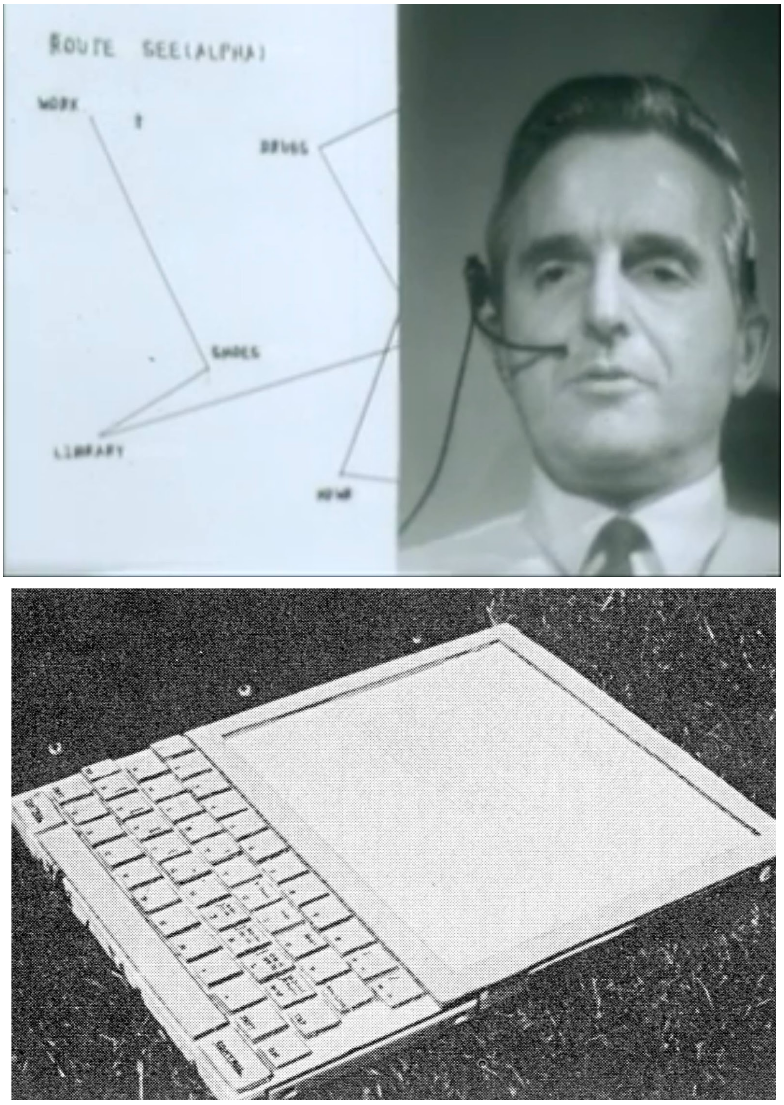

Figure 1.5.: This figure shows two visions of what interaction might be that predated the actual technology. To the left is Engelbart in the "mother of all demos" in 1968. He pursued a vision of using computers to augment the human intellect that predated collaborative and distributed writing, among many other things. To the right is the Dynabook, created by Kay and Goldberg in the late 1970s Kay and Goldberg [407]. This vision predated tablets, and contained many ideas for creative and programmable use of media.

that HCI phenomena span eye movements, emotional reactions, aesthetic experiences, social interactions, and organizational structures; it spans behaviors at the millisecond level to changes in the use of interactive systems over decades; and it spans individuals, groups, and societies. The book covers many of these phenomena and theories about them, but makes no argument that any of them is more important than others.

1.5.3. Essential Insights Supported by Research

This book focuses on some essential insights in HCI, rather than analyzing current user interfaces or enumerating the vogues of HCI research as found in present-day research. We have distilled those principled insights that we think will hold and be valuable to academics and practitioners for decades. Thereby, the reader (and their instructors) may need to invest effort in applying those essentials to actual HCI problems. But the benefit is that essential insights will outlive particular interaction problems, fashions, and fads.

We have picked those essential insights that we believe are supported by evidence, possibly in other areas of scholarship than HCI. We prioritize this approach over any allegiance to a particular approach, method, philosophical stance, or set of beliefs. To demonstrate supporting evidence, we often cite empirical studies of whether the insights work. For example, consider the gestalt principles of visual perception (Chapter 3, a set of ideas about how people group visual stimuli. Our reason for including them in this book is the evidence that they are useful in HCI, for instance by Parush et al. [628]. Therefore, many parts of the book will explain empirical findings relating to principles, insights, and methods.

What makes HCI exciting is that what may have started as a sub-area in HCI may eventually turn out to change mainstream HCI. For example, accessibility as a field is interested in how the vastly different abilities of people could be better accounted for in design. Recently, however, it has been realized that recognition of individual abilities is a valuable starting point for *all* activity in HCI, not just accessibility. This is sometimes referred to as ability-based design.

1.5.4. Optimism that HCI Problems are Solvable

Our fundamental attitude towards HCI is that many of the issues that its practitioners and researchers try to address are solvable. We base this attitude on the historical observation that many of the world's most successful systems are based on HCI research (e.g., [558, 752]). They include mobil devices, wikipeda, search engines, extended realities, and computer games. According to such observations, current key technologies—such as e-commerce systems, social media, augmented reality, text input and editing—have been shaped by HCI. Figure 1.6 shows an overview of innovations in computing where substantial, if not indispensable, impact has been made from HCI. To us, this type of analysis shows that with the right combination of innovation, strong theories about people, and careful evaluation, problems *are* solvable.

Furthermore, HCI insights are currently helping design and improve numerous interactive systems. It does not mean that there is necessarily one complete solution for a

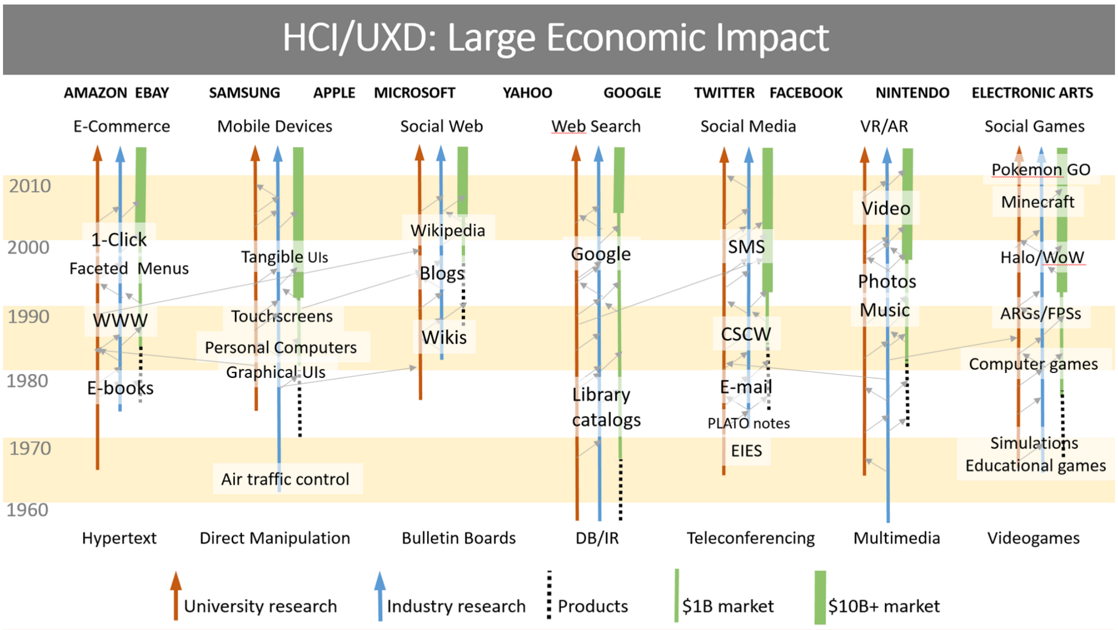

Figure 1.6.: Economic impact of HCI by Shneiderman [752]. The figure shows how well-known successes in interactive computing are related to research on HCI in academia and industry.

given HCI issue, that all situations are straightforward to design for, or that HCI is easy. However, for a surprisingly large number of problems in HCI we actually *have* suitable methods or actionable insights. We can apply known principles and findings which means that "it depends" need to be evoked as an answer less often in HCI. Instead, we emphasize that there are known answers in HCI. The reader will find that this book takes a critical stance toward many popular beliefs in the field. Thus, this book emphasizes how the field has developed its capacity to solve problems. We want to give the reader actionable access to the collective insights that underpin this statement.

Do not mistake this optimism for the belief that all problems are solvable with HCI. We do not subscribe to the idea that any societal or individual problem are solvable by technology such as an app. We believe that in some situations, the best design decision is to not implement a system. Such decisions, just as decisions to design, should be based on principled understanding of users, the stakeholders.

Summary

- Computing is a powerful tool; interactive systems and user interfaces help control and tame it.
- Human-computer interaction is concerned with people, creating technology, and understanding interaction.

- Essential activities in HCI are understanding people, studying what users need and want, designing and engineering interactive systems, and evaluating their benefits to users.
- HCI is important because you are not the user. HCI offers a disciplined approach to some hard problems faced in design and innovation.

Exercises

1. Can you identify the user? Identify three relevant user groups for the following systems: (1) a mobile phone app allowing users to view timetables for buses in their city; (2) an online banking website; (3) an educational website that teaches children early stage mathematics; and (4) a C++ compiler (a piece of software that translates program code into machine code).
2. Recognizing user–centered design or the lack thereof on everyday objects. As you go through your day, take note of examples of everyday things that are *not* designed well. Try to adopt the mindset that made Norman [583] see so many difficult doors; see Paper Example 1.4.1. Why are they designed or not designed well? What do you think their designers had in mind? How could they be improved?
3. Analyze the bottleneck. Think about a product or service you frequently use and consider a feature or function you find annoying or frustrating. Why do you find this feature or function annoying? What are you trying to achieve? Why is it difficult to achieve? What are the assumptions that the product or service is making that cause the bottleneck? Can you think of all the relevant factors that determine the function or feature? Can you think of a redesign that might work better? Why do you think that your redesign would solve the problem? How would you test your assumptions?
4. Approaches to a problem. HCI is pluralistic, but what does this mean in practice? Consider being responsible for a multidisciplinary effort to improve the usefulness and usability of a social media application. How might the following disciplines contribute to such effort: (1) psychology, (2) computer science, (3) design?
5. Investigating frustrations in computer use. Please pick an hour during which you will track the frustrations you run into during computer use. Do not fuss about a definition of frustration, just log whatever you experience as frustrating. For each frustration, write down what it concerned, how frustrated you became, and how much time you lost on the episode. You can use a spreadsheet or a piece of paper. When you are done, look at your frustrations or those of fellow learners. Are they about the user interface or something else? Could they be avoided through better design? Are they frequent or rare? For examples of findings on frustrations this that you can compare to, see Ceaparu et al. [140] or Hertzum and Hornbæk [334].

Bibliography

[1] The tyranny of evaluation. https://web.media.mit.edu/~lieber/Misc/Tyranny-Evaluation.html. Accessed: 2022-10-07; First made public: 2003 (CHI Fringe).

[2] A beginner's guide to finding user needs, 2022. URL https://jdittrich.github.io/userNeedResearchBook.

[3] D. A. Abbink, T. Carlson, M. Mulder, J. C. De Winter, F. Aminravan, T. L. Gibo, and E. R. Boer. A topology of shared control systems—finding common ground in diversity. *IEEE Transactions on Human-Machine Systems*, 48(5):509–525, 2018.

[4] V. V. Abeele, K. Spiel, L. Nacke, D. Johnson, and K. Gerling. Development and validation of the player experience inventory: A scale to measure player experiences at the level of functional and psychosocial consequences. *International Journal of Human-Computer Studies*, 135:102370, 2020.

[5] G. D. Abowd. Classroom 2000: An experiment with the instrumentation of a living educational environment. *IBM systems journal*, 38(4):508–530, 1999.

[6] G. D. Abowd, H.-M. Wang, and A. F. Monk. A formal technique for automated dialogue development. In *Proceedings of the 1st conference on Designing interactive systems: processes, practices, methods, & techniques*, pages 219–226, 1995.

[7] J. Accot and S. Zhai. Beyond fitts' law: models for trajectory-based hci tasks. In *Proceedings of the ACM SIGCHI Conference on Human factors in computing systems*, pages 295–302, 1997.

[8] J. Accot and S. Zhai. More than dotting the i's—foundations for crossing-based interfaces. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 73–80, 2002.

[9] M. S. Ackerman. The intellectual challenge of cscw: The gap between social requirements and technical feasibility. *Human–Computer Interaction*, 15(2-3):179–203, 2000. doi: 10.1207/S15327051HCI1523_5.

[10] A. T. Adams, J. Costa, M. F. Jung, and T. Choudhury. Mindless computing: designing technologies to subtly influence behavior. In *Proceedings of the 2015 ACM international joint conference on pervasive and ubiquitous computing*, pages 719–730, 2015.

[11] E. Adar, J. Teevan, and S. T. Dumais. Large scale analysis of web revisitation patterns. In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems*, pages 1197–1206, 2008.

[12] A. Agarawala and R. Balakrishnan. Keepin'it real: pushing the desktop metaphor with physics, piles and the pen. In *Proceedings of the SIGCHI conference on Human Factors in computing systems*, pages 1283–1292, 2006.

[13] D. Ahlström. Modeling and improving selection in cascading pull-down menus using fitts' law, the steering law and force fields. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 61–70, 2005.

[14] D. Akers, M. Simpson, R. Jeffries, and T. Winograd. Undo and erase events as indicators of usability problems. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '09, page 659–668, New York, NY, USA, 2009. Association for Computing Machinery. ISBN 9781605582467. doi: 10.1145/1518701.1518804. URL `https://doi.org/10.1145/1518701.1518804`.

[15] D. Alais and D. Burr. The ventriloquist effect results from near-optimal bimodal integration. *Current biology*, 14(3):257–262, 2004.

[16] O. Alhadreti and P. Mayhew. Rethinking thinking aloud: A comparison of three think-aloud protocols. In *Proceedings of the 2018 CHI conference on human factors in computing systems*, pages 1–12, 2018.

[17] E. M. Altmann and J. G. Trafton. Memory for goals: An activation-based model. *Cognitive science*, 26(1):39–83, 2002.

[18] T. M. Amabile. Motivating creativity in organizations: On doing what you love and loving what you do. *California management review*, 40(1):39–58, 1997.

[19] S. Amershi, D. Weld, M. Vorvoreanu, A. Fourney, B. Nushi, P. Collisson, J. Suh, S. Iqbal, P. N. Bennett, K. Inkpen, J. Teevan, R. Kikin-Gil, and E. Horvitz. Guidelines for human-ai interaction. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, CHI '19, page 1–13, New York, NY, USA, 2019. Association for Computing Machinery. ISBN 9781450359702. doi: 10.1145/3290605.3300233. URL `https://doi.org/10.1145/3290605.3300233`.

[20] S. Amershi, D. Weld, M. Vorvoreanu, A. Fourney, B. Nushi, P. Collisson, J. Suh, S. Iqbal, P. N. Bennett, K. Inkpen, et al. Guidelines for human-ai interaction. In *Proceedings of the 2019 chi conference on human factors in computing systems*, pages 1–13, 2019.

[21] M. Ames and M. Naaman. Why we tag: motivations for annotation in mobile and online media. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 971–980, 2007.

[22] J. R. Anderson and L. J. Schooler. The adaptive nature of memory, 2000.

[23] J. R. Anderson, D. Bothell, C. Lebiere, and M. Matessa. An integrated theory of list memory. *Journal of Memory and Language*, 38(4):341–380, 1998.

[24] C. Andrews, A. Endert, and C. North. Space to think: Large high-resolution displays for sensemaking. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '10, page 55–64, New York, NY, USA, 2010. Association for Computing Machinery. ISBN 9781605589299. doi: 10.1145/1753326.1753336. URL `https://doi.org/10.1145/1753326.1753336`.

[25] J. Annett. Hierarchical task analysis. *Handbook of cognitive task design*, 2:17–35, 2003.

[26] L. Anthony, Y. Kim, and L. Findlater. Analyzing user-generated youtube videos to understand touchscreen use by people with motor impairments. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 1223–1232, 2013.

[27] G. Apitz and F. Guimbretière. Crossy: a crossing-based drawing application. In *Proceedings of the 17th annual ACM symposium on User interface software and technology*, pages 3–12, 2004.

[28] C. Appert and J.-D. Fekete. Orthozoom scroller: 1d multi-scale navigation. In *Proceedings of the SIGCHI conference on Human Factors in computing systems*, pages 21–30, 2006.

[29] C. Araujo, E. Kowler, and M. Pavel. Eye movements during visual search: The costs of choosing the optimal path. *Vision research*, 41(25-26):3613–3625, 2001.

[30] D. Ascone, T. Tonja Lindsey, C. Varghese, et al. An examination of driver distraction as recorded in nhtsa databases. Technical report, United States. National Highway Traffic Safety Administration, 2009.

[31] T. Augsten, K. Kaefer, R. Meusel, C. Fetzer, D. Kanitz, T. Stoff, T. Becker, C. Holz, and P. Baudisch. Multitoe: high-precision interaction with back-projected floors based on high-resolution multi-touch input. In *Proceedings of the 23nd annual ACM symposium on User interface software and technology*, pages 209–218, 2010.

[32] L. Azzopardi and G. Zuccon. Economic models of interaction. *Computational Interaction*, page 311, 2018.

[33] C. Baber and N. A. Stanton. Human error identification techniques applied to public technology: predictions compared with observed use. *Applied ergonomics*, 27 (2):119–131, 1996.

[34] P. Bach-y Rita, C. C. Collins, F. A. Saunders, B. White, and L. Scadden. Vision substitution by tactile image projection. *Nature*, 221(5184):963–964, 1969.

[35] M. Bachynskyi, G. Palmas, A. Oulasvirta, J. Steimle, and T. Weinkauf. Performance and ergonomics of touch surfaces: A comparative study using biomechanical simulation. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, pages 1817–1826, 2015.

[36] G. Bailly, E. Lecolinet, and L. Nigay. Visual menu techniques. *ACM Computing Surveys (CSUR)*, 49(4):1–41, 2016.

[37] L. Bainbridge. Ironies of automation. *Automatica*, 19(6):775–779, 1983.

[38] T. Ballendat, N. Marquardt, and S. Greenberg. Proxemic interaction: Designing for a proximity and orientation-aware environment. In *ACM International Conference on Interactive Tabletops and Surfaces*, ITS '10, page 121–130, New York, NY, USA, 2010. Association for Computing Machinery. ISBN 9781450303996. doi: 10.1145/1936652.1936676. URL https://doi.org/10.1145/1936652.1936676.

[39] D. Banakou and M. Slater. Body ownership causes illusory self-attribution of speaking and influences subsequent real speaking. *Proceedings of the National Academy of Sciences*, 111(49):17678–17683, 2014.

[40] A. Bangor, P. T. Kortum, and J. T. Miller. An empirical evaluation of the system usability scale. *Intl. Journal of Human–Computer Interaction*, 24(6):574–594, 2008.

[41] J. E. Bardram, M. Frost, K. Szántó, M. Faurholt-Jepsen, M. Vinberg, and L. V. Kessing. Designing mobile health technology for bipolar disorder: a field trial of the monarca system. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 2627–2636, 2013.

[42] J. Bardzell and S. Bardzell. What is" critical" about critical design? In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 3297–3306, 2013.

[43] J. A. Bargas-Avila and K. Hornbæk. Old wine in new bottles or novel challenges: A critical analysis of empirical studies of user experience. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '11, pages 2689–2698, New York, NY, USA, 2011. ACM. ISBN 978-1-4503-0228-9. doi: 10.1145/1978942.1979336. URL http://doi.acm.org/10.1145/1978942.1979336.

[44] I. Bark, A. Følstad, and J. Gulliksen. Use and usefulness of hci methods: results from an exploratory study among nordic hci practitioners. In *People and Computers XIX—The Bigger Picture*, pages 201–217. Springer, 2006.

[45] L. Barkhuus and J. A. Rode. From mice to men-24 years of evaluation in chi. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 1–16, 2007.

[46] S. B. Barnes. Alan kay: Transforming the computer into a communication medium. *IEEE Annals of the History of Computing*, 29(2):18–30, 2007.

[47] L. F. Barrett. *How emotions are made: The secret life of the brain.* Pan Macmillan, 2017.

[48] R. Barrett, E. Kandogan, P. P. Maglio, E. M. Haber, L. A. Takayama, and M. Prabaker. Field studies of computer system administrators: analysis of system management tools and practices. In *Proceedings of the 2004 ACM conference on Computer supported cooperative work*, pages 388–395, 2004.

[49] C. Bartneck, D. Kulić, E. Croft, and S. Zoghbi. Measurement instruments for the anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety of robots. *International journal of social robotics*, 1(1):71–81, 2009.

[50] L. Bass, C. Kasabach, R. Martin, D. Siewiorek, A. Smailagic, and J. Stivoric. The design of a wearable computer. In *Proceedings of the ACM SIGCHI Conference on Human factors in computing systems*, pages 139–146, 1997.

[51] T. Baudel and M. Beaudouin-Lafon. Charade: Remote control of objects using free-hand gestures. *Commun. ACM*, 36(7):28–35, jul 1993. ISSN 0001-0782. doi: 10.1145/159544.159562. URL `https://doi.org/10.1145/159544.159562`.

[52] P. Baudisch and R. Rosenholtz. Halo: a technique for visualizing off-screen objects. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 481–488, 2003.

[53] N. K. Baym. Social networks 2.0. *The handbook of Internet studies*, pages 384–405, 2011.

[54] M. Beaudouin-Lafon. Instrumental interaction: an interaction model for designing post-wimp user interfaces. In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems*, pages 446–453, 2000.

[55] M. Beaudouin-Lafon. Designing interaction, not interfaces. In *Proceedings of the Working Conference on Advanced Visual Interfaces*, AVI '04, page 15–22, New York, NY, USA, 2004. Association for Computing Machinery. ISBN 1581138679. doi: 10.1145/989863.989865. URL `https://doi.org/10.1145/989863.989865`.

[56] M. Beaudouin-Lafon. Designing interaction, not interfaces. In *Proceedings of the working conference on Advanced visual interfaces*, pages 15–22, 2004.

[57] B. B. Bederson and B. Shneiderman. *The craft of information visualization: readings and reflections.* Morgan Kaufmann, 2003.

[58] B. B. Bederson, B. Lee, R. M. Sherman, P. S. Herrnson, and R. G. Niemi. Electronic voting system usability issues. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 145–152, 2003.

[59] V. Bellotti and S. Bly. Walking away from the desktop computer: distributed collaboration and mobility in a product design team. In *Proceedings of the 1996 ACM conference on Computer supported cooperative work*, pages 209–218, 1996.

[60] V. Bellotti, M. Back, W. K. Edwards, R. E. Grinter, A. Henderson, and C. Lopes. Making sense of sensing systems: five questions for designers and researchers. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 415–422, 2002.

[61] E. Beneteau, O. K. Richards, M. Zhang, J. A. Kientz, J. Yip, and A. Hiniker. Communication breakdowns between families and alexa. In *Proceedings of the 2019 CHI conference on human factors in computing systems*, pages 1–13, 2019.

[62] M. Bengtsson. How to plan and perform a qualitative study using content analysis. *NursingPlus Open*, 2:8–14, 2016.

[63] D. Benyon. *Designing user experience*. Pearson UK, 2019.

[64] J. Bergstrom-Lehtovirta, A. Oulasvirta, and S. Brewster. The effects of walking speed on target acquisition on a touchscreen interface. In *Proceedings of the 13th International Conference on Human Computer Interaction with Mobile Devices and Services*, pages 143–146, 2011.

[65] T. Berlage. A selective undo mechanism for graphical user interfaces based on command objects. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 1(3):269–294, 1994.

[66] M. Bernstein. The bookmark and the compass: orientation tools for hypertext users. *ACM SIGOIS Bulletin*, 9(4):34–45, 1988.

[67] J. Berström and K. Hornbæk. A Model of the User Interface. Technical report, 2022.

[68] E. Bertini, S. Gabrielli, S. Kimani, T. Catarci, and G. Santucci. Appropriating and assessing heuristics for mobile computing. In *Proceedings of the Working Conference on Advanced Visual Interfaces*, AVI '06, page 119–126, New York, NY, USA, 2006. Association for Computing Machinery. ISBN 1595933530. doi: 10.1145/1133265.1133291. URL `https://doi.org/10.1145/1133265.1133291`.

[69] N. Bevan. Quality in use: Meeting user needs for quality. *Journal of systems and software*, 49(1):89–96, 1999.

[70] W. L. Bewley, T. L. Roberts, D. Schroit, and W. L. Verplank. Human factors testing in the design of xerox's 8010 "star" office workstation. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '83, page 72–77, New York, NY, USA, 1983. Association for Computing Machinery. ISBN 0897911210. doi: 10.1145/800045.801584. URL `https://doi.org/10.1145/800045.801584`.

[71] X. Bi, B. A. Smith, and S. Zhai. Multilingual touchscreen keyboard design and optimization. *Human–Computer Interaction*, 27(4):352–382, 2012.

[72] R. G. Bias and D. J. Mayhew. *Cost-justifying usability: An update for the Internet age*. Elsevier, 2005.

[73] V. Biener, T. Gesslein, D. Schneider, F. Kawala, A. Otte, P. O. Kristensson, M. Pahud, E. Ofek, C. Campos, M. Kljun, et al. Povrpoint: Authoring presentations in mobile virtual reality. *IEEE Transactions on Visualization and Computer Graphics*, 28(5):2069–2079, 2022.

[74] C. M. Bishop and N. M. Nasrabadi. *Pattern recognition and machine learning*, volume 4. Springer, 2006.

[75] J. B. Black and T. P. Moran. Learning and remembering command names. In *Proceedings of the 1982 Conference on Human Factors in Computing Systems*, CHI '82, page 8–11, New York, NY, USA, 1982. Association for Computing Machinery. ISBN 9781450373890. doi: 10.1145/800049.801745. URL `https://doi.org/10.1145/800049.801745`.

[76] R. Black, A. Waller, R. Turner, and E. Reiter. Supporting personal narrative for children with complex communication needs. *ACM transactions on computer-human interaction (TOCHI)*, 19(2):1–35, 2012.

[77] A. Blackwell and T. Green. Notational systems–the cognitive dimensions of notations framework. *HCI models, theories, and frameworks: toward an interdisciplinary science. Morgan Kaufmann*, 2003.

[78] A. E. Blandford, J. K. Hyde, I. Connell, and T. R. Green. Scoping analytical usability evaluation methods: a case study. Technical report, Working paper available from http://www. uclic. ucl. ac. uk/annb/CASSMpapers ..., 2004.

[79] E. Blevis. Sustainable interaction design: invention & disposal, renewal & reuse. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 503–512, 2007.

[80] J. O. Blom and A. F. Monk. Theory of personalization of appearance: Why users personalize their pcs and mobile phones. *Human-computer interaction*, 18(3): 193–228, 2003.

[81] D. J. Blomberg and H. Karasti. Ethnography: Positioning ethnography within participatory design. In *Routledge international handbook of participatory design*, pages 106–136. Routledge, 2012.

[82] M. Blythe. Research through design fiction: narrative in real and imaginary abstracts. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 703–712, 2014.

[83] M. A. Boden. *The creative mind: Myths and mechanisms*. Routledge, 2004.

[84] S. Bødker. Through the interface-a human activity approach to user interface design. *DAIMI Report Series*, (224), 1991.

[85] R. Bogdan. Teaching fieldwork to educational researchers. *Anthropology & education quarterly*, 14(3):171–178, 1983.

[86] J. O. Borchers. A pattern approach to interaction design. In *Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques*, pages 369–378, 2000.

[87] C. P. Borchgrevink, J. Cha, and S. Kim. Hand washing practices in a college town environment. *Journal of environmental health*, 75(8):18–25, 2013.

[88] T. Boren and J. Ramey. Thinking aloud: Reconciling theory and practice. *IEEE transactions on professional communication*, 43(3):261–278, 2000.

[89] J. P. Borst, N. A. Taatgen, and H. van Rijn. What makes interruptions disruptive? a process-model account of the effects of the problem state bottleneck on task interruption and resumption. In *Proceedings of the 33rd annual ACM conference on human factors in computing systems*, pages 2971–2980, 2015.

[90] N. Bos, J. Olson, D. Gergle, G. Olson, and Z. Wright. Effects of four computer-mediated communications channels on trust development. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 135–140, 2002.

[91] J. Bowers, G. Button, and W. Sharrock. Workflow from within and without: Technology and cooperative work on the print industry shopfloor. In *Proceedings of the Fourth European Conference on Computer-Supported Cooperative Work ECSCW'95: 10–14 September, 1995, Stockholm, Sweden*, pages 51–66. Springer, 1995.

[92] D. M. Boyd and N. B. Ellison. Social network sites: Definition, history, and scholarship. *Journal of computer-mediated Communication*, 13(1):210–230, 2007.

[93] M. M. Bradley and P. J. Lang. Measuring emotion: the self-assessment manikin and the semantic differential. *Journal of behavior therapy and experimental psychiatry*, 25(1):49–59, 1994.

[94] E. Brandt, T. Binder, and E. B.-N. Sanders. Tools and techniques: Ways to engage telling, making and enacting. In *Routledge international handbook of participatory design*, pages 145–181. Routledge, 2012.

[95] V. Braun and V. Clarke. Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2):77–101, 2006. doi: 10.1191/1478088706qp063oa. URL `https://www.tandfonline.com/doi/abs/10.1191/1478088706qp063oa`.

[96] S. A. Brewster and L. M. Brown. Tactons: structured tactile messages for non-visual information display. 2004.

[97] S. A. Brewster, P. C. Wright, and A. D. Edwards. Experimentally derived guidelines for the creation of earcons. In *Adjunct Proceedings of HCI*, volume 95, pages 155–159, 1995.

[98] J. Brooke. Sus: a retrospective. *Journal of usability studies*, 8(2):29–40, 2013.

[99] J. Brooke et al. Sus-a quick and dirty usability scale. *Usability evaluation in industry*, 189(194):4–7, 1996.

[100] F. P. Brooks Jr. *The mythical man-month: essays on software engineering*. Pearson Education, 1995.

[101] B. Brown and E. Laurier. The trouble with autopilots: Assisted and autonomous driving on the social road. In *Proceedings of the 2017 CHI conference on human factors in computing systems*, pages 416–429, 2017.

[102] J. R. Brubaker, G. R. Hayes, and P. Dourish. Beyond the grave: Facebook as a site for the expansion of death and mourning. *The Information Society*, 29(3):152–163, 2013.

[103] F. Brudy, C. Holz, R. Rädle, C.-J. Wu, S. Houben, C. N. Klokmose, and N. Marquardt. Cross-device taxonomy: Survey, opportunities and challenges of interactions spanning across multiple devices. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, CHI '19, page 1–28, New York, NY, USA, 2019. Association for Computing Machinery. ISBN 9781450359702. doi: 10.1145/3290605.3300792. URL `https://doi.org/10.1145/3290605.3300792`.

[104] F. Brühlmann, B. Vollenwyder, K. Opwis, and E. D. Mekler. Measuring the "why" of interaction: Development and validation of the user motivation inventory (umi). In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, pages 1–13, 2018.

[105] D. P. Brumby and S. Zhuang. Visual grouping in menu interfaces. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, pages 4203–4206, 2015.

[106] A. B. Brush, B. Lee, R. Mahajan, S. Agarwal, S. Saroiu, and C. Dixon. Home automation in the wild: Challenges and opportunities. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '11, page 2115–2124, New York, NY, USA, 2011. Association for Computing Machinery. ISBN 9781450302289. doi: 10.1145/1978942.1979249. URL `https://doi.org/10.1145/1978942.1979249`.

[107] S. L. Bryant, A. Forte, and A. Bruckman. Becoming wikipedian: Transformation of participation in a collaborative online encyclopedia. In *Proceedings of the 2005 International ACM SIGGROUP Conference on Supporting Group Work*, GROUP '05, page 1–10, New York, NY, USA, 2005. Association for Computing Machinery. ISBN 1595932232. doi: 10.1145/1099203.1099205. URL `https://doi.org/10.1145/1099203.1099205`.

[108] L. L. Bucciarelli and L. L. Bucciarelli. *Designing engineers*. MIT press, 1994.

[109] R. Buchanan. Wicked problems in design thinking. *Design issues*, 8(2):5–21, 1992.

[110] M. Bunge. Towards a technoethics. *The Monist*, 60(1):96–107, 1977.

[111] M. Bunge. *Causality and modern science*. Routledge, 2017.

[112] M. Burnett, S. Stumpf, J. Macbeth, S. Makri, L. Beckwith, I. Kwan, A. Peters, and W. Jernigan. Gendermag: A method for evaluating software's gender inclusiveness. *Interacting with Computers*, 28(6):760–787, 2016.

[113] G. Button and W. Sharrock. How to conduct ethnomethodological studies of work. In *Studies of work and the workplace in HCI: Concepts and techniques*, pages 51–82. Springer, 2009.

[114] G. Button and W. Sharrock. Making observations. In *Studies of Work and the Workplace in HCI: Concepts and Techniques*, pages 83–87. Springer, 2009.

[115] W. Buxton. A three-state model of graphical input. In *Human-computer interaction-INTERACT*, volume 90, pages 449–456, 1990.

[116] D. Byrne, A. R. Doherty, G. J. Jones, A. F. Smeaton, S. Kumpulainen, and K. Järvelin. The sensecam as a tool for task observation. *People and Computers XXII Culture, Creativity, Interaction 22*, pages 19–22, 2008.

[117] S. Bødker and C. N. Klokmose. The human–artifact model: An activity theoretical approach to artifact ecologies. *Human–Computer Interaction*, 26(4):315–371, 2011. doi: 10.1080/07370024.2011.626709. URL `https://doi.org/10.1080/07370024.2011.626709`.

[118] C. J. Cai, S. Winter, D. Steiner, L. Wilcox, and M. Terry. "hello ai": Uncovering the onboarding needs of medical practitioners for human-ai collaborative decision-making. *Proc. ACM Hum.-Comput. Interact.*, 3(CSCW), nov 2019. doi: 10.1145/3359206. URL `https://doi.org/10.1145/3359206`.

[119] K. Caine. Local standards for sample size at chi. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, CHI '16, page 981–992, New York, NY, USA, 2016. Association for Computing Machinery. ISBN 9781450333627. doi: 10.1145/2858036.2858498. URL `https://doi.org/10.1145/2858036.2858498`.

[120] K. Caine. Local standards for sample size at chi. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, CHI '16, pages 981–992, New York, NY, USA, 2016. ACM. ISBN 978-1-4503-3362-7. doi: 10.1145/2858036.2858498. URL `http://doi.acm.org/10.1145/2858036.2858498`.

[121] P. Cairns and H. Thimbleby. Interaction programming. *Computational Interaction*, 2018.

[122] J. Callahan, D. Hopkins, M. Weiser, and B. Shneiderman. An empirical comparison of pie vs. linear menus. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 95–100, 1988.

[123] N. Campo Woytuk, M. L. J. Søndergaard, M. Ciolfi Felice, and M. Balaam. Touching and being in touch with the menstruating body. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, pages 1–14, 2020.

[124] J. C. Campos, C. Fayollas, M. D. Harrison, C. Martinie, P. Masci, and P. Palanque. Supporting the analysis of safety critical user interfaces: an exploration of three formal tools. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 27(5): 1–48, 2020.

[125] X. Cao and S. Zhai. Modeling human performance of pen stroke gestures. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 1495–1504, 2007.

[126] A. Caraban, E. Karapanos, D. Gonçalves, and P. Campos. 23 ways to nudge: A review of technology-mediated nudging in human-computer interaction. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, pages 1–15, 2019.

[127] S. K. Card. User perceptual mechanisms in the search of computer command menus. In *Proceedings of the 1982 conference on Human factors in computing systems*, pages 190–196, 1982.

[128] S. K. Card, W. K. English, and B. J. Burr. Evaluation of mouse, rate-controlled isometric joystick, step keys, and text keys for text selection on a crt. *Ergonomics*, 21(8):601–613, 1978.

[129] S. K. Card, T. P. Moran, and A. Newell. The psychology of human-computer interaction. 1983, 1983.

[130] S. K. Card, J. D. Mackinlay, and G. G. Robertson. A morphological analysis of the design space of input devices. *ACM Transactions on Information Systems (TOIS)*, 9(2):99–122, 1991.

[131] J. H. Carlisle. Evaluating the impact of office automation on top management communication. In *Proceedings of the June 7-10, 1976, national computer conference and exposition*, pages 611–616, 1976.

[132] J. M. Carroll and C. Carrithers. Training wheels in a user interface. *Commun. ACM*, 27(8):800–806, Aug. 1984. ISSN 0001-0782. doi: 10.1145/358198.358218. URL `https://doi.org/10.1145/358198.358218`.

[133] J. M. Carroll and J. C. Thomas. Fun. *ACM SIGCHI Bulletin*, 19(3):21–24, 1988.

[134] J. M. Carroll, R. L. Mack, and W. A. Kellogg. Interface metaphors and user interface design. In *Handbook of human-computer interaction*, pages 67–85. Elsevier, 1988.

[135] J. M. Carroll, W. A. Kellogg, and M. B. Rosson. The task-artifact cycle. In *Designing interaction: Psychology at the human-computer interface*, pages 74–102. 1991.

[136] G. Casiez, D. Vogel, R. Balakrishnan, and A. Cockburn. The impact of control-display gain on user performance in pointing tasks. *Human–computer interaction*, 23(3):215–250, 2008.

[137] G. Casiez, D. Vogel, R. Balakrishnan, and A. Cockburn. The impact of control-display gain on user performance in pointing tasks. *Human–computer interaction*, 23(3):215–250, 2008.

[138] G. Casiez, N. Roussel, and D. Vogel. 1€ filter: a simple speed-based low-pass filter for noisy input in interactive systems. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 2527–2530, 2012.

[139] J. Cassell, T. Bickmore, M. Billinghurst, L. Campbell, K. Chang, H. Vilhjálmsson, and H. Yan. Embodiment in conversational interfaces: Rea. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '99, page 520–527, New York, NY, USA, 1999. Association for Computing Machinery. ISBN 0201485591. doi: 10.1145/302979.303150. URL `https://doi.org/10.1145/302979.303150`.

[140] I. Ceaparu, J. Lazar, K. Bessiere, J. Robinson, and B. Shneiderman. Determining causes and severity of end-user frustration. *International journal of human-computer interaction*, 17(3):333–356, 2004.

[141] M. Chalmers, I. MacColl, and M. Bell. Seamful design: Showing the seams in wearable computing. In *2003 IEE Eurowearable*, pages 11–16. IET, 2003.

[142] E. Chandrasekharan, M. Samory, S. Jhaver, H. Charvat, A. Bruckman, C. Lampe, J. Eisenstein, and E. Gilbert. The internet's hidden rules: An empirical study of reddit norm violations at micro, meso, and macro scales. *Proceedings of the ACM on Human-Computer Interaction*, 2(CSCW):1–25, 2018.

[143] A. Chapanis. Words, words, words. *Human factors*, 7(1):1–17, 1965.

[144] O. Chapuis, R. Blanch, and M. Beaudouin-Lafon. Fitts' Law in the Wild: A Field Study of Aimed Movements. Technical report, Dec. 2007. URL `https://hal.archives-ouvertes.fr/hal-00612026`. LRI Technical Repport Number 1480, Univ. Paris-Sud, 11 pages.

[145] P.-H. C. Chen, K. Gadepalli, R. MacDonald, Y. Liu, S. Kadowaki, K. Nagpal, T. Kohlberger, J. Dean, G. S. Corrado, J. D. Hipp, et al. An augmented reality microscope with real-time artificial intelligence integration for cancer diagnosis. *Nature medicine*, 25(9):1453–1457, 2019.

[146] X. Chen, G. Bailly, D. P. Brumby, A. Oulasvirta, and A. Howes. The emergence of interactive behavior: A model of rational menu search. In *Proceedings of the 33rd annual ACM conference on human factors in computing systems*, pages 4217–4226, 2015.

[147] M. Chetty, R. Banks, A. Brush, J. Donner, and R. Grinter. You're capped: understanding the effects of bandwidth caps on broadband use in the home. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 3021–3030, 2012.

[148] P. K. Chilana, A. J. Ko, J. O. Wobbrock, T. Grossman, and G. Fitzmaurice. Post-deployment usability: a survey of current practices. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 2243–2246, 2011.

[149] J. P. Chin, V. A. Diehl, and K. L. Norman. Development of an instrument measuring user satisfaction of the human-computer interface. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 213–218, 1988.

[150] V. Chotpitayasunondh and K. M. Douglas. How "phubbing" becomes the norm: The antecedents and consequences of snubbing via smartphone. *Computers in human behavior*, 63:9–18, 2016.

[151] D. D. Chrislip and C. E. Larson. *Collaborative leadership: How citizens and civic leaders can make a difference*, volume 24. Jossey-Bass, 1994.

[152] T. Clemmensen, M. Hertzum, K. Hornbæk, Q. Shi, and P. Yammiyavar. Cultural cognition in usability evaluation. *Interacting with computers*, 21(3):212–220, 2009.

[153] W. S. Cleveland and R. McGill. Graphical perception: Theory, experimentation, and application to the development of graphical methods. *Journal of the American statistical association*, 79(387):531–554, 1984.

[154] C. Clifton Jr, F. Ferreira, J. M. Henderson, A. W. Inhoff, S. P. Liversedge, E. D. Reichle, and E. R. Schotter. Eye movements in reading and information processing: Keith rayner's 40 year legacy. *Journal of Memory and Language*, 86:1–19, 2016.

[155] A. Cockburn, C. Gutwin, and S. Greenberg. A predictive model of menu performance. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 627–636, 2007.

[156] A. Cockburn, C. Gutwin, J. Scarr, and S. Malacria. Supporting novice to expert transitions in user interfaces. *ACM Computing Surveys (CSUR)*, 47(2):1–36, 2014.

[157] A. Cockburn, P. Quinn, and C. Gutwin. Examining the peak-end effects of subjective experience. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, CHI '15, page 357–366, New York, NY, USA, 2015. Association for Computing Machinery. ISBN 9781450331456. doi: 10.1145/2702123.2702139. URL `https://doi.org/10.1145/2702123.2702139`.

[158] A. Cockburn, P. Quinn, C. Gutwin, Z. Chen, and P. Suwanaposee. Probability weighting in interactive decisions: Evidence for overuse of bad assistance, underuse of good assistance. In *CHI Conference on Human Factors in Computing Systems*, pages 1–12, 2022.

[159] G. Cockton and A. Woolrych. Understanding inspection methods: lessons from an assessment of heuristic evaluation. In *People and computers XV—Interaction without frontiers*, pages 171–191. Springer, 2001.

[160] G. Cockton, A. Woolrych, K. Hornbæk, and E. Frøkjær. Inspection-based evaluations. In *The Human–Computer Interaction Handbook*, pages 1279–1298. CRC Press, 2012.

[161] J. Cohen. A power primer. *Psychological bulletin*, 112(1):155, 1992.

[162] G. Cohn, D. Morris, S. N. Patel, and D. S. Tan. Your noise is my command: sensing gestures using the body as an antenna. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 791–800, 2011.

[163] L. Colusso, C. L. Bennett, G. Hsieh, and S. A. Munson. Translational resources: Reducing the gap between academic research and hci practice. In *Proceedings of the 2017 Conference on Designing Interactive Systems*, pages 957–968, 2017.

[164] S. Consolvo, D. W. McDonald, T. Toscos, M. Y. Chen, J. Froehlich, B. Harrison, P. Klasnja, A. LaMarca, L. LeGrand, R. Libby, I. Smith, and J. A. Landay. Activity sensing in the wild: A field trial of ubifit garden. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '08, page 1797–1806, New York, NY, USA, 2008. Association for Computing Machinery. ISBN 9781605580111. doi: 10.1145/1357054.1357335. URL `https://doi.org/10.1145/1357054.1357335`.

[165] S. Consolvo, D. W. McDonald, T. Toscos, M. Y. Chen, J. Froehlich, B. Harrison, P. Klasnja, A. LaMarca, L. LeGrand, R. Libby, et al. Activity sensing in the wild: a field trial of ubifit garden. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 1797–1806, 2008.

[166] S. Consolvo, D. W. McDonald, and J. A. Landay. Theory-driven design strategies for technologies that support behavior change in everyday life. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 405–414, 2009.

[167] R. I. Cook. How complex systems fail. *Cognitive Technologies Laboratory, University of Chicago. Chicago IL*, pages 64–118, 1998.

[168] A. Cooper, R. Reimann, D. Cronin, and C. Noessel. *About face: the essentials of interaction design.* John Wiley & Sons, 2014.

[169] N. Cowan. The magical mystery four: How is working memory capacity limited, and why? *Current directions in psychological science*, 19(1):51–57, 2010.

[170] D. R. Cox. *Principles of statistical inference*. Cambridge university press, 2006.

[171] F. I. Craik and R. S. Lockhart. Levels of processing: A framework for memory research. *Journal of verbal learning and verbal behavior*, 11(6):671–684, 1972.

[172] N. Crilly. Fixation and creativity in concept development: The attitudes and practices of expert designers. *Design studies*, 38:54–91, 2015.

[173] E. R. F. Crossman and P. Goodeve. Feedback control of hand-movement and fitts' law. *The Quarterly Journal of Experimental Psychology Section A*, 35(2):251–278, 1983.

[174] R. M. Currano and M. Steinert. A framework for reflective practice in innovative design. *International Journal of Engineering Education*, 28(2):270, 2012.

[175] Cyberglove Systems. Hand motion capturing and force feedback with cybergrasp, 2015. URL `http://www.cyberglovesystems.com/`.

[176] A. Cypher. Eager: Programming repetitive tasks by example. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 33–39, 1991.

[177] N. Dahlbäck, A. Jönsson, and L. Ahrenberg. Wizard of oz studies—why and how. *Knowledge-based systems*, 6(4):258–266, 1993.

[178] P. Dalsgaard and K. Halskov. Designing urban media façades: cases and challenges. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 2277–2286, 2010.

[179] T. Davies and A. Beeharee. The case of the missed icon: change blindness on mobile devices. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 1451–1460, 2012.

[180] F. D. Davis. Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, pages 319–340, 1989.

[181] F. D. Davis, R. P. Bagozzi, and P. R. Warshaw. Extrinsic and intrinsic motivation to use computers in the workplace 1. *Journal of applied social psychology*, 22(14): 1111–1132, 1992.

[182] E. L. Deci and R. M. Ryan. Self-determination theory: A macrotheory of human motivation, development, and health. *Canadian psychology/Psychologie canadienne*, 49(3):182, 2008.

[183] N. Dell and N. Kumar. The ins and outs of hci for development. In *Proceedings of the 2016 CHI conference on human factors in computing systems*, pages 2220–2232, 2016.

[184] G. Denes, K. Maruszczyk, G. Ash, and R. K. Mantiuk. Temporal resolution multiplexing: Exploiting the limitations of spatio-temporal vision for more efficient vr rendering. *IEEE Transactions on Visualization and Computer Graphics*, 25(5): 2072–2082, 2019. doi: 10.1109/TVCG.2019.2898741.

[185] G. DeSanctis and M. S. Poole. Capturing the complexity in advanced technology use: Adaptive structuration theory. *Organization science*, 5(2):121–147, 1994.

[186] P. M. Desmet. Faces of product pleasure: 25 positive emotions in human-product interactions. *International Journal of Design*, 6(2), 2012.

[187] H. Desurvire, M. Caplan, and J. A. Toth. Using heuristics to evaluate the playability of games. In *CHI'04 extended abstracts on Human factors in computing systems*, pages 1509–1512, 2004.

[188] A. K. Dey. Understanding and using context. *Personal and ubiquitous computing*, 5(1):4–7, 2001.

[189] V. Dhakal, A. M. Feit, P. O. Kristensson, and A. Oulasvirta. Observations on typing from 136 million keystrokes. In *Proceedings of the 2018 CHI conference on human factors in computing systems*, pages 1–12, 2018.

[190] R. Dhamija, J. D. Tygar, and M. Hearst. Why phishing works. In *Proceedings of the SIGCHI conference on Human Factors in computing systems*, pages 581–590, 2006.

[191] S. Diefenbach, N. Kolb, and M. Hassenzahl. The'hedonic'in human-computer interaction: history, contributions, and future research directions. In *Proceedings of the 2014 conference on Designing interactive systems*, pages 305–314, 2014.

[192] P. Dietz and D. Leigh. Diamondtouch: a multi-user touch technology. In *Proceedings of the 14th annual ACM symposium on User interface software and technology*, pages 219–226, 2001.

[193] A. Dillon and C. Watson. User analysis in hci: The historical lesson from individual differences research. *International journal of human-computer studies*, 45(6):619–637, 1996.

[194] J. DiMicco, D. R. Millen, W. Geyer, C. Dugan, B. Brownholtz, and M. Muller. Motivations for social networking at work. In *Proceedings of the 2008 ACM Conference on Computer Supported Cooperative Work*, CSCW '08, page 711–720, New York, NY, USA, 2008. Association for Computing Machinery. ISBN 9781605580074. doi: 10.1145/1460563.1460674. URL `https://doi.org/10.1145/1460563.1460674`.

[195] M. T. Dishaw and D. M. Strong. Extending the technology acceptance model with task–technology fit constructs. *Information & management*, 36(1):9–21, 1999.

[196] A. Dix. Designing for appropriation. In *Proceedings of HCI 2007 The 21st British HCI Group Annual Conference University of Lancaster, UK 21*, pages 1–4, 2007.

[197] A. Dix, R. Mancini, and S. Levialdi. The cube–extending systems for undo. *School of Computing, Staffordshire University. UK*, 1997.

[198] E. Y.-L. Do and M. D. Gross. Drawing as a means to design reasoning. In *AI and Design*, 1996.

[199] K. Doherty and G. Doherty. The construal of experience in hci: Understanding self-reports. *International Journal of Human-Computer Studies*, 110:63–74, 2018.

[200] K. Doherty and G. Doherty. Engagement in hci: conception, theory and measurement. *ACM Computing Surveys (CSUR)*, 51(5):1–39, 2018.

[201] K. Doherty, A. Balaskas, and G. Doherty. The Design of Ecological Momentary Assessment Technologies. *Interacting with Computers*, 32(3):257–278, 08 2020. ISSN 1873-7951. doi: 10.1093/iwcomp/iwaa019. URL `https://doi.org/10.1093/iwcomp/iwaa019`.

[202] J. Donath. Signals in social supernets. *Journal of Computer-Mediated Communication*, 13(1):231–251, 2007.

[203] A. Dong, A. W. Hill, and A. M. Agogino. A document analysis method for characterizing design team performance. *J. Mech. Des.*, 126(3):378–385, 2004.

[204] K. Dorst. *Frame innovation: Create new thinking by design.* MIT press, 2015.

[205] K. Dorst and N. Cross. Creativity in the design process: co-evolution of problem–solution. *Design studies*, 22(5):425–437, 2001.

[206] P. Dourish. The appropriation of interactive technologies: Some lessons from placeless documents. *Computer Supported Cooperative Work (CSCW)*, 12(4):465–490, 2003.

[207] P. Dourish. Implications for design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '06, page 541–550, New York, NY, USA, 2006. Association for Computing Machinery. ISBN 1595933727. doi: 10.1145/1124772.1124855. URL `https://doi.org/10.1145/1124772.1124855`.

[208] P. Dourish and V. Bellotti. Awareness and coordination in shared workspaces. In *Proceedings of the 1992 ACM conference on Computer-supported cooperative work*, pages 107–114, 1992.

[209] C. Downey and S. W. Kamel. Storytime with hue: An innovative approach to storytelling where storytellers control a dynamic lighting environment. In *Proceedings of the TEI'16: Tenth International Conference on Tangible, Embedded, and Embodied Interaction*, pages 422–427, 2016.

[210] P. Dragicevic. Combining crossing-based and paper-based interaction paradigms for dragging and dropping between overlapping windows. In *Proceedings of the 17th*

annual ACM symposium on User interface software and technology, pages 193–196, 2004.

[211] P. Dragicevic, G. Ramos, J. Bibliowitcz, D. Nowrouzezahrai, R. Balakrishnan, and K. Singh. Video browsing by direct manipulation. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '08, page 237–246, New York, NY, USA, 2008. Association for Computing Machinery. ISBN 9781605580111. doi: 10.1145/1357054.1357096. URL `https://doi.org/10.1145/1357054.1357096`.

[212] A. Druin. The role of children in the design of new technology. *Behaviour and information technology*, 21(1):1–25, 2002.

[213] N. Ducheneaut, N. Yee, E. Nickell, and R. J. Moore. Alone together? exploring the social dynamics of massively multiplayer online games. In *Proceedings of the SIGCHI conference on Human Factors in computing systems*, pages 407–416, 2006.

[214] R. O. Duda, P. E. Hart, and D. G. Stork. *Pattern classification and scene analysis*, volume 3. Wiley New York, 1973.

[215] J. Dudley, H. Benko, D. Wigdor, and P. O. Kristensson. Performance envelopes of virtual keyboard text input strategies in virtual reality. In *2019 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pages 289–300. IEEE, 2019.

[216] J. S. Dumas and B. A. Loring. *Moderating usability tests: Principles and practices for interacting*. Elsevier, 2008.

[217] R. J. Dwyer, K. Kushlev, and E. W. Dunn. Smartphone use undermines enjoyment of face-to-face social interactions. *Journal of Experimental Social Psychology*, 78: 233–239, 2018.

[218] D. E. Egan, J. R. Remde, L. M. Gomez, T. K. Landauer, J. Eberhardt, and C. C. Lochbaum. Formative design evaluation of superbook. *ACM Trans. Inf. Syst.*, 7(1):30–57, Jan. 1989. ISSN 1046-8188. doi: 10.1145/64789.64790. URL `http://doi.acm.org/10.1145/64789.64790`.

[219] S. Egelman, L. F. Cranor, and J. Hong. You've been warned: an empirical study of the effectiveness of web browser phishing warnings. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 1065–1074, 2008.

[220] P. Ekkekakis. *The measurement of affect, mood, and emotion: A guide for health-behavioral research*. Cambridge University Press, 2013.

[221] C. Elliott and P. Deasley. Creating systems that work: Principles of engineering systems for the 21st century. *R Acad Eng*, 293074, 2007.

[222] C. A. Ellis, S. J. Gibbs, and G. Rein. Groupware: Some issues and experiences. *Commun. ACM*, 34(1):39–58, jan 1991. ISSN 0001-0782. doi: 10.1145/99977.99987. URL `https://doi.org/10.1145/99977.99987`.

[223] N. B. Ellison, C. Steinfield, and C. Lampe. The benefits of facebook "friends:" social capital and college students' use of online social network sites. *Journal of computer-mediated communication*, 12(4):1143–1168, 2007.

[224] S. Elrod, R. Bruce, R. Gold, D. Goldberg, F. Halasz, W. Janssen, D. Lee, K. McCall, E. Pedersen, K. Pier, J. Tang, and B. Welch. Liveboard: A large interactive display supporting group meetings, presentations, and remote collaboration. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '92, page 599–607, New York, NY, USA, 1992. Association for Computing Machinery. ISBN 0897915135. doi: 10.1145/142750.143052. URL `https://doi.org/10.1145/142750.143052`.

[225] D. C. Engelbart. Augmenting human intellect: A conceptual framework. *Menlo Park, CA*, 21, 1962.

[226] Y. Engeström. *Learning by expanding*. Cambridge University Press, 2015.

[227] J. M. Entwistle, M. K. Rasmussen, N. Verdezoto, R. S. Brewer, and M. S. Andersen. *Beyond the Individual: The Contextual Wheel of Practice as a Research Framework for Sustainable HCI*, page 1125–1134. Association for Computing Machinery, New York, NY, USA, 2015. ISBN 9781450331456. URL `https://doi.org/10.1145/2702123.2702232`.

[228] K. A. Ericsson and H. A. Simon. *Protocol Analysis. Verbal reports as data (Revised edition)*. 1993.

[229] S. K. Ernala, M. Burke, A. Leavitt, and N. B. Ellison. How well do people report time spent on facebook? an evaluation of established survey questions with recommendations. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, CHI '20, page 1–14, New York, NY, USA, 2020. Association for Computing Machinery. ISBN 9781450367080. doi: 10.1145/3313831.3376435. URL `https://doi.org/10.1145/3313831.3376435`.

[230] M. O. Ernst and M. S. Banks. Humans integrate visual and haptic information in a statistically optimal fashion. *Nature*, 415(6870):429–433, 2002.

[231] A. Esteves, E. Velloso, A. Bulling, and H. Gellersen. Orbits: Gaze interaction for smart watches using smooth pursuit eye movements. In *Proceedings of the 28th annual ACM symposium on user interface software & technology*, pages 457–466, 2015.

[232] J. a. M. Evangelista Belo, A. M. Feit, T. Feuchtner, and K. Grønbæk. Xrgonomics: Facilitating the creation of ergonomic 3d interfaces. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, CHI '21, New York, NY, USA, 2021. Association for Computing Machinery. ISBN 9781450380966. doi: 10.1145/3411764.3445349. URL `https://doi.org/10.1145/3411764.3445349`.

[233] J. M. Evangelista Belo, M. N. Lystbæk, A. M. Feit, K. Pfeuffer, P. Kán, A. Oulasvirta, and K. Grønbæk. Auit–the adaptive user interfaces toolkit for designing xr applications. In *Proceedings of the 35th Annual ACM Symposium on User Interface Software and Technology*, pages 1–16, 2022.

[234] J. A. Fails and D. R. Olsen Jr. Interactive machine learning. In *Proceedings of the 8th international conference on Intelligent user interfaces*, pages 39–45, 2003.

[235] S. H. Fairclough and K. Houston. A metabolic measure of mental effort. *Biological psychology*, 66(2):177–190, 2004.

[236] M. Fan, S. Shi, and K. N. Truong. Practices and challenges of using think-aloud protocols in industry: An international survey. *Journal of Usability Studies*, 15(2), 2020.

[237] M. Farzandipour, E. Nabovati, H. Tadayon, and M. S. Jabali. Usability evaluation of a nursing information system by applying cognitive walkthrough method. *International Journal of Medical Informatics*, 152:104459, 2021.

[238] A. M. Feit, M. Nancel, M. John, A. Karrenbauer, D. Weir, and A. Oulasvirta. Azerty amélioré: computational design on a national scale. *Communications of the ACM*, 64(2):48–58, 2021.

[239] G. Firebaugh. *Seven rules for social research.* Princeton University Press, 2008.

[240] A. J. Fisher, J. D. Medaglia, and B. F. Jeronimus. Lack of group-to-individual generalizability is a threat to human subjects research. *Proceedings of the National Academy of Sciences*, 115(27):E6106–E6115, 2018.

[241] P. M. Fitts. Human engineering for an effective air-navigation and traffic-control system. 1951.

[242] P. M. Fitts. The information capacity of the human motor system in controlling the amplitude of movement. *Journal of experimental psychology*, 47(6):381, 1954.

[243] G. W. Fitzmaurice, H. Ishii, and W. A. Buxton. Bricks: laying the foundations for graspable user interfaces. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 442–449, 1995.

[244] J. Fjeld, N. Achten, H. Hilligoss, A. Nagy, and M. Srikumar. Principled artificial intelligence: Mapping consensus in ethical and rights-based approaches to principles for ai. *Berkman Klein Center Research Publication*, (2020-1), 2020.

[245] P. Flach. *Machine learning: the art and science of algorithms that make sense of data.* Cambridge university press, 2012.

[246] D. R. Flatla, K. Reinecke, C. Gutwin, and K. Z. Gajos. Sprweb: Preserving subjective responses to website colour schemes through automatic recolouring. In

Proceedings of the SIGCHI conference on human factors in computing systems, pages 2069–2078, 2013.

[247] F. O. Flemisch, C. A. Adams, S. R. Conway, K. H. Goodrich, M. T. Palmer, and P. C. Schutte. The h-metaphor as a guideline for vehicle automation and interaction. Technical report, 2003.

[248] J. Fogarty, C. Au, and S. E. Hudson. Sensing from the basement: a feasibility study of unobtrusive and low-cost home activity recognition. In *Proceedings of the 19th annual ACM symposium on User interface software and technology*, pages 91–100, 2006.

[249] B. J. Fogg. A behavior model for persuasive design. In *Proceedings of the 4th international Conference on Persuasive Technology*, pages 1–7, 2009.

[250] J. D. Foley, V. L. Wallace, and P. Chan. The human factors of computer graphics interaction techniques. *IEEE computer Graphics and Applications*, 4(11):13–48, 1984.

[251] S. Follmer, D. Leithinger, A. Olwal, A. Hogge, and H. Ishii. inform: dynamic physical affordances and constraints through shape and object actuation. In *Uist*, volume 13, pages 2501–988, 2013.

[252] A. Følstad, E. Law, and K. Hornbæk. Analysis in practical usability evaluation: A survey study. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '12, page 2127–2136, New York, NY, USA, 2012. Association for Computing Machinery. ISBN 9781450310154. doi: 10.1145/2207676.2208365. URL `https://doi.org/10.1145/2207676.2208365`.

[253] M. Fontana de Vargas, J. Dai, and K. Moffatt. Aac with automated vocabulary from photographs: Insights from school and speech-language therapy settings. In *The 24th International ACM SIGACCESS Conference on Computers and Accessibility*, pages 1–18, 2022.

[254] J. Forlizzi and K. Battarbee. Understanding experience in interactive systems. In *Proceedings of the 5th conference on Designing interactive systems: processes, practices, methods, and techniques*, pages 261–268, 2004.

[255] G. Freeman, J. Bardzell, and S. Bardzell. Revisiting computer-mediated intimacy: In-game marriage and dyadic gameplay in audition. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, pages 4325–4336, 2016.

[256] M. J. French, J. Gravdahl, and M. French. *Conceptual design for engineers.* Springer, 1985.

[257] J. Frich, L. MacDonald Vermeulen, C. Remy, M. M. Biskjaer, and P. Dalsgaard. Mapping the landscape of creativity support tools in hci. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, pages 1–18, 2019.

[258] B. Friedman. Value-sensitive design. *interactions*, 3(6):16–23, 1996.

[259] B. Friedman, D. G. Hendry, A. Borning, et al. A survey of value sensitive design methods. *Foundations and Trends® in Human–Computer Interaction*, 11(2):63–125, 2017.

[260] D. M. Frohlich. The history and future of direct manipulation. *Behaviour & Information Technology*, 12(6):315–329, 1993.

[261] D. M. Frohlich. Direct manipulation and other lessons. In *Handbook of human-computer interaction*, pages 463–488. Elsevier, 1997.

[262] E. Frøkjær, M. Hertzum, and K. Hornbæk. Measuring usability: are effectiveness, efficiency, and satisfaction really correlated? In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems*, pages 345–352, 2000.

[263] H. L. Fromkin and S. Streufert. Laboratory experimentation. *Handbook of industrial and organizational psychology*, pages 415–465, 1976.

[264] G. W. Furnas. New graphical reasoning models for understanding graphical interfaces. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 71–78, 1991.

[265] G. W. Furnas and B. B. Bederson. Space-scale diagrams: Understanding multiscale interfaces. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 234–241, 1995.

[266] G. W. Furnas, T. K. Landauer, L. M. Gomez, and S. T. Dumais. The vocabulary problem in human-system communication. *Commun. ACM*, 30(11):964–971, nov 1987. ISSN 0001-0782. doi: 10.1145/32206.32212. URL `https://doi.org/10.1145/32206.32212`.

[267] K. Z. Gajos, J. O. Wobbrock, and D. S. Weld. Automatically generating user interfaces adapted to users' motor and vision capabilities. In *Proceedings of the 20th Annual ACM Symposium on User Interface Software and Technology*, UIST '07, page 231–240, New York, NY, USA, 2007. Association for Computing Machinery. ISBN 9781595936790. doi: 10.1145/1294211.1294253. URL `https://doi.org/10.1145/1294211.1294253`.

[268] D. F. Galletta, A. Durcikova, A. Everard, and B. M. Jones. Does spell-checking software need a warning label? *Communications of the ACM*, 48(7):82–86, 2005.

[269] M. Gantt and B. A. Nardi. Gardeners and gurus: Patterns of cooperation among cad users. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '92, page 107–117, New York, NY, USA, 1992. Association for Computing Machinery. ISBN 0897915135. doi: 10.1145/142750.142767. URL `https://doi.org/10.1145/142750.142767`.

[270] X. Gao, Y. Yang, C. Liu, C. Mitropoulos, J. Lindqvist, and A. Oulasvirta. Forgetting of passwords: ecological theory and data. In *27th USENIX Security Symposium (USENIX Security 18)*, pages 221–238, 2018.

[271] L. Gasser. The integration of computing and routine work. *ACM Transactions on Information Systems (TOIS)*, 4(3):205–225, 1986.

[272] E. Gatti, E. Calzolari, E. Maggioni, and M. Obrist. Emotional ratings and skin conductance response to visual, auditory and haptic stimuli. *Scientific data*, 5(1): 1–12, 2018.

[273] B. Gaver and J. Bowers. Annotated portfolios. *interactions*, 19(4):40–49, 2012.

[274] W. Gaver. What should we expect from research through design? In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 937–946, 2012.

[275] H. Gelderblom and L. Menge. The invisible gorilla revisited: using eye tracking to investigate inattentional blindness in interface design. In *Proceedings of the 2018 International Conference on Advanced Visual Interfaces*, pages 1–9, 2018.

[276] T. Gesslein, V. Biener, P. Gagel, D. Schneider, P. O. Kristensson, E. Ofek, M. Pahud, and J. Grubert. Pen-based interaction with spreadsheets in mobile virtual reality. In *2020 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, pages 361–373. IEEE, 2020.

[277] M. Ghassemi, L. Oakden-Rayner, and A. L. Beam. The false hope of current approaches to explainable artificial intelligence in health care. *The Lancet Digital Health*, 3(11):e745–e750, 2021.

[278] J. P. Goetz and M. D. LeCompte. Ethnographic research and the problem of data reduction 1. *Anthropology & Education Quarterly*, 12(1):51–70, 1981.

[279] A. Goguey, G. Casiez, A. Cockburn, and C. Gutwin. Storyboard-based empirical modeling of touch interface performance. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, pages 1–12, 2018.

[280] D. Golden. A plea for friendly software. *ACM SIGSOFT Software Engineering Notes*, 5(4):4–5, 1980.

[281] G. Goldschmidt. The dialectics of sketching. *Creativity research journal*, 4(2): 123–143, 1991.

[282] M. Gonçalves, C. Cardoso, and P. Badke-Schaub. What inspires designers? preferences on inspirational approaches during idea generation. *Design studies*, 35(1): 29–53, 2014.

[283] V. M. González and G. Mark. "constant, constant, multi-tasking craziness": Managing multiple working spheres. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '04, page 113–120, New York, NY, USA, 2004. Association for Computing Machinery. ISBN 1581137028. doi: 10.1145/985692.985707. URL `https://doi.org/10.1145/985692.985707`.

[284] C. Goodwin and J. Heritage. Conversation analysis. *Annual review of anthropology*, 19:283–307, 1990.

[285] J. D. Gould and C. Lewis. Designing for usability: key principles and what designers think. *Communications of the ACM*, 28(3):300–311, 1985.

[286] M. S. Granovetter. The strength of weak ties. *American journal of sociology*, 78(6): 1360–1380, 1973.

[287] W. D. Gray and W.-T. Fu. Ignoring perfect knowledge in-the-world for imperfect knowledge in-the-head. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 112–119, 2001.

[288] W. D. Gray and W.-T. Fu. Soft constraints in interactive behavior: The case of ignoring perfect knowledge in-the-world for imperfect knowledge in-the-head. *Cognitive science*, 28(3):359–382, 2004.

[289] W. D. Gray, B. E. John, and M. E. Atwood. Project ernestine: Validating a goms analysis for predicting and explaining real-world task performance. *Human-computer interaction*, 8(3):237–309, 1993.

[290] S. Greenberg and B. Buxton. Usability evaluation considered harmful (some of the time). In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 111–120, 2008.

[291] S. Greenberg and H. Kuzuoka. Using digital but physical surrogates to mediate awareness, communication and privacy in media spaces. *Personal Technologies*, 3 (4):182–198, 1999.

[292] C. F. Griggio, M. Nouwens, and C. N. Klokmose. Caught in the network: The impact of whatsapp's 2021 privacy policy update on users' messaging app ecosystems. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*, CHI '22, New York, NY, USA, 2022. Association for Computing Machinery. ISBN 9781450391573. doi: 10.1145/3491102.3502032. URL `https://doi.org/10.1145/3491102.3502032`.

[293] E. Grönvall, S. Kinch, M. G. Petersen, and M. K. Rasmussen. Causing commotion with a shape-changing bench: experiencing shape-changing interfaces in use. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 2559–2568, 2014.

[294] T. Grossman and R. Balakrishnan. The bubble cursor: enhancing target acquisition by dynamic resizing of the cursor's activation area. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 281–290, 2005.

[295] T. Grossman, P. Dragicevic, and R. Balakrishnan. Strategies for accelerating on-line learning of hotkeys. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 1591–1600, 2007.

[296] T. Grossman, G. Fitzmaurice, and R. Attar. A survey of software learnability: Metrics, methodologies and guidelines. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '09, pages 649–658, New York, NY, USA, 2009. ACM. ISBN 978-1-60558-246-7. doi: 10.1145/1518701.1518803. URL `http://doi.acm.org/10.1145/1518701.1518803`.

[297] T. Grossman, G. Fitzmaurice, and R. Attar. A survey of software learnability: metrics, methodologies and guidelines. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 649–658, 2009.

[298] J. Grubert, E. Ofek, M. Pahud, and P. O. Kristensson. The office of the future: Virtual, portable, and global. *IEEE computer graphics and applications*, 38(6): 125–133, 2018.

[299] J. Grudin. The case against user interface consistency. *Communications of the ACM*, 32(10):1164–1173, 1989.

[300] J. Grudin. Utility and usability: research issues and development contexts. *Interacting with computers*, 4(2):209–217, 1992.

[301] J. Grudin. Computer-supported cooperative work: History and focus. *Computer*, 27(5):19–26, 1994.

[302] J. Grudin. Groupware and social dynamics: Eight challenges for developers. *Communications of the ACM*, 37(1):92–105, 1994.

[303] J. Grudin. Partitioning digital worlds: Focal and peripheral awareness in multiple monitor use. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '01, page 458–465, New York, NY, USA, 2001. Association for Computing Machinery. ISBN 1581133278. doi: 10.1145/365024.365312. URL `https://doi.org/10.1145/365024.365312`.

[304] X. Gu, Y. Zhang, W. Sun, Y. Bian, D. Zhou, and P. O. Kristensson. Dexmo: An inexpensive and lightweight mechanical exoskeleton for motion capture and force feedback in vr. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, pages 1991–1995, 2016.

[305] S. Gustafson, D. Bierwirth, and P. Baudisch. Imaginary interfaces: spatial interaction with empty hands and without visual feedback. In *Proceedings of the 23nd annual ACM symposium on User interface software and technology*, pages 3–12, 2010.

[306] C. Gutwin and S. Greenberg. Effects of awareness support on groupware usability. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '98, pages 511–518, New York, NY, USA, 1998. ACM Press/Addison-Wesley Publishing Co. ISBN 0-201-30987-4. doi: 10.1145/274644.274713. URL http://dx.doi.org/10.1145/274644.274713.

[307] R. Haeuslschmid, B. Pfleging, and F. Alt. A design space to support the development of windshield applications for the car. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, CHI '16, page 5076–5091, New York, NY, USA, 2016. Association for Computing Machinery. ISBN 9781450333627. doi: 10.1145/2858036.2858336. URL https://doi.org/10.1145/2858036.2858336.

[308] K. Halskov and P. Dalsgård. Inspiration card workshops. In *Proceedings of the 6th conference on Designing Interactive systems*, pages 2–11, 2006.

[309] C. A. Halverson, D. B. Horn, C.-M. Karat, and J. Karat. The beauty of errors: Patterns of error correction in desktop speech systems. In *INTERACT*, pages 133–140, 1999.

[310] J. Y. Han. Low-cost multi-touch sensing through frustrated total internal reflection. In *Proceedings of the 18th annual ACM symposium on User interface software and technology*, pages 115–118, 2005.

[311] W. J. Hansen. User engineering principles for interactive systems. In *Proceedings of the November 16-18, 1971, Fall Joint Computer Conference*, AFIPS '71 (Fall), page 523–532, New York, NY, USA, 1972. Association for Computing Machinery. ISBN 9781450379106. doi: 10.1145/1479064.1479159. URL https://doi.org/10.1145/1479064.1479159.

[312] C. Harper. Overcome barriers to end to end research with demonstrated roi. *Design Management Review*, 30(4):8–13, 2019.

[313] C. Harrison and A. K. Dey. Lean and zoom: proximity-aware user interface and content magnification. In *Proceedings of the sigchi conference on human factors in computing systems*, pages 507–510, 2008.

[314] C. Harrison, D. Tan, and D. Morris. Skinput: appropriating the body as an input surface. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 453–462, 2010.

[315] P. E. Hart, D. G. Stork, and R. O. Duda. *Pattern classification.* Wiley, 2000.

[316] S. G. Hart and L. E. Staveland. Development of nasa-tlx (task load index): Results of empirical and theoretical research. In *Advances in psychology*, volume 52, pages 139–183. Elsevier, 1988.

[317] H. R. Hartson, T. S. Andre, R. C. Williges, and L. van Rens. The user action framework: A theory-based foundation for inspection and classification of usability problems. *HCI (1)*, 1999:1058–1062, 1999.

[318] M. Hassenzahl. The thing and i: understanding the relationship between user and product. In *Funology*, pages 31–42. Springer, 2003.

[319] M. Hassenzahl. User experience (ux) towards an experiential perspective on product quality. In *Proceedings of the 20th Conference on l'Interaction Homme-Machine*, pages 11–15, 2008.

[320] M. Hassenzahl. Experience design: Technology for all the right reasons. *Synthesis lectures on human-centered informatics*, 3(1):1–95, 2010.

[321] M. Hassenzahl and N. Tractinsky. User experience-a research agenda. *Behaviour & information technology*, 25(2):91–97, 2006.

[322] M. Hassenzahl, S. Diefenbach, and A. Göritz. Needs, affect, and interactive products–facets of user experience. *Interacting with computers*, 22(5):353–362, 2010.

[323] M. Hassenzahl, S. Heidecker, K. Eckoldt, S. Diefenbach, and U. Hillmann. All you need is love: Current strategies of mediating intimate relationships through technology. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 19(4): 1–19, 2012.

[324] H. A. He, S. Greenberg, and E. M. Huang. One size does not fit all: Applying the transtheoretical model to energy feedback technology design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '10, page 927–936, New York, NY, USA, 2010. Association for Computing Machinery. ISBN 9781605589299. doi: 10.1145/1753326.1753464. URL `https://doi.org/10.1145/1753326.1753464`.

[325] J. He and W. R. King. The role of user participation in information systems development: implications from a meta-analysis. *Journal of management information systems*, 25(1):301–331, 2008.

[326] C. Heath and P. Luff. Collaboration and control: Crisis management and multimedia technology in london underground line control rooms. *Computer Supported Cooperative Work (CSCW)*, 1(1):69–94, 1992.

[327] J. Heer and M. Bostock. Crowdsourcing graphical perception: using mechanical turk to assess visualization design. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 203–212, 2010.

[328] M. L. Heilig. Sensorama simulator, Aug. 28 1962. US Patent 3,050,870.

[329] E. B. Hekler, P. Klasnja, J. E. Froehlich, and M. P. Buman. Mind the theoretical gap: Interpreting, using, and developing behavioral theory in hci research. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '13, page 3307–3316, New York, NY, USA, 2013. Association for Computing Machinery. ISBN 9781450318990. doi: 10.1145/2470654.2466452. URL `https://doi.org/10.1145/2470654.2466452`.

[330] A. Henderson and M. Kyng. *There's No Place like Home: Continuing Design in Use*, page 219–240. L. Erlbaum Associates Inc., USA, 1992. ISBN 0805806121.

[331] A. Henderson and M. Kyng. There's no place like home: Continuing design in use. In *Readings in Human–Computer Interaction*, pages 793–803. Elsevier, 1995.

[332] M. Hertzum. Images of usability. *Intl. Journal of Human–Computer Interaction*, 26 (6):567–600, 2010.

[333] M. Hertzum. A usability test is not an interview. *interactions*, 23(2):82–84, Feb. 2016.

[334] M. Hertzum and K. Hornbæk. Frustration: Still a Common User Experience. *ACM Transaction on Computer-Human Interaction*, 2023.

[335] M. Hertzum and J. Simonsen. Positive effects of electronic patient records on three clinical activities. *International journal of medical informatics*, 77(12):809–817, 2008.

[336] M. Hertzum, K. D. Hansen, and H. H. K. Andersen. Scrutinising usability evaluation: does thinking aloud affect behaviour and mental workload? *Behaviour & Information Technology*, 28(2):165–181, Mar. 2009.

[337] M. Hertzum, J. P. Bansler, E. C. Havn, and J. Simonsen. Pilot implementation: Learning from field tests in is development. *Communications of the Association for Information Systems*, 30(1):20, 2012.

[338] M. Hertzum, M. I. Manikas, and A. á Torkilsheyggi. Grappling with the future: The messiness of pilot implementation in information systems design. *Health Informatics Journal*, 25(2):372–388, 2019.

[339] T. T. Hewett, R. Baecker, S. Card, T. Carey, J. Gasen, M. Mantei, G. Perlman, G. Strong, and W. Verplank. *ACM SIGCHI curricula for human-computer interaction*. ACM, 1992.

[340] W. E. Hick. On the rate of gain of information. *Quarterly Journal of experimental psychology*, 4(1):11–26, 1952.

[341] D. M. Hilbert and D. F. Redmiles. Extracting usability information from user interface events. *ACM Computing Surveys (CSUR)*, 32(4):384–421, 2000.

[342] K. Hinckley, R. Pausch, J. C. Goble, and N. F. Kassell. Passive real-world interface props for neurosurgical visualization. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '94, page 452–458, New York, NY, USA, 1994. Association for Computing Machinery. ISBN 0897916506. doi: 10.1145/191666.191821. URL `https://doi.org/10.1145/191666.191821`.

[343] A. Hiniker, S. Y. Schoenebeck, and J. A. Kientz. Not at the dinner table: Parents' and children's perspectives on family technology rules. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing*, CSCW '16, page 1376–1389, New York, NY, USA, 2016. Association for Computing Machinery. ISBN 9781450335928. doi: 10.1145/2818048.2819940. URL `https://doi.org/10.1145/2818048.2819940`.

[344] T. Hirzle, F. Fischbach, J. Karlbauer, P. Jansen, J. Gugenheimer, E. Rukzio, and A. Bulling. Understanding, addressing, and analysing digital eye strain in virtual reality head-mounted displays. *ACM Trans. Comput.-Hum. Interact.*, 29(4), mar 2022. ISSN 1073-0516. doi: 10.1145/3492802. URL `https://doi.org/10.1145/3492802`.

[345] S. Hodges, L. Williams, E. Berry, S. Izadi, J. Srinivasan, A. Butler, G. Smyth, N. Kapur, and K. Wood. Sensecam: A retrospective memory aid. In *International Conference on Ubiquitous Computing*, pages 177–193. Springer, 2006.

[346] J. Hollan and S. Stornetta. Beyond being there. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 119–125, 1992.

[347] L. E. Holmquist, J. Redström, and P. Ljungstrand. Token-based access to digital information. In *International Symposium on Handheld and Ubiquitous Computing*, pages 234–245. Springer, 1999.

[348] K. Holtzblatt and H. Beyer. *Contextual design*. Morgan Kaufmann, second edition, 2017.

[349] K. Holtzblatt, J. B. Wendell, and S. Wood. *Rapid contextual design: a how-to guide to key techniques for user-centered design*. Elsevier, 2004.

[350] C. Holz and P. Baudisch. Understanding touch. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 2501–2510, 2011.

[351] J. I. Hong and J. A. Landay. Webquilt: A framework for capturing and visualizing the web experience. In *Proceedings of the 10th International Conference on World Wide Web*, WWW '01, page 717–724, New York, NY, USA, 2001. Association for Computing Machinery. ISBN 1581133480. doi: 10.1145/371920.372188. URL `https://doi.org/10.1145/371920.372188`.

[352] K. Hornbæk. Current practice in measuring usability: Challenges to usability studies and research. *International journal of human-computer studies*, 64(2):79–102, 2006.

[353] K. Hornbæk and E. Frøkjær. Comparing usability problems and redesign proposals as input to practical systems development. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 391–400, 2005.

[354] K. Hornbæk and M. Hertzum. Technology acceptance and user experience: A review of the experiential component in hci. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 24(5):1–30, 2017.

[355] K. Hornbæk and E. L.-C. Law. Meta-analysis of correlations among usability measures. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 617–626, 2007.

[356] K. Hornbæk and A. Oulasvirta. What is interaction? In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, CHI '17, page 5040–5052, New York, NY, USA, 2017. Association for Computing Machinery. ISBN 9781450346559. doi: 10.1145/3025453.3025765. URL `https://doi.org/10.1145/3025453.3025765`.

[357] K. Hornbæk et al. Some whys and hows of experiments in human–computer interaction. *Foundations and Trends® in Human–Computer Interaction*, 5(4): 299–373, 2013.

[358] E. Hornecker and J. Buur. Getting a grip on tangible interaction: a framework on physical space and social interaction. In *Proceedings of the SIGCHI conference on Human Factors in computing systems*, pages 437–446, 2006.

[359] E. Horvitz. Principles of mixed-initiative user interfaces. In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems*, pages 159–166, 1999.

[360] X. E. Hu, M. E. Whiting, and M. S. Bernstein. Can online juries make consistent, repeatable decisions? In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, pages 1–16, 2021.

[361] B. A. Huberman, P. L. Pirolli, J. E. Pitkow, and R. M. Lukose. Strong regularities in world wide web surfing. *Science*, 280(5360):95–97, 1998.

[362] Z. Hussain, W. Slany, and A. Holzinger. Current state of agile user-centered design: A survey. In *Symposium of the Austrian HCI and Usability Engineering Group*, pages 416–427. Springer, 2009.

[363] E. Hutchins. How a cockpit remembers its speeds. *Cognitive science*, 19(3):265–288, 1995.

[364] E. L. Hutchins, J. D. Hollan, and D. A. Norman. Direct manipulation interfaces. *Human–computer interaction*, 1(4):311–338, 1985.

[365] H. Hutchinson, W. Mackay, B. Westerlund, B. B. Bederson, A. Druin, C. Plaisant, M. Beaudouin-Lafon, S. Conversy, H. Evans, H. Hansen, N. Roussel, and B. Eiderbäck. Technology probes: Inspiring design for and with families. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '03, page 17–24, New York, NY, USA, 2003. Association for Computing Machinery. ISBN 1581136307. doi: 10.1145/642611.642616. URL `https://doi.org/10.1145/642611.642616`.

[366] H. Hutchinson, W. Mackay, B. Westerlund, B. B. Bederson, A. Druin, C. Plaisant, M. Beaudouin-Lafon, S. Conversy, H. Evans, H. Hansen, et al. Technology probes: inspiring design for and with families. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 17–24, 2003.

[367] E. T. Hvannberg, E. L.-C. Law, and M. K. Lérusdóttir. Heuristic evaluation: Comparing ways of finding and reporting usability problems. *Interacting with computers*, 19(2):225–240, 2007.

[368] R. Hyman. Stimulus information as a determinant of reaction time. *Journal of experimental psychology*, 45(3):188, 1953.

[369] G. Iacucci, K. Kuutti, and M. Ranta. On the move with a magic thing: Role playing in concept design of mobile services and devices. In *Proceedings of the 3rd Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques*, DIS '00, page 193–202, New York, NY, USA, 2000. Association for Computing Machinery. ISBN 1581132190. doi: 10.1145/347642.347715. URL https://doi.org/10.1145/347642.347715.

[370] T. Igarashi and K. Hinckley. Speed-dependent automatic zooming for browsing large documents. In *Proceedings of the 13th annual ACM symposium on User interface software and technology*, pages 139–148, 2000.

[371] Y. Inal, T. Clemmensen, D. Rajanen, N. Iivari, K. Rizvanoglu, and A. Sivaji. Positive developments but challenges still ahead: A survey study on ux professionals' work practices. *Journal of Usability Studies*, 15(4), 2020.

[372] S. T. Iqbal, X. S. Zheng, and B. P. Bailey. Task-evoked pupillary response to mental workload in human-computer interaction. In *CHI '04 Extended Abstracts on Human Factors in Computing Systems*, CHI EA '04, page 1477–1480, New York, NY, USA, 2004. Association for Computing Machinery. ISBN 1581137036. doi: 10.1145/985921.986094. URL https://doi.org/10.1145/985921.986094.

[373] E. Isaacs, A. Konrad, A. Walendowski, T. Lennig, V. Hollis, and S. Whittaker. Echoes from the past: How technology mediated reflection improves well-being. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '13, page 1071–1080, New York, NY, USA, 2013. Association for Computing Machinery. ISBN 9781450318990. doi: 10.1145/2470654.2466137. URL https://doi.org/10.1145/2470654.2466137.

[374] H. Ishii and B. Ullmer. Tangible bits: Towards seamless interfaces between people, bits and atoms. In *Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems*, CHI '97, page 234–241, New York, NY, USA, 1997. Association for Computing Machinery. ISBN 0897918029. doi: 10.1145/258549.258715. URL https://doi.org/10.1145/258549.258715.

[375] Iso. INTERNATIONAL ISO STANDARD 9241-210. Technical report, 2019.

[376] M. Y. Ivory and M. A. Hearst. The state of the art in automating usability evaluation of user interfaces. *ACM Comput. Surv.*, 33(4):470–516, Dec. 2001. ISSN 0360-0300. doi: 10.1145/503112.503114. URL https://doi.org/10.1145/503112.503114.

[377] S. Izadi, D. Kim, O. Hilliges, D. Molyneaux, R. Newcombe, P. Kohli, J. Shotton, S. Hodges, D. Freeman, A. Davison, et al. Kinectfusion: real-time 3d reconstruction and interaction using a moving depth camera. In *Proceedings of the 24th annual ACM symposium on User interface software and technology*, pages 559–568, 2011.

[378] J. A. Jacko and G. Salvendy. Hierarchical menu design: Breadth, depth, and task complexity. *Perceptual and Motor skills*, 82(3_suppl):1187–1201, 1996.

[379] R. J. Jacob, L. E. Sibert, D. C. McFarlane, and M. P. Mullen Jr. Integrality and separability of input devices. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 1(1):3–26, 1994.

[380] R. J. Jacob, A. Girouard, L. M. Hirshfield, M. S. Horn, O. Shaer, E. T. Solovey, and J. Zigelbaum. Reality-based interaction: a framework for post-wimp interfaces. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 201–210, 2008.

[381] N. E. Jacobsen, M. Hertzum, and B. E. John. The evaluator effect in usability tests. In *CHI 98 conference summary on Human factors in computing systems*, pages 255–256. Citeseer, 1998.

[382] L.-E. Janlert and E. Stolterman. The meaning of interactivity—some proposals for definitions and measures. *Human–Computer Interaction*, 32(3):103–138, 2017.

[383] C. P. Janssen, D. P. Brumby, and R. Garnett. Natural break points: The influence of priorities and cognitive and motor cues on dual-task interleaving. *Journal of Cognitive Engineering and Decision Making*, 6(1):5–29, 2012.

[384] Y. Jiang, L. A. Leiva, H. R. Tavakoli, P. R. B. Houssel, J. Kylmälä, and A. Oulasvirta. Ueyes: Understanding visual saliency across user interface types. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, CHI '23, New York, NY, USA, 2023. Association for Computing Machinery.

[385] G. H. J. Johannessen and K. Hornbæk. Must evaluation methods be about usability? devising and assessing the utility inspection method. *Behaviour & Information Technology*, 33(2):195–206, 2014.

[386] B. E. John and S. J. Marks. Tracking the effectiveness of usability evaluation methods. *Behaviour & Information Technology*, 16(4-5):188–202, 1997.

[387] B. E. John, K. Prevas, D. D. Salvucci, and K. Koedinger. Predictive human performance modeling made easy. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 455–462, 2004.

[388] D. Johnson, M. J. Gardner, and R. Perry. Validation of two game experience scales: the player experience of need satisfaction (pens) and game experience questionnaire (geq). *International Journal of Human-Computer Studies*, 118:38–46, 2018.

[389] J. Johnson. *Designing with the mind in mind: simple guide to understanding user interface design guidelines.* Morgan Kaufmann, 2020.

[390] J. Johnson, T. L. Roberts, W. Verplank, D. C. Smith, C. H. Irby, M. Beard, and K. Mackey. The xerox star: A retrospective. *Computer*, 22(9):11–26, 1989.

[391] J. Jokinen, A. Acharya, M. Uzair, X. Jiang, and A. Oulasvirta. Touchscreen typing as optimal supervisory control. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, pages 1–14, 2021.

[392] J. P. Jokinen, Z. Wang, S. Sarcar, A. Oulasvirta, and X. Ren. Adaptive feature guidance: Modelling visual search with graphical layouts. *International Journal of Human-Computer Studies*, 136:102376, 2020.

[393] W. P. Jones and S. T. Dumais. The spatial metaphor for user interfaces: Experimental tests of reference by location versus name. *ACM Trans. Inf. Syst.*, 4(1):42–63, jan 1986. ISSN 1046-8188. doi: 10.1145/5401.5405. URL `https://doi.org/10.1145/5401.5405`.

[394] S. Jordà, G. Geiger, M. Alonso, and M. Kaltenbrunner. The reactable: exploring the synergy between live music performance and tabletop tangible interfaces. In *Proceedings of the 1st international conference on Tangible and embedded interaction*, pages 139–146, 2007.

[395] P. W. Jordan. *Designing pleasurable products: An introduction to the new human factors.* CRC press, 2000.

[396] S. Jörg, A. Normoyle, and A. Safonova. How responsiveness affects players' perception in digital games. In *Proceedings of the ACM symposium on applied perception*, pages 33–38, 2012.

[397] W. Jorritsma, P.-J. Haga, F. Cnossen, R. A. Dierckx, M. Oudkerk, and P. M. van Ooijen. Predicting human performance differences on multiple interface alternatives: Klm, goms and cogtool are unreliable. *Procedia Manufacturing*, 3:3725–3731, 2015.

[398] S. Jul and G. W. Furnas. Critical zones in desert fog: aids to multiscale navigation. In *Proceedings of the 11th annual ACM symposium on User interface software and technology*, pages 97–106, 1998.

[399] S.-G. Jung, J. An, H. Kwak, M. Ahmad, L. Nielsen, and B. J. Jansen. Persona generation from aggregated social media data. In *Proceedings of the 2017 CHI conference extended abstracts on human factors in computing systems*, pages 1748–1755, 2017.

[400] D. Kahneman. *Thinking, fast and slow.* Macmillan, 2011.

[401] D. Kahneman and J. Riis. Living, and thinking about it: Two perspectives on life. *The science of well-being*, 1:285–304, 2005.

[402] D. Kahneman and A. Tversky. Prospect theory: An analysis of decision under risk. In *Handbook of the fundamentals of financial decision making: Part I*, pages 99–127. World Scientific, 2013.

[403] E. Karapanos, J. Zimmerman, J. Forlizzi, and J.-B. Martens. User experience over time: An initial framework. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '09, page 729–738, New York, NY, USA, 2009. Association for Computing Machinery. ISBN 9781605582467. doi: 10.1145/1518701.1518814. URL `https://doi.org/10.1145/1518701.1518814`.

[404] M. Kavakli and J. S. Gero. Sketching as mental imagery processing. *Design studies*, 22(4):347–364, 2001.

[405] J. Kawakita. The original kj method. *Tokyo: Kawakita Research Institute*, 5, 1991.

[406] M. Kawato. Internal models for motor control and trajectory planning. *Current opinion in neurobiology*, 9(6):718–727, 1999.

[407] A. Kay and A. Goldberg. Personal dynamic media. *Computer*, 10(3):31–41, 1977.

[408] C. R. Kelley. Manual control: Theory and applications. Technical report, United States Office of Naval Research, 1964.

[409] F. Kensing and J. Blomberg. Participatory design: Issues and concerns. *Computer supported cooperative work (CSCW)*, 7(3-4):167–185, 1998.

[410] F. Kensing and H. Madsen. Generating visions: future workshops and metaphorical. In *Design at work*, pages 155–168. CRC Press, 2020.

[411] D. Kieras, D. Meyer, and J. Ballas. Towards demystification of direct manipulation: Cognitive modeling charts the gulf of execution. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 128–135, 2001.

[412] D. E. Kieras and A. J. Hornof. Towards accurate and practical predictive models of active-vision-based visual search. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 3875–3884, 2014.

[413] S. Kiesler, D. Zubrow, A. M. Moses, and V. Geller. Affect in computer-meditated communication: An experiment in synchronous terminal-to-terminal discussion. *Human-Computer Interaction*, 1(1):77–104, 1985.

[414] D. Kirk, A. Sellen, C. Rother, and K. Wood. Understanding photowork. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '06, page 761–770, New York, NY, USA, 2006. Association for Computing Machinery. ISBN 1595933727. doi: 10.1145/1124772.1124885. URL `https://doi.org/10.1145/1124772.1124885`.

[415] D. Kirsh. Interactivity and multimedia interfaces. *Instructional Science*, 25(2): 79–96, 1997.

[416] D. Kirsh and P. Maglio. On distinguishing epistemic from pragmatic action. *Cognitive science*, 18(4):513–549, 1994.

[417] A. Kittur, E. H. Chi, and B. Suh. Crowdsourcing user studies with mechanical turk. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 453–456, 2008.

[418] J. Kjeldskov and M. B. Skov. Was it worth the hassle? ten years of mobile hci research discussions on lab and field evaluations. In *Proceedings of the 16th international conference on Human-computer interaction with mobile devices & services*, pages 43–52, 2014.

[419] J. Kjeldskov, M. B. Skov, B. S. Als, and R. T. Høegh. Is it worth the hassle? exploring the added value of evaluating the usability of context-aware mobile systems in the field. In *International Conference on Mobile Human-Computer Interaction*, pages 61–73. Springer, 2004.

[420] R. Kling. The organizational context of user-centered software designs. *MIS quarterly*, pages 41–52, 1977.

[421] D. C. Knill and A. Pouget. The bayesian brain: the role of uncertainty in neural coding and computation. *TRENDS in Neurosciences*, 27(12):712–719, 2004.

[422] J. Koch, M. Laszlo, A. Lucero, and A. Oulasvirta. Surfing for inspiration: digital inspirational material in design practice. In *Design Research Society International Conference*, pages 1247–1260. Design Research Society, 2018.

[423] M. Koelle, A. El Ali, V. Cobus, W. Heuten, and S. C. Boll. All about acceptability? identifying factors for the adoption of data glasses. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, pages 295–300, 2017.

[424] M. Koelle, S. Ananthanarayan, and S. Boll. Social acceptability in hci: A survey of methods, measures, and design strategies. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, CHI '20, page 1–19, New York, NY, USA, 2020. Association for Computing Machinery. ISBN 9781450367080. doi: 10.1145/3313831.3376162. URL `https://doi.org/10.1145/3313831.3376162`.

[425] R. Kohavi, R. M. Henne, and D. Sommerfield. Practical guide to controlled experiments on the web: listen to your customers not to the hippo. In *Proceedings of the 13th ACM SIGKDD international conference on Knowledge discovery and data mining*, pages 959–967. ACM, 2007.

[426] J. Kolko. Abductive thinking and sensemaking: The drivers of design synthesis. *Design issues*, 26(1):15–28, 2010.

[427] G. Kotonya and I. Sommerville. *Requirements engineering: processes and techniques*. Wiley Publishing, 1998.

[428] Y. Kou and X. Gui. Playing with strangers: understanding temporary teams in league of legends. In *Proceedings of the first ACM SIGCHI annual symposium on Computer-human interaction in play*, pages 161–169, 2014.

[429] A. D. Kramer, J. E. Guillory, and J. T. Hancock. Experimental evidence of massive-scale emotional contagion through social networks. *Proceedings of the National Academy of Sciences*, 111(24):8788–8790, 2014.

[430] L. Kraus, I. Wechsung, and S. Möller. Psychological needs as motivators for security and privacy actions on smartphones. *Journal of Information Security and Applications*, 34:34–45, 2017.

[431] K. Krippendorff. *Content analysis: An introduction to its methodology.* Sage publications, 2018.

[432] P. O. Kristensson. Next-generation text entry. *Computer*, 48(07):84–87, 2015.

[433] P. O. Kristensson. Statistical language processing for text entry. In A. Oulasvirta, P. O. Kristensson, X. Bi, and A. Howes, editors, *Computational Interaction*, pages 41–61. Oxford University Press, Oxford, 2018.

[434] P. O. Kristensson and T. Müllners. Design and analysis of intelligent text entry systems with function structure models and envelope analysis. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, pages 1–12, 2021.

[435] P. O. Kristensson and K. Vertanen. The potential of dwell-free eye-typing for fast assistive gaze communication. In *Proceedings of the symposium on eye tracking research and applications*, pages 241–244, 2012.

[436] S. Krug. Dont make me think: a common sense approach to usability testing. *New Riders, Berkeley*, 2005.

[437] S. Kujala. User involvement: a review of the benefits and challenges. *Behaviour & information technology*, 22(1):1–16, 2003.

[438] S. Kujala, V. Roto, K. Väänänen-Vainio-Mattila, E. Karapanos, and A. Sinnelä. Ux curve: A method for evaluating long-term user experience. *Interacting with computers*, 23(5):473–483, 2011.

[439] A. Kumar and T. Gilovich. Some "thing" to talk about? differential story utility from experiential and material purchases. *Personality and Social Psychology Bulletin*, 41 (10):1320–1331, 2015.

[440] N. Kumar, N. Jafarinaimi, and M. Bin Morshed. Uber in bangladesh: The tangled web of mobility and justice. *Proceedings of the ACM on Human-Computer Interaction*, 2(CSCW):1–21, 2018.

[441] V. Kumar and P. Whitney. Faster, cheaper, deeper user research. *Design Management Journal (Former Series)*, 14(2):50–57, 2003.

[442] G. Kurtenbach and W. Buxton. User learning and performance with marking menus. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 258–264, 1994.

[443] K. Kuutti and L. J. Bannon. The turn to practice in hci: towards a research agenda. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 3543–3552, 2014.

[444] K. Kuutti et al. Activity theory as a potential framework for human-computer interaction research. *Context and consciousness: Activity theory and human-computer interaction*, 1744, 1996.

[445] S. Kvale. *Doing interviews.* Sage, 2008.

[446] M. Kyng. Designing for a dollar a day. In *Proceedings of the 1988 ACM conference on Computer-supported cooperative work*, pages 178–188, 1988.

[447] C. Lampe, N. B. Ellison, and C. Steinfield. Changes in use and perception of facebook. In *Proceedings of the 2008 ACM Conference on Computer Supported Cooperative Work*, CSCW '08, page 721–730, New York, NY, USA, 2008. Association for Computing Machinery. ISBN 9781605580074. doi: 10.1145/1460563.1460675. URL `https://doi.org/10.1145/1460563.1460675`.

[448] T. Landauer. Research methods in human-computer interaction. In *Handbook of human-computer interaction*, pages 203–227. Elsevier, second edition, 1997.

[449] T. K. Landauer. Let's get real: a position paper on the role of cognitive psychology in the design of humanly useful and usable systems. In *Readings in Human–Computer Interaction*, pages 659–665. Elsevier, 1995.

[450] T. K. Landauer. *The trouble with computers: Usefulness, usability, and productivity.* MIT press, 1995.

[451] N. D. Lane, E. Miluzzo, H. Lu, D. Peebles, T. Choudhury, and A. T. Campbell. A survey of mobile phone sensing. *IEEE Communications Magazine*, 48(9):140–150, 2010. doi: 10.1109/MCOM.2010.5560598.

[452] R. Langevin, R. J. Lordon, T. Avrahami, B. R. Cowan, T. Hirsch, and G. Hsieh. Heuristic evaluation of conversational agents. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, pages 1–15, 2021.

[453] K. R. Larsen and C. H. Bong. A tool for addressing construct identity in literature reviews and meta-analyses. *MIS Q.*, 40(3):529–551, Sept. 2016. ISSN 0276-7783. doi: 10.25300/MISQ/2016/40.3.01. URL `https://doi.org/10.25300/MISQ/2016/40.3.01`.

[454] J. Lave and E. Wenger. *Situated learning: Legitimate peripheral participation.* Cambridge university press, 1991.

[455] T. Lavie and N. Tractinsky. Assessing dimensions of perceived visual aesthetics of web sites. *International journal of human-computer studies*, 60(3):269–298, 2004.

[456] E. L.-C. Law, V. Roto, M. Hassenzahl, A. P. Vermeeren, and J. Kort. Understanding, scoping and defining user experience: a survey approach. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 719–728, 2009.

[457] E. L.-C. Law, F. Brühlmann, and E. D. Mekler. Systematic review and validation of the game experience questionnaire (geq) - implications for citation and reporting practice. In *Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play*, CHI PLAY '18, pages 257–270, New York, NY, USA, 2018. ACM. ISBN 978-1-4503-5624-4. doi: 10.1145/3242671.3242683. URL `http://doi.acm.org/10.1145/3242671.3242683`.

[458] H. J. Leavitt. *Managerial psychology.* Chicago University of Chicago Press, 1978.

[459] S. J. Lederman and R. L. Klatzky. Hand movements: A window into haptic object recognition. *Cognitive psychology*, 19(3):342–368, 1987.

[460] H. Ledgard, J. A. Whiteside, A. Singer, and W. Seymour. The natural language of interactive systems. *Communications of the ACM*, 23(10):556–563, 1980.

[461] B. Lee, S. Kim, A. Oulasvirta, J.-I. Lee, and E. Park. Moving target selection: A cue integration model. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, pages 1–12, 2018.

[462] C. P. Lee and D. Paine. From the matrix to a model of coordinated action (moca) a conceptual framework of and for cscw. In *Proceedings of the 18th ACM conference on computer supported cooperative work & social computing*, pages 179–194, 2015.

[463] K. J. Lee, W. Roldan, T. Q. Zhu, H. Kaur Saluja, S. Na, B. Chin, Y. Zeng, J. H. Lee, and J. Yip. The show must go on: A conceptual model of conducting synchronous participatory design with children online. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, CHI '21, New York, NY, USA, 2021. Association for Computing Machinery. ISBN 9781450380966. doi: 10.1145/3411764.3445715. URL `https://doi.org/10.1145/3411764.3445715`.

[464] Y.-K. Lee, C.-T. Chang, Y. Lin, and Z.-H. Cheng. The dark side of smartphone usage: Psychological traits, compulsive behavior and technostress. *Computers in human behavior*, 31:373–383, 2014.

[465] L. A. Leiva, Y. Xue, A. Bansal, H. R. Tavakoli, T. Köroðlu, J. Du, N. R. Dayama, and A. Oulasvirta. Understanding visual saliency in mobile user interfaces. In *22nd International Conference on Human-Computer Interaction with Mobile Devices and Services*, pages 1–12, 2020.

[466] C. Lewis. *Using the" thinking-aloud" method in cognitive interface design.* IBM TJ Watson Research Center Yorktown Heights, NY, 1982.

[467] C. Lewis, P. G. Polson, C. Wharton, and J. Rieman. Testing a walkthrough methodology for theory-based design of walk-up-and-use interfaces. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 235–242, 1990.

[468] R. L. Lewis, A. Howes, and S. Singh. Computational rationality: Linking mechanism and behavior through bounded utility maximization. *Topics in cognitive science*, 6 (2):279–311, 2014.

[469] J. C. R. Licklider and W. E. Clark. On-line man-computer communication. In *Proceedings of the May 1-3, 1962, Spring Joint Computer Conference*, AIEE-IRE '62 (Spring), page 113–128, New York, NY, USA, 1962. Association for Computing Machinery. ISBN 9781450378758. doi: 10.1145/1460833.1460847. URL `https://doi.org/10.1145/1460833.1460847`.

[470] W. Lidwell, K. Holden, and J. Butler. *Universal principles of design, revised and updated: 125 ways to enhance usability, influence perception, increase appeal, make better design decisions, and teach through design*. Rockport Pub, 2010.

[471] H. Lieberman. An example based environment for beginning programmers. *Instructional Science*, 14(3):277–292, 1986.

[472] F. Lieder and T. L. Griffiths. Resource-rational analysis: Understanding human cognition as the optimal use of limited computational resources. *Behavioral and brain sciences*, 43, 2020.

[473] J. Liedtka. Perspective: Linking design thinking with innovation outcomes through cognitive bias reduction. *Journal of product innovation management*, 32(6):925–938, 2015.

[474] Y.-k. Lim, S.-S. Lee, and K.-y. Lee. Interactivity attributes: a new way of thinking and describing interactivity. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 105–108, 2009.

[475] Y. S. Lincoln and E. G. Cuba. The only generalization is: There is no generalization. *Case Study Method: Key Issues, Key Texts*, page 27, 2000.

[476] J. K. Lindstedt and W. D. Gray. Distinguishing experts from novices by the mind's hand and mind's eye. *Cognitive psychology*, 109:1–25, 2019.

[477] S. Lindtner, G. D. Hertz, and P. Dourish. Emerging sites of hci innovation: hackerspaces, hardware startups & incubators. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 439–448, 2014.

[478] E. Litt, E. Spottswood, J. Birnholtz, J. T. Hancock, M. E. Smith, and L. Reynolds. Awkward encounters of an "other" kind: Collective self-presentation and face threat on facebook. In *Proceedings of the 17th ACM Conference on Computer Supported Cooperative Work and Social Computing*, CSCW '14, page 449–460, New York,

NY, USA, 2014. Association for Computing Machinery. ISBN 9781450325400. doi: 10.1145/2531602.2531646. URL `https://doi.org/10.1145/2531602.2531646`.

[479] V. Liu and L. B. Chilton. Design guidelines for prompt engineering text-to-image generative models. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*, CHI '22, New York, NY, USA, 2022. Association for Computing Machinery. ISBN 9781450391573. doi: 10.1145/3491102.3501825. URL `https://doi.org/10.1145/3491102.3501825`.

[480] W. Liu, R. L. d'Oliveira, M. Beaudouin-Lafon, and O. Rioul. Bignav: Bayesian information gain for guiding multiscale navigation. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, pages 5869–5880, 2017.

[481] W. Liu, J. Gori, O. Rioul, M. Beaudouin-Lafon, and Y. Guiard. How relevant is hick's law for hci? In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, pages 1–11, 2020.

[482] S. Ljungblad, Y. Man, M. A. Baytaş, M. Gamboa, M. Obaid, and M. Fjeld. What matters in professional drone pilots' practice? an interview study to understand the complexity of their work and inform human-drone interaction research. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, pages 1–16, 2021.

[483] D. Lockton, D. Harrison, and N. A. Stanton. Exploring design patterns for sustainable behaviour. *The Design Journal*, 16(4):431–459, 2013.

[484] D. Lockton, D. Singh, S. Sabnis, M. Chou, S. Foley, and A. Pantoja. New metaphors: A workshop method for generating ideas and reframing problems in design and beyond. In *Proceedings of the 2019 on Creativity and Cognition*, pages 319–332. 2019.

[485] J. Lofland and L. H. Lofland. Analyzing social settings. 1971.

[486] G. L. Lohse and E. J. Johnson. A comparison of two process tracing methods for choice tasks. *Organizational Behavior and Human Decision Processes*, 68(1):28–43, 1996.

[487] D. M. Lottridge, C. Rosakranse, C. S. Oh, S. J. Westwood, K. A. Baldoni, A. S. Mann, and C. I. Nass. The effects of chronic multitasking on analytical writing. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, pages 2967–2970, 2015.

[488] A. Lucero. Using affinity diagrams to evaluate interactive prototypes. In J. Abascal, S. Barbosa, M. Fetter, T. Gross, P. Palanque, and M. Winckler, editors, *Human-Computer Interaction – INTERACT 2015*, pages 231–248, Cham, 2015. Springer International Publishing. ISBN 978-3-319-22668-2.

[489] E. Luger and A. Sellen. "like having a really bad pa": The gulf between user expectation and experience of conversational agents. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, CHI '16, page 5286–5297, New York, NY, USA, 2016. Association for Computing Machinery. ISBN 9781450333627. doi: 10.1145/2858036.2858288. URL `https://doi.org/10.1145/2858036.2858288`.

[490] J. Lundberg, A. Ibrahim, D. Jönsson, S. Lindquist, and P. Qvarfordt. " the snatcher catcher" an interactive refrigerator. In *Proceedings of the second Nordic conference on Human-computer interaction*, pages 209–212, 2002.

[491] U. Lyngs, K. Lukoff, P. Slovak, R. Binns, A. Slack, M. Inzlicht, M. Van Kleek, and N. Shadbolt. Self-control in cyberspace: Applying dual systems theory to a review of digital self-control tools. In *proceedings of the 2019 CHI conference on human factors in computing systems*, pages 1–18, 2019.

[492] K. Mack, E. McDonnell, D. Jain, L. Lu Wang, J. E. Froehlich, and L. Findlater. What do we mean by "accessibility research"? a literature survey of accessibility papers in chi and assets from 1994 to 2019. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, pages 1–18, 2021.

[493] R. L. Mack, C. H. Lewis, and J. M. Carroll. Learning to use word processors: Problems and prospects. *ACM Trans. Inf. Syst.*, 1(3):254–271, July 1983. ISSN 1046-8188. doi: 10.1145/357436.357440. URL `https://doi.org/10.1145/357436.357440`.

[494] D. J. MacKay, C. J. Ball, and M. Donegan. Efficient communication with one or two buttons. In *AIP Conference Proceedings*, volume 735, pages 207–218. AIP, 2004.

[495] W. E. Mackay. Triggers and barriers to customizing software. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '91, page 153–160, New York, NY, USA, 1991. Association for Computing Machinery. ISBN 0897913833. doi: 10.1145/108844.108867. URL `https://doi.org/10.1145/108844.108867`.

[496] W. E. MacKay. Is paper safer? the role of paper flight strips in air traffic control. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 6(4):311–340, 1999.

[497] I. S. MacKenzie. Fitts' law as a research and design tool in human-computer interaction. *Human-computer interaction*, 7(1):91–139, 1992.

[498] I. S. MacKenzie and W. Buxton. Extending fitts' law to two-dimensional tasks. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 219–226, 1992.

[499] I. S. MacKenzie and R. W. Soukoreff. Card, english, and burr (1978): 25 years later. In *CHI '03 Extended Abstracts on Human Factors in Computing Systems*, CHI EA '03, pages 760–761, New York, NY, USA, 2003. ACM. ISBN 1-58113-637-4. doi: 10.1145/765891.765974. URL `http://doi.acm.org/10.1145/765891.765974`.

[500] A. MacLean, R. M. Young, V. M. Bellotti, and T. P. Moran. Questions, options, and criteria: Elements of design space analysis. *Human–computer interaction*, 6 (3-4):201–250, 1991.

[501] R. Mahajan and B. Shneiderman. Visual and textual consistency checking tools for graphical user interfaces. *IEEE Transactions on Software Engineering*, 23(11): 722–735, 1997.

[502] T. Mahatody, M. Sagar, and C. Kolski. State of the art on the cognitive walkthrough method, its variants and evolutions. *Intl. Journal of Human–Computer Interaction*, 26(8):741–785, 2010.

[503] M. L. Maher, J. Poon, and S. Boulanger. Formalising design exploration as co-evolution. In *Advances in formal design methods for CAD*, pages 3–30. Springer, 1996.

[504] M. A. Makary and M. Daniel. Medical error—the third leading cause of death in the us. *Bmj*, 353, 2016.

[505] R. Mancini, A. Dix, and S. Levialdi. Reflections on undo. *University of Rome*, 1996.

[506] J. Mankoff, A. K. Dey, G. Hsieh, J. Kientz, S. Lederer, and M. Ames. Heuristic evaluation of ambient displays. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '03, page 169–176, New York, NY, USA, 2003. Association for Computing Machinery. ISBN 1581136307. doi: 10.1145/642611.642642. URL https://doi.org/10.1145/642611.642642.

[507] J. Mankoff, A. K. Dey, G. Hsieh, J. Kientz, S. Lederer, and M. Ames. Heuristic evaluation of ambient displays. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 169–176, 2003.

[508] A. Mannocci, F. Osborne, and E. Motta. The evolution of ijhcs and chi: A quantitative analysis. *International Journal of Human-Computer Studies*, 131: 23–40, 2019.

[509] A. Markussen, M. R. Jakobsen, and K. Hornbæk. Selection-based mid-air text entry on large displays. In *Human-Computer Interaction–INTERACT 2013: 14th IFIP TC 13 International Conference, Cape Town, South Africa, September 2-6, 2013, Proceedings, Part I 14*, pages 401–418. Springer, 2013.

[510] N. Marquardt, R. Diaz-Marino, S. Boring, and S. Greenberg. The proximity toolkit: Prototyping proxemic interactions in ubiquitous computing ecologies. In *Proceedings of the 24th Annual ACM Symposium on User Interface Software and Technology*, UIST '11, page 315–326, New York, NY, USA, 2011. Association for Computing Machinery. ISBN 9781450307161. doi: 10.1145/2047196.2047238. URL https://doi.org/10.1145/2047196.2047238.

[511] J. Marshall, C. Linehan, J. Spence, and S. Rennick Egglestone. Throwaway citation of prior work creates risk of bad hci research. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, pages 827–836, 2017.

[512] P. Masci, A. Ayoub, P. Curzon, M. D. Harrison, I. Lee, and H. Thimbleby. Verification of interactive software for medical devices: Pca infusion pumps and fda regulation as an example. In *Proceedings of the 5th ACM SIGCHI symposium on Engineering interactive computing systems*, pages 81–90, 2013.

[513] A. H. Maslow. A theory of human motivation. *Psychological review*, 50(4):370, 1943.

[514] T. H. Massie, J. K. Salisbury, et al. The phantom haptic interface: A device for probing virtual objects. In *Proceedings of the ASME winter annual meeting, symposium on haptic interfaces for virtual environment and teleoperator systems*, volume 55, pages 295–300. Chicago, IL, 1994.

[515] A. Mathur, G. Acar, M. J. Friedman, E. Lucherini, J. Mayer, M. Chetty, and A. Narayanan. Dark patterns at scale: Findings from a crawl of 11k shopping websites. *Proc. ACM Hum.-Comput. Interact.*, 3(CSCW), nov 2019. doi: 10.1145/3359183. URL https://doi.org/10.1145/3359183.

[516] T. Matthews, A. K. Dey, J. Mankoff, S. Carter, and T. Rattenbury. A toolkit for managing user attention in peripheral displays. In *Proceedings of the 17th Annual ACM Symposium on User Interface Software and Technology*, UIST '04, page 247–256, New York, NY, USA, 2004. Association for Computing Machinery. ISBN 1581139578. doi: 10.1145/1029632.1029676. URL https://doi.org/10.1145/1029632.1029676.

[517] D. L. Maulsby and I. H. Witten. Inducing programs in a direct-manipulation environment. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 57–62, 1989.

[518] R. E. Mayer and J. K. Gallini. When is an illustration worth ten thousand words? *Journal of educational psychology*, 82(4):715, 1990.

[519] E. Mayo. *The human problems of an industrial civilization.* 1933.

[520] J. McCarthy and P. Wright. *Technology as experience.* MIT Press, 2004.

[521] N. McDonald, S. Schoenebeck, and A. Forte. Reliability and inter-rater reliability in qualitative research: Norms and guidelines for cscw and hci practice. *Proceedings of the ACM on Human-Computer Interaction*, 3(CSCW):1–23, 2019.

[522] J. E. McGrath. *Groups: Interaction and performance*, volume 14. Prentice-Hall Englewood Cliffs, NJ, 1984.

[523] J. E. McGrath. Methodology matters: Doing research in the behavioral and social sciences. In *Readings in Human–Computer Interaction*, pages 152–169. Elsevier, 1995.

[524] R. McKinlay. Technology: Use or lose our navigation skills. *Nature*, 531(7596): 573–575, 2016.

[525] D. McMillan, A. Morrison, O. Brown, M. Hall, and M. Chalmers. Further into the wild: Running worldwide trials of mobile systems. In *International Conference on Pervasive Computing*, pages 210–227. Springer, 2010.

[526] M. C. Medlock, D. Wixon, M. Terrano, R. Romero, and B. Fulton. Using the rite method to improve products: A definition and a case study. *Usability Professionals Association*, 51:1963813932–1562338474, 2002.

[527] C. Mendez, L. Letaw, M. Burnett, S. Stumpf, A. Sarma, and C. Hilderbrand. From gendermag to inclusivemag: An inclusive design meta-method. In *2019 IEEE Symposium on Visual Languages and Human-Centric Computing (VL/HCC)*, pages 97–106. IEEE, 2019.

[528] H. M. Mentis. Collocated use of imaging systems in coordinated surgical practice. *Proceedings of the ACM on Human-Computer Interaction*, 1(CSCW):1–17, 2017.

[529] J. Meredith. Conversation analysis and online interaction. *Research on Language and Social Interaction*, 52(3):241–256, 2019.

[530] D. E. Meyer, R. A. Abrams, S. Kornblum, C. E. Wright, and J. Keith Smith. Optimality in human motor performance: ideal control of rapid aimed movements. *Psychological review*, 95(3):340, 1988.

[531] L. Micallef, G. Palmas, A. Oulasvirta, and T. Weinkauf. Towards perceptual optimization of the visual design of scatterplots. *IEEE transactions on visualization and computer graphics*, 23(6):1588–1599, 2017.

[532] P. Micheli, S. J. Wilner, S. H. Bhatti, M. Mura, and M. B. Beverland. Doing design thinking: Conceptual review, synthesis, and research agenda. *Journal of Product Innovation Management*, 36(2):124–148, 2019.

[533] E. Miguel, C. Camerer, K. Casey, J. Cohen, K. M. Esterling, A. Gerber, R. Glennerster, D. P. Green, M. Humphreys, G. Imbens, et al. Promoting transparency in social science research. *Science*, 343(6166):30–31, 2014.

[534] P. Milgram and F. Kishino. A taxonomy of mixed reality visual displays. *IEICE TRANSACTIONS on Information and Systems*, 77(12):1321–1329, 1994.

[535] P. Milgram, H. Takemura, A. Utsumi, and F. Kishino. Augmented reality: A class of displays on the reality-virtuality continuum. In *Telemanipulator and telepresence technologies*, volume 2351, pages 282–292. International Society for Optics and Photonics, 1995.

[536] D. R. Millen. Rapid ethnography: time deepening strategies for hci field research. In *Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques*, pages 280–286, 2000.

[537] D. P. Miller. The depth/breadth tradeoff in hierarchical computer menus. In *Proceedings of the Human Factors Society Annual Meeting*, volume 25, pages 296–300. SAGE Publications Sage CA: Los Angeles, CA, 1981.

[538] H. Mintzberg. Structured observation as a method to study managerial work. *Journal of management studies*, 7(1):87–104, 1970.

[539] R. K. Mitchell, B. R. Agle, and D. J. Wood. Toward a theory of stakeholder identification and salience: Defining the principle of who and what really counts. *Academy of management review*, 22(4):853–886, 1997.

[540] B. Moggridge and B. Atkinson. *Designing interactions*, volume 17. MIT press Cambridge, MA, 2007.

[541] R. Molich. Are usability evaluations reproducible? *Interactions*, 25(6):82–85, oct 2018. ISSN 1072-5520. doi: 10.1145/3278154. URL `https://doi.org/10.1145/3278154`.

[542] R. Molich. Are usability evaluations reproducible? *Interactions*, 25(6):82–85, 2018.

[543] R. Molich and J. Nielsen. Improving a human-computer dialogue. *Communications of the ACM*, 33(3):338–348, 1990.

[544] J. P. Monat and T. F. Gannon. Applying systems thinking to engineering and design. *Systems*, 6(3):34, 2018.

[545] A. Monk and S. Howard. Methods & tools: the rich picture: a tool for reasoning about work context. *interactions*, 5(2):21–30, 1998.

[546] A. Mørch. Three levels of end-user tailoring: Customization, integration, and extension. *Computers and design in context*, pages 51–76, 1997.

[547] M. Moshagen and M. T. Thielsch. Facets of visual aesthetics. *International journal of human-computer studies*, 68(10):689–709, 2010.

[548] A. Mottelson, J. Knibbe, and K. Hornbæk. Veritaps: Truth estimation from mobile interaction. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, CHI '18, page 1–12, New York, NY, USA, 2018. Association for Computing Machinery. ISBN 9781450356206. doi: 10.1145/3173574.3174135. URL `https://doi.org/10.1145/3173574.3174135`.

[549] G. Mowbray and M. Rhoades. On the reduction of choice reaction times with practice. *Quarterly Journal of Experimental Psychology*, 11(1):16–23, 1959.

[550] F. F. Mueller, P. Lopes, P. Strohmeier, W. Ju, C. Seim, M. Weigel, S. Nanayakkara, M. Obrist, Z. Li, J. Delfa, et al. Next steps for human-computer integration. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, pages 1–15, 2020.

[551] G. Müller and M. Möser. *Handbook of engineering acoustics.* Springer Science & Business Media, 2012.

[552] H. Müller, A. Sedley, and E. Ferrall-Nunge. Survey research in hci. In *Ways of Knowing in HCI*, pages 229–266. Springer, 2014.

[553] M. R. Munafò and G. D. Smith. Robust research needs many lines of evidence, 2018.

[554] T. Munzner. Process and pitfalls in writing information visualization research papers. In *Information visualization*, pages 134–153. Springer, 2008.

[555] T. Munzner. *Visualization analysis and design.* CRC press, 2014.

[556] R. Murray-Smith, A. Oulasvirta, A. Howes, J. Müller, A. Ikkala, M. Bachinski, A. Fleig, F. Fischer, and M. Klar. What simulation can do for hci research. *Interactions*, 29(6):48–53, 2022.

[557] B. A. Myers. Uimss, toolkits, interface builders. *Human Computer Interaction Institute, Carnegie Mellon University*, 1996.

[558] B. A. Myers. A brief history of human-computer interaction technology. *interactions*, 5(2):44–54, 1998.

[559] B. A. Myers and M. B. Rosson. Survey on user interface programming. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 195–202, 1992.

[560] B. A. Myers and J. Stylos. Improving api usability. *Communications of the ACM*, 59(6):62–69, 2016.

[561] B. A. Myers, R. G. McDaniel, R. C. Miller, A. S. Ferrency, A. Faulring, B. D. Kyle, A. Mickish, A. Klimovitski, and P. Doane. The amulet environment: New models for effective user interface software development. *IEEE Transactions on software engineering*, 23(6):347–365, 1997.

[562] M. A. Nacenta, Y. Kamber, Y. Qiang, and P. O. Kristensson. Memorability of pre-designed and user-defined gesture sets. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 1099–1108, 2013.

[563] K. Z. Naqshbandi, C. Liu, S. Taylor, R. Lim, N. Ahmadpour, and R. Calvo. "i am most grateful." using gratitude to improve the sense of relatedness and motivation for online volunteerism. *International Journal of Human–Computer Interaction*, 36 (14):1325–1341, 2020.

[564] S. Narayan, J. Orlowitz, J. Morgan, B. M. Hill, and A. Shaw. The wikipedia adventure: field evaluation of an interactive tutorial for new users. In *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing*, pages 1785–1799, 2017.

[565] B. A. Nardi and J. R. Miller. Twinkling lights and nested loops: distributed problem solving and spreadsheet development. *International Journal of Man-Machine Studies*, 34(2):161–184, 1991.

[566] B. A. Nardi, S. Whittaker, and E. Bradner. Interaction and outeraction: Instant messaging in action. In *Proceedings of the 2000 ACM conference on Computer supported cooperative work*, pages 79–88, 2000.

[567] C. Nass, J. Steuer, and E. R. Tauber. Computers are social actors. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 72–78, 1994.

[568] C. Nass, Y. Moon, B. J. Fogg, B. Reeves, and C. Dryer. Can computer personalities be human personalities? In *Conference Companion on Human Factors in Computing Systems*, CHI '95, pages 228–229, New York, NY, USA, 1995. ACM. ISBN 0-89791-755-3. doi: 10.1145/223355.223538. URL `http://doi.acm.org/10.1145/223355.223538`.

[569] P. Naur. *Computing: a human activity*. ACM, 1992.

[570] A. B. Neang, W. Sutherland, M. W. Beach, and C. P. Lee. Data integration as coordination: The articulation of data work in an ocean science collaboration. *Proceedings of the ACM on Human-Computer Interaction*, 4(CSCW3):1–25, 2021.

[571] M. Nebeling, M. Speicher, and M. Norrie. W3touch: Metrics-based web page adaptation for touch. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '13, page 2311–2320, New York, NY, USA, 2013. Association for Computing Machinery. ISBN 9781450318990. doi: 10.1145/2470654.2481319. URL `https://doi.org/10.1145/2470654.2481319`.

[572] T. H. Nelson. Complex information processing: a file structure for the complex, the changing and the indeterminate. In *Proceedings of the 1965 20th national conference*, pages 84–100, 1965.

[573] A. Newell, H. A. Simon, et al. *Human problem solving*, volume 104. Prentice-hall Englewood Cliffs, NJ, 1972.

[574] W. M. Newman and A. S. Taylor. Towards a methodology employing critical parameters to deliver performance improvements in interactive systems. In *INTERACT*, volume 99, pages 605–612. Citeseer, 1999.

[575] R. S. Nickerson. Man-computer interaction: A challenge for human factors research. *Ergonomics*, 12(4):501–517, 1969. doi: 10.1080/00140136908931076. URL `https://doi.org/10.1080/00140136908931076`. PMID: 5823965.

[576] J. Nielsen. Noncommand user interfaces. *Communications of the ACM*, 36(4):83–99, 1993.

[577] J. Nielsen. *Usability engineering.* Morgan Kaufmann, 1994.

[578] J. Nielsen and J. Levy. Measuring usability: preference vs. performance. *Communications of the ACM*, 37(4):66–75, 1994.

[579] J. Nielsen and R. Molich. Heuristic evaluation of user interfaces. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 249–256, 1990.

[580] L. Nielsen. *Personas-user focused design*, volume 1373. Springer, 2013.

[581] M. Nørgaard and K. Hornbæk. What do usability evaluators do in practice? an explorative study of think-aloud testing. In *Proceedings of the 6th conference on Designing Interactive systems*, pages 209–218, 2006.

[582] D. A. Norman. Errors in human performance. Technical report, California Univ San Diego LA JOLLA Center For Human Information Processing, 1980.

[583] D. A. Norman. Design rules based on analyses of human error. *Communications of the ACM*, 26(4):254–258, 1983.

[584] D. A. Norman. Some observations on mental models. *Mental models*, 7(112):7–14, 1983.

[585] D. A. Norman. Cognitive engineering. *User centered system design*, 31:61, 1986.

[586] D. A. Norman. *The psychology of everyday things.* Basic books, 1988.

[587] D. A. Norman. *The invisible computer: why good products can fail, the personal computer is so complex, and information appliances are the solution.* MIT press, 1998.

[588] D. A. Norman. Human-centered design considered harmful. *interactions*, 12(4): 14–19, 2005.

[589] D. A. Norman. The way i see it memory is more important than actuality. *Interactions*, 16(2):24–26, 2009.

[590] D. A. Norman and S. W. Draper. *User centered system design; new perspectives on human-computer interaction.* L. Erlbaum Associates Inc., 1986.

[591] K. L. Nowak and F. Biocca. The effect of the agency and anthropomorphism on users' sense of telepresence, copresence, and social presence in virtual environments. *Presence: Teleoperators & Virtual Environments*, 12(5):481–494, 2003.

[592] R. Nozick. *Anarchy, state, and utopia*, volume 5038. new york: Basic Books, 1974.

[593] K. Oberauer, S. Lewandowsky, E. Awh, G. D. Brown, A. Conway, N. Cowan, C. Donkin, S. Farrell, G. J. Hitch, M. J. Hurlstone, et al. Benchmarks for models of short-term and working memory. *Psychological bulletin*, 144(9):885, 2018.

[594] H. L. O'Brien and E. G. Toms. The development and evaluation of a survey to measure user engagement. *Journal of the American Society for Information Science and Technology*, 61(1):50–69, 2010.

[595] M. Obrist, R. Bernhaupt, and M. Tscheligi. Interactive tv for the home: An ethnographic study on users' requirements and experiences. *Intl. Journal of Human–Computer Interaction*, 24(2):174–196, 2008.

[596] M. Obrist, S. A. Seah, and S. Subramanian. Talking about tactile experiences. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '13, page 1659–1668, New York, NY, USA, 2013. Association for Computing Machinery. ISBN 9781450318990. doi: 10.1145/2470654.2466220. URL `https://doi.org/10.1145/2470654.2466220`.

[597] W. Odom, J. Zimmerman, and J. Forlizzi. Teenagers and their virtual possessions: design opportunities and issues. In *Proceedings of the SIGCHI conference on Human Factors in computing systems*, pages 1491–1500, 2011.

[598] D. of Transportation. An examination of driver distraction as recorded in nhtsa databases. Technical report, United States. National Highway Traffic Safety Administration, 2014.

[599] A. A. Ogunyemi, D. Lamas, M. K. Lárusdóttir, and F. Loizides. A systematic mapping study of hci practice research. *International Journal of Human–Computer Interaction*, 35(16):1461–1486, 2019.

[600] C. Oh, S. Kim, J. Choi, J. Eun, S. Kim, J. Kim, J. Lee, and B. Suh. Understanding how people reason about aesthetic evaluations of artificial intelligence. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference*, pages 1169–1181, 2020.

[601] K. O'Hara and A. Sellen. A comparison of reading paper and on-line documents. In *Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems*, CHI '97, pages 335–342, New York, NY, USA, 1997. ACM. ISBN 0-89791-802-9. doi: 10.1145/258549.258787. URL `http://doi.acm.org/10.1145/258549.258787`.

[602] K. O'Hara, G. Gonzalez, A. Sellen, G. Penney, A. Varnavas, H. Mentis, A. Criminisi, R. Corish, M. Rouncefield, N. Dastur, et al. Touchless interaction in surgery. *Communications of the ACM*, 57(1):70–77, 2014.

[603] A. Oliva and A. Torralba. The role of context in object recognition. *Trends in cognitive sciences*, 11(12):520–527, 2007.

[604] G. M. Olson and J. S. Olson. Distance matters. *Human–computer interaction*, 15 (2-3):139–178, 2000.

[605] J. R. Olson and G. M. Olson. The growth of cognitive modeling in human-computer interaction since goms. In *Readings in Human–Computer Interaction*, pages 603–625. Elsevier, 1995.

[606] A. N. Oppenheim. *Questionnaire design, interviewing and attitude measurement.* Bloomsbury Publishing, 2000.

[607] D. M. Oppenheimer, T. Meyvis, and N. Davidenko. Instructional manipulation checks: Detecting satisficing to increase statistical power. *Journal of experimental social psychology*, 45(4):867–872, 2009.

[608] W. J. Orlikowski. Learning from notes: Organizational issues in groupware implementation. In *Readings in Human–Computer Interaction*, pages 197–204. Elsevier, 1995.

[609] W. J. Orlikowski. Using technology and constituting structures: A practice lens for studying technology in organizations. *Organization science*, 11(4):404–428, 2000.

[610] A. Oulasvirta. Task demands and memory in web interaction: a levels of processing approach. *Interacting with Computers*, 16(2):217–241, 2004.

[611] A. Oulasvirta and K. Hornbæk. Hci research as problem-solving. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, CHI '16, pages 4956–4967, New York, NY, USA, 2016. ACM. ISBN 978-1-4503-3362-7. doi: 10.1145/2858036.2858283. URL `http://doi.acm.org/10.1145/2858036.2858283`.

[612] A. Oulasvirta, S. Tamminen, V. Roto, and J. Kuorelahti. Interaction in 4-second bursts: the fragmented nature of attentional resources in mobile hci. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 919–928, 2005.

[613] A. Oulasvirta, M. Wahlström, and K. A. Ericsson. What does it mean to be good at using a mobile device? an investigation of three levels of experience and skill. *International journal of human-computer studies*, 69(3):155–169, 2011.

[614] A. Oulasvirta, S. De Pascale, J. Koch, T. Langerak, J. Jokinen, K. Todi, M. Laine, M. Kristhombuge, Y. Zhu, A. Miniukovich, G. Palmas, and T. Weinkauf. Aalto interface metrics (aim): A service and codebase for computational gui evaluation. In *The 31st Annual ACM Symposium on User Interface Software and Technology Adjunct Proceedings*, UIST '18 Adjunct, pages 16–19, New York, NY, USA, 2018. ACM. ISBN 978-1-4503-5949-8. doi: 10.1145/3266037.3266087. URL `http://doi.acm.org/10.1145/3266037.3266087`.

[615] A. Oulasvirta, S. Kim, and B. Lee. Neuromechanics of a button press. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, CHI '18,

page 1–13, New York, NY, USA, 2018. Association for Computing Machinery. ISBN 9781450356206. doi: 10.1145/3173574.3174082. URL https://doi.org/10.1145/3173574.3174082.

[616] A. Oulasvirta, S. Kim, and B. Lee. Neuromechanics of a button press. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, pages 1–13, 2018.

[617] A. Oulasvirta, N. R. Dayama, M. Shiripour, M. John, and A. Karrenbauer. Combinatorial optimization of graphical user interface designs. *Proceedings of the IEEE*, 108(3):434–464, 2020.

[618] A. Oulasvirta, J. P. Jokinen, and A. Howes. Computational rationality as a theory of interaction. In *CHI Conference on Human Factors in Computing Systems*, pages 1–14, 2022.

[619] S. Paea, C. Katsanos, and G. Bulivou. Information architecture: Using best merge method, category validity, and multidimensional scaling for open card sort data analysis. *International Journal of Human–Computer Interaction*, pages 1–21, 2022.

[620] G. Pahl and W. Beitz. *Engineering design: a systematic approach*. Springer Science & Business Media, 2013.

[621] L. Palen and P. Dourish. Unpacking" privacy" for a networked world. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 129–136, 2003.

[622] L. Palen and M. Salzman. Voice-mail diary studies for naturalistic data capture under mobile conditions. In *Proceedings of the 2002 ACM Conference on Computer Supported Cooperative Work*, CSCW '02, page 87–95, New York, NY, USA, 2002. Association for Computing Machinery. ISBN 1581135602. doi: 10.1145/587078.587092. URL https://doi.org/10.1145/587078.587092.

[623] K. Palin, A. M. Feit, S. Kim, P. O. Kristensson, and A. Oulasvirta. How do people type on mobile devices? observations from a study with 37,000 volunteers. In *Proceedings of the 21st International Conference on Human-Computer Interaction with Mobile Devices and Services*, pages 1–12, 2019.

[624] R. Parasuraman and V. Riley. Humans and automation: Use, misuse, disuse, abuse. *Human factors*, 39(2):230–253, 1997.

[625] R. Parasuraman, T. B. Sheridan, and C. D. Wickens. A model for types and levels of human interaction with automation. *IEEE Transactions on systems, man, and cybernetics-Part A: Systems and Humans*, 30(3):286–297, 2000.

[626] D. L. Parnas and P. C. Clements. A rational design process: How and why to fake it. *IEEE transactions on software engineering*, (2):251–257, 1986.

[627] A. Parush, R. Nadir, and A. Shtub. Evaluating the layout of graphical user interface screens: Validation of a numerical computerized model. *International Journal of Human-Computer Interaction*, 10(4):343–360, 1998.

[628] A. Parush, Y. Shwarts, A. Shtub, and M. J. Chandra. The impact of visual layout factors on performance in web pages: A cross-language study. *Human Factors*, 47 (1):141–157, 2005.

[629] J. Patten and H. Ishii. Mechanical constraints as computational constraints in tabletop tangible interfaces. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 809–818, 2007.

[630] S. A. Paul and M. C. Reddy. Understanding together: sensemaking in collaborative information seeking. In *Proceedings of the 2010 ACM conference on Computer supported cooperative work*, pages 321–330, 2010.

[631] S. J. Payne and T. R. G. Green. The structure of command languages: an experiment on task-action grammar. *International Journal of Man-Machine Studies*, 30(2): 213–234, 1989.

[632] S. J. Payne and A. Howes. Adaptive interaction: A utility maximization approach to understanding human interaction with technology. *Synthesis Lectures on Human-Centered Informatics*, 6(1):1–111, 2013.

[633] E. R. Pedersen, K. McCall, T. P. Moran, and F. G. Halasz. Tivoli: An electronic whiteboard for informal workgroup meetings. In *Readings in Human–Computer Interaction*, pages 509–516. Elsevier, 1995.

[634] C. Perrow. *Normal accidents: Living with high risk technologies.* Princeton university press, 1999.

[635] D. Peters, R. A. Calvo, and R. M. Ryan. Designing for motivation, engagement and wellbeing in digital experience. *Frontiers in psychology*, 9:797, 2018.

[636] D. Peters, L. Loke, and N. Ahmadpour. Toolkits, cards and games–a review of analogue tools for collaborative ideation. *CoDesign*, 17(4):410–434, 2021.

[637] C. Petitmengin, M. Van Beek, M. Bitbol, J.-M. Nissou, and A. Roepstorff. Studying the experience of meditation through micro-phenomenology. *Current opinion in psychology*, 28:54–59, 2019.

[638] H. Petroski. *Success through failure: The paradox of design*, volume 92. Princeton University Press, 2018.

[639] I. Pettersson, F. Lachner, A.-K. Frison, A. Riener, and A. Butz. A bermuda triangle? a review of method application and triangulation in user experience evaluation. In *Proceedings of the 2018 CHI conference on human factors in computing systems*, pages 1–16, 2018.

[640] R. W. Picard, E. Vyzas, and J. Healey. Toward machine emotional intelligence: Analysis of affective physiological state. *IEEE transactions on pattern analysis and machine intelligence*, 23(10):1175–1191, 2001.

[641] M. Pielot, T. Dingler, J. S. Pedro, and N. Oliver. When attention is not scarce - detecting boredom from mobile phone usage. In *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, UbiComp '15, page 825–836, New York, NY, USA, 2015. Association for Computing Machinery. ISBN 9781450335744. doi: 10.1145/2750858.2804252. URL `https://doi.org/10.1145/2750858.2804252`.

[642] M. Pielot, T. Dingler, J. S. Pedro, and N. Oliver. When attention is not scarce-detecting boredom from mobile phone usage. In *Proceedings of the 2015 ACM international joint conference on pervasive and ubiquitous computing*, pages 825–836, 2015.

[643] C. Pinder, J. Vermeulen, B. R. Cowan, and R. Beale. Digital behaviour change interventions to break and form habits. *ACM Trans. Comput.-Hum. Interact.*, 25 (3), June 2018. ISSN 1073-0516. doi: 10.1145/3196830. URL `https://doi.org/10.1145/3196830`.

[644] D. Pinelle and C. Gutwin. Groupware walkthrough: adding context to groupware usability evaluation. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 455–462, 2002.

[645] B. Piper, C. Ratti, and H. Ishii. Illuminating clay: A 3-d tangible interface for landscape analysis. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '02, page 355–362, New York, NY, USA, 2002. Association for Computing Machinery. ISBN 1581134533. doi: 10.1145/503376.503439. URL `https://doi.org/10.1145/503376.503439`.

[646] P. Pirolli and S. Card. Information foraging. *Psychological review*, 106(4):643, 1999.

[647] D. Pitcher and L. G. Ungerleider. Evidence for a third visual pathway specialized for social perception. *Trends in Cognitive Sciences*, 2020.

[648] J. Pitkow and M. Recker. Results from the first world-wide web user survey. *Computer Networks and ISDN Systems*, 27(2):243–254, 1994.

[649] S. Pizza, B. Brown, D. McMillan, and A. Lampinen. Smartwatch in vivo. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, pages 5456–5469, 2016.

[650] L. Plowman, Y. Rogers, and M. Ramage. What are workplace studies for? In *Proceedings of the Fourth European Conference on Computer-Supported Cooperative Work ECSCW'95*, pages 309–324. Springer, 1995.

[651] H. Pohl and R. Murray-Smith. Focused and casual interactions: Allowing users to vary their level of engagement. In *Proceedings of the sigchi conference on human factors in computing systems*, pages 2223–2232, 2013.

[652] H. Pohl, D. Stanke, and M. Rohs. Emojizoom: emoji entry via large overview maps. In *Proceedings of the 18th international conference on human-computer interaction with mobile devices and services*, pages 510–517, 2016.

[653] H. Pohl, P. Brandes, H. Ngo Quang, and M. Rohs. Squeezeback: Pneumatic compression for notifications. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, pages 5318–5330, 2017.

[654] K. Pohl. *Requirements engineering: fundamentals, principles, and techniques*. Springer Publishing Company, Incorporated, 2010.

[655] M. Polanyi. *The tacit dimension*. University of Chicago press, 2009.

[656] P. G. Polson and C. H. Lewis. Theory-based design for easily learned interfaces. *Human–Computer Interaction*, 5(2-3):191–220, 1990.

[657] M. Porcheron, J. E. Fischer, S. Reeves, and S. Sharples. *Voice Interfaces in Everyday Life*, page 1–12. Association for Computing Machinery, New York, NY, USA, 2018. ISBN 9781450356206. URL `https://doi.org/10.1145/3173574.3174214`.

[658] I. Poupyrev, M. Billinghurst, S. Weghorst, and T. Ichikawa. The go-go interaction technique: non-linear mapping for direct manipulation in vr. In *Proceedings of the 9th annual ACM symposium on User interface software and technology*, pages 79–80, 1996.

[659] I. Poupyrev, P. Schoessler, J. Loh, and M. Sato. Botanicus interacticus: interactive plants technology. In *ACM SIGGRAPH 2012 Emerging Technologies*, pages 1–1. 2012.

[660] C. Preist, D. Schien, and P. Shabajee. Evaluating sustainable interaction design of digital services: The case of youtube. In *Proceedings of the 2019 CHI conference on human factors in computing systems*, pages 1–12, 2019.

[661] J. O. Prochaska and W. F. Velicer. The transtheoretical model of health behavior change. *American journal of health promotion*, 12(1):38–48, 1997.

[662] M. Prpa, S. Fdili-Alaoui, T. Schiphorst, and P. Pasquier. Articulating experience: Reflections from experts applying micro-phenomenology to design research in hci. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, pages 1–14, 2020.

[663] J. Pruitt and J. Grudin. Personas: practice and theory. In *Proceedings of the 2003 conference on Designing for user experiences*, pages 1–15, 2003.

[664] A. K. Przybylski and N. Weinstein. Can you connect with me now? how the presence of mobile communication technology influences face-to-face conversation quality. *Journal of Social and Personal Relationships*, 30(3):237–246, 2013.

[665] Q. Pu, S. Gupta, S. Gollakota, and S. Patel. Whole-home gesture recognition using wireless signals. In *Proceedings of the 19th annual international conference on Mobile computing & networking*, pages 27–38, 2013.

[666] G. Pullin and A. Newell. Focussing on extra-ordinary users. In *International Conference on Universal Access in Human-Computer Interaction*, pages 253–262. Springer, 2007.

[667] C. Puri, L. Olson, I. Pavlidis, J. Levine, and J. Starren. Stresscam: Non-contact measurement of users' emotional states through thermal imaging. In *CHI '05 Extended Abstracts on Human Factors in Computing Systems*, CHI EA '05, page 1725–1728, New York, NY, USA, 2005. Association for Computing Machinery. ISBN 1595930027. doi: 10.1145/1056808.1057007. URL `https://doi.org/10.1145/1056808.1057007`.

[668] A. Pusch and A. Lécuyer. Pseudo-haptics: from the theoretical foundations to practical system design guidelines. In *Proceedings of the 13th international conference on multimodal interfaces*, pages 57–64, 2011.

[669] A. J. Quinn and B. B. Bederson. Human computation: a survey and taxonomy of a growing field. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 1403–1412, 2011.

[670] H. S. Raffle, A. J. Parkes, and H. Ishii. Topobo: a constructive assembly system with kinetic memory. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 647–654, 2004.

[671] G. Ramos, M. Boulos, and R. Balakrishnan. Pressure widgets. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '04, page 487–494, New York, NY, USA, 2004. Association for Computing Machinery. ISBN 1581137028. doi: 10.1145/985692.985754. URL `https://doi.org/10.1145/985692.985754`.

[672] J. Raskin. *The humane interface: new directions for designing interactive systems*. Addison-Wesley Professional, 2000.

[673] J. Rasmussen. Skills, rules, and knowledge; signals, signs, and symbols, and other distinctions in human performance models. *IEEE transactions on systems, man, and cybernetics*, (3):257–266, 1983.

[674] R. Ratcliff and H. P. Van Dongen. Diffusion model for one-choice reaction-time tasks and the cognitive effects of sleep deprivation. *Proceedings of the National Academy of Sciences*, 108(27):11285–11290, 2011.

[675] T. Rattenbury, J. M. Hellerstein, J. Heer, S. Kandel, and C. Carreras. *Principles of data wrangling: Practical techniques for data preparation.* " O'Reilly Media, Inc.", 2017.

[676] R. Rauschenberger, C. Wood, and J. Sala. *Human factors and the design of medical devices*, pages 215–226. 01 2013.

[677] M. Rauterberg. An empirical comparison of menu-selection (((cui) and desktop (gui) computer programs carried out by beginners and experts. *Behaviour & Information Technology*, 11(4):227–236, 1992.

[678] J. Reason. *Human error.* Cambridge university press, 1990.

[679] F. F. Reichheld. The one number you need to grow. *Harvard business review*, 81 (12):46–55, 2003.

[680] M. A. Renom, B. Caramiaux, and M. Beaudouin-Lafon. Exploring technical reasoning in digital tool use. In *CHI Conference on Human Factors in Computing Systems*, pages 1–17, 2022.

[681] S. Reyal, S. Zhai, and P. O. Kristensson. Performance and user experience of touchscreen and gesture keyboards in a lab setting and in the wild. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, pages 679–688, 2015.

[682] P. D. Reynolds. *Primer in theory construction: An A&B classics edition.* Routledge, 2015.

[683] J. Rico and S. Brewster. Usable gestures for mobile interfaces: evaluating social acceptability. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 887–896, 2010.

[684] J. Rieman. A field study of exploratory learning strategies. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 3(3):189–218, 1996.

[685] E. Ries. *The lean startup : how constant innovation creates radically successful businesses.* Portfolio Penguin, London; New York, 2011. ISBN 9780670921607 0670921602. URL `http://www.amazon.de/The-Lean-Startup-Innovation-Successful/dp/0670921602/ref=sr_1_2?ie=UTF8&qid=1396199893&sr=8-2&keywords=eric+ries`.

[686] J. Robertson and M. Kaptein. *Modern statistical methods for HCI.* Springer, 2016.

[687] T. Robertson and J. Simonsen. Challenges and opportunities in contemporary participatory design. *Design Issues*, 28(3):3–9, 2012.

[688] C. Robson. *Real world research: A resource for social scientists and practitioner-researchers*, volume 2. Blackwell Oxford, 2002.

[689] D. J. Roedl and E. Stolterman. Design research at chi and its applicability to design practice. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 1951–1954, 2013.

[690] Y. Rogers. New theoretical approaches for human-computer interaction. *Annual review of information science and technology*, 38(1):87–143, 2004.

[691] Y. Rogers. Hci theory: classical, modern, and contemporary. *Synthesis lectures on human-centered informatics*, 5(2):1–129, 2012.

[692] J. Roschelle and S. D. Teasley. The construction of shared knowledge in collaborative problem solving. In *Computer supported collaborative learning*, pages 69–97. Springer, 1995.

[693] M. S. Rosenbaum, M. L. Otalora, and G. C. Ramírez. How to create a realistic customer journey map. *Business horizons*, 60(1):143–150, 2017.

[694] S. Rosenbaum, J. A. Rohn, and J. Humburg. A toolkit for strategic usability: Results from workshops, panels, and surveys. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '00, page 337–344, New York, NY, USA, 2000. Association for Computing Machinery. ISBN 1581132166. doi: 10.1145/332040.332454. URL `https://doi.org/10.1145/332040.332454`.

[695] L. Rosenfeld and P. Morville. *Information architecture for the world wide web.* " O'Reilly Media, Inc.", 2002.

[696] R. Rosenholtz, A. Dorai, and R. Freeman. Do predictions of visual perception aid design? *ACM Transactions on Applied Perception (TAP)*, 8(2):1–20, 2011.

[697] R. Rosenthal and R. L. Rosnow. *Essentials of behavioral research: Methods and data analysis.* 2008.

[698] M. B. Rosson and J. M. Carroll. Scenario-based design. In *Human-computer interaction*, pages 161–180. CRC Press, 2009.

[699] Q. Roy, F. Zhang, and D. Vogel. Automation accuracy is good, but high controllability may be better. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, pages 1–8, 2019.

[700] H. J. Rubin and I. S. Rubin. *Qualitative interviewing: The art of hearing data.* sage, 2011.

[701] J. Rubin and D. Chisnell. How to plan, design, and conduct effective tests. *Handbook of usability testing*, 2008.

[702] E. M. Russek, I. Momennejad, M. M. Botvinick, S. J. Gershman, and N. D. Daw. Predictive representations can link model-based reinforcement learning to model-free mechanisms. *PLoS computational biology*, 13(9):e1005768, 2017.

[703] J. A. Russell. Core affect and the psychological construction of emotion. *Psychological review*, 110(1):145, 2003.

[704] K. Ryokai, S. Marti, and H. Ishii. I/o brush: Drawing with everyday objects as ink. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '04, page 303–310, New York, NY, USA, 2004. Association for Computing Machinery. ISBN 1581137028. doi: 10.1145/985692.985731. URL `https://doi.org/10.1145/985692.985731`.

[705] H. Sacks, E. A. Schegloff, and G. Jefferson. A simplest systematics for the organization of turn taking for conversation. In *Studies in the organization of conversational interaction*, pages 7–55. Elsevier, 1978.

[706] A. Salovaara, S. Helfenstein, and A. Oulasvirta. Everyday appropriations of information technology: A study of creative uses of digital cameras. *Journal of the American Society for Information Science and Technology*, 62(12):2347–2363, 2011.

[707] D. D. Salvucci. An integrated model of eye movements and visual encoding. *Cognitive Systems Research*, 1(4):201–220, 2001.

[708] D. D. Salvucci, M. Zuber, E. Beregovaia, and D. Markley. Distract-r: Rapid prototyping and evaluation of in-vehicle interfaces. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 581–589, 2005.

[709] H. A. Samani, R. Parsani, L. T. Rodriguez, E. Saadatian, K. H. Dissanayake, and A. D. Cheok. Kissenger: Design of a kiss transmission device. In *Proceedings of the Designing Interactive Systems Conference*, DIS '12, page 48–57, New York, NY, USA, 2012. Association for Computing Machinery. ISBN 9781450312103. doi: 10.1145/2317956.2317965. URL `https://doi.org/10.1145/2317956.2317965`.

[710] E. B.-N. Sanders. From user-centered to participatory design approaches. In *Design and the social sciences*, pages 18–25. CRC Press, 2002.

[711] E. B.-N. Sanders and P. J. Stappers. Co-creation and the new landscapes of design. *Co-design*, 4(1):5–18, 2008.

[712] C. Sas and S. Whittaker. Design for forgetting: disposing of digital possessions after a breakup. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 1823–1832, 2013.

[713] T. Sasaki, M. Y. Saraiji, C. L. Fernando, K. Minamizawa, and M. Inami. Metalimbs: multiple arms interaction metamorphism. In *ACM SIGGRAPH 2017 Emerging Technologies*, pages 1–2. 2017.

[714] S. A. Satpute, J. R. Canady, R. L. Klatzky, and G. D. Stetten. Fingersight: A vibrotactile wearable ring for assistance with locating and reaching objects in peripersonal space. *IEEE transactions on haptics*, 13(2):325–333, 2019.

[715] J. Sauro and J. S. Dumas. Comparison of three one-question, post-task usability questionnaires. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 1599–1608, 2009.

[716] J. Sauro and J. R. Lewis. Correlations among prototypical usability metrics: evidence for the construct of usability. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 1609–1618, 2009.

[717] J. Sauro and J. R. Lewis. *Quantifying the user experience: Practical statistics for user research.* Morgan Kaufmann, 2016.

[718] J. Scarr, A. Cockburn, C. Gutwin, and P. Quinn. Dips and ceilings: understanding and supporting transitions to expertise in user interfaces. In *Proceedings of the sigchi conference on human factors in computing systems*, pages 2741–2750, 2011.

[719] S. Schaal and D. Sternad. Origins and violations of the 2/3 power law in rhythmic three-dimensional arm movements. *Experimental brain research*, 136(1):60–72, 2001.

[720] N. C. Schaeffer and S. Presser. The science of asking questions. *Annual review of sociology*, 29, 2003.

[721] M. Scharkow. The accuracy of self-reported internet use—a validation study using client log data. *Communication Methods and Measures*, 10(1):13–27, 2016.

[722] A. Schmidt, M. Beigl, and H.-W. Gellersen. There is more to context than location. *Computers & Graphics*, 23(6):893–901, 1999.

[723] K. Schmidt. Riding a tiger, or computer supported cooperative work. In *Proceedings of the Second European Conference on Computer-Supported Cooperative Work ECSCW'91*, pages 1–16. Springer, 1991.

[724] K. Schmidt. Cooperative work and its articulation: requirements for computer support. *Le travail humain*, pages 345–366, 1994.

[725] K. Schmidt. The concept of 'practice': What's the point? In *COOP 2014-Proceedings of the 11th International Conference on the Design of Cooperative Systems, 27-30 May 2014, Nice (France)*, pages 427–444. Springer, 2014.

[726] K. Schmidt and C. Simonee. Coordination mechanisms: Towards a conceptual foundation of cscw systems design. *Computer Supported Cooperative Work (CSCW)*, 5(2):155–200, 1996.

[727] D. Schneider, A. Otte, T. Gesslein, P. Gagel, B. Kuth, M. S. Damlakhi, O. Dietz, E. Ofek, M. Pahud, P. O. Kristensson, et al. Reconviguration: Reconfiguring physical keyboards in virtual reality. *IEEE transactions on visualization and computer graphics*, 25(11):3190–3201, 2019.

[728] J. Scholtz. Theory and evaluation of human robot interactions. In *36th Annual Hawaii International Conference on System Sciences, 2003. Proceedings of the*, pages 10–pp. IEEE, 2003.

[729] D. A. Schön. *The reflective practitioner: How professionals think in action.* Routledge, 2017.

[730] I. Schuetz, T. S. Murdison, K. J. MacKenzie, and M. Zannoli. An explanation of fitts' law-like performance in gaze-based selection tasks using a psychophysics approach. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, pages 1–13, 2019.

[731] N. D. Schüll. *Addiction by design.* Princeton University Press, 2012.

[732] V. Schwind, P. Knierim, N. Haas, and N. Henze. Using presence questionnaires in virtual reality. In *Proceedings of the 2019 CHI conference on human factors in computing systems*, pages 1–12, 2019.

[733] J. Scott, A. Bernheim Brush, J. Krumm, B. Meyers, M. Hazas, S. Hodges, and N. Villar. Preheat: controlling home heating using occupancy prediction. In *Proceedings of the 13th international conference on Ubiquitous computing*, pages 281–290, 2011.

[734] S. D. Scott, M. S. T. Carpendale, and K. Inkpen. Territoriality in collaborative tabletop workspaces. In *Proceedings of the 2004 ACM conference on Computer supported cooperative work*, pages 294–303, 2004.

[735] S. D. Scott, M. S. T. Carpendale, and K. M. Inkpen. Territoriality in collaborative tabletop workspaces. In *Proceedings of the 2004 ACM Conference on Computer Supported Cooperative Work*, CSCW '04, page 294–303, New York, NY, USA, 2004. Association for Computing Machinery. ISBN 1581138105. doi: 10.1145/1031607.1031655. URL `https://doi.org/10.1145/1031607.1031655`.

[736] S. A. Seah, D. Martinez Plasencia, P. D. Bennett, A. Karnik, V. S. Otrocol, J. Knibbe, A. Cockburn, and S. Subramanian. Sensabubble: a chrono-sensory mid-air display of sight and smell. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 2863–2872, 2014.

[737] A. Sears. Layout appropriateness: A metric for evaluating user interface widget layout. *IEEE Transactions on Software Engineering*, 19(7):707–719, 1993.

[738] S. C. Seow. Information theoretic models of hci: A comparison of the hick-hyman law and fitts' law. *Human-computer interaction*, 20(3):315–352, 2005.

[739] S. C. Seow. *Designing and engineering time: The psychology of time perception in software.* Addison-Wesley Professional, 2008.

[740] A. Serino, M. Bassolino, A. Farne, and E. Ladavas. Extended multisensory space in blind cane users. *Psychological science*, 18(7):642–648, 2007.

[741] B. Shackel. Usability–context, framework, definition, design and evaluation. *Interacting with computers*, 21(5-6):339–346, 2009.

[742] W. R. Shadish, T. Cook, and D. Campbell. *Experimental and quasi-experimental designs for generalized causal inference*. Houghton Mifflin Company, 2002.

[743] W. R. Shadish, T. D. Cook, D. T. Campbell, et al. *Experimental and quasi-experimental designs for generalized causal inference/William R. Shedish, Thomas D. Cook, Donald T. Campbell.* Boston: Houghton Mifflin,, 2002.

[744] O. Shaer and E. Hornecker. *Tangible user interfaces: past, present, and future directions*. Now Publishers Inc, 2010.

[745] C. E. Shannon. A mathematical theory of communication. *The Bell system technical journal*, 27(3):379–423, 1948.

[746] M. Sharples. A study of breakdowns and repairs in a computer-mediated communication system. *Interacting with computers*, 5(1):61–77, 1993.

[747] K. M. Sheldon, A. J. Elliot, Y. Kim, and T. Kasser. What is satisfying about satisfying events? testing 10 candidate psychological needs. *Journal of personality and social psychology*, 80(2):325, 2001.

[748] J. Shen, J. Dudley, G. Mo, and P. O. Kristensson. Gesture spotter: A rapid prototyping tool for key gesture spotting in virtual and augmented reality applications. *IEEE Transactions on Visualization and Computer Graphics*, 28(11):3618–3628, 2022.

[749] B. Shneiderman. The future of interactive systems and the emergence of direct manipulation. *Behaviour & Information Technology*, 1(3):237–256, 1982.

[750] B. Shneiderman. Creativity support tools. *Communications of the ACM*, 45(10): 116–120, 2002.

[751] B. Shneiderman. *The new ABCs of research: Achieving breakthrough collaborations*. Oxford University Press, 2016.

[752] B. Shneiderman. Revisiting the astonishing growth of human–computer interaction research. *IEEE Computer*, 50(10):8–11, 2017.

[753] B. Shneiderman. Bridging the gap between ethics and practice: guidelines for reliable, safe, and trustworthy human-centered ai systems. *ACM Transactions on Interactive Intelligent Systems (TiiS)*, 10(4):1–31, 2020.

[754] B. Shneiderman and P. Maes. Direct manipulation vs. interface agents. *Interactions*, 4(6):42–61, nov 1997. ISSN 1072-5520. doi: 10.1145/267505.267514. URL `https://doi.org/10.1145/267505.267514`.

[755] B. Shneiderman and P. Maes. Direct manipulation vs. interface agents. *interactions*, 4(6):42–61, 1997.

[756] B. Shneiderman and C. Plaisant. *Designing the user interface: Strategies for effective human-computer interaction.* Pearson Education, 2010.

[757] R. W. Shumaker, K. R. Walkup, and B. B. Beck. *Animal tool behavior: the use and manufacture of tools by animals.* JHU Press, 2011.

[758] M. Sicart and I. Shklovski. 'pataphysical software: (ridiculous) technological solutions for imaginary problems. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference*, pages 1859–1871, 2020.

[759] H. A. Simon. The science of design: Creating the artificial. *Design Issues*, pages 67–82, 1988.

[760] H. A. Simon. *The sciences of the artificial.* MIT press, 2019.

[761] E. Simpson and B. Semaan. For you, or for" you"? everyday lgbtq+ encounters with tiktok. *Proceedings of the ACM on human-computer interaction*, 4(CSCW3): 1–34, 2021.

[762] C. U. M. Smith. *Biology of sensory systems.* John Wiley & Sons, 2008.

[763] D. C. Smith. *Pygmalion: a creative programming environment.* Stanford University, 1975.

[764] D. C. Smith. Pygmalion: An executable electronic blackboard. In *Watch What I Do: Programming by Demonstration*, pages 19–48. 1993.

[765] D. C. Smith, A. Cypher, and J. Spohrer. Kidsim: Programming agents without a programming language. *Communications of the ACM*, 37(7):54–67, 1994.

[766] C. Snyder. *Paper prototyping: The fast and easy way to design and refine user interfaces.* Morgan Kaufmann, 2003.

[767] B. L. Somberg. A comparison of rule-based and positionally constant arrangements of computer menu items. In *Proceedings of the SIGCHI/GI Conference on Human Factors in Computing Systems and Graphics Interface*, CHI '87, page 255–260, New York, NY, USA, 1986. Association for Computing Machinery. ISBN 0897912136. doi: 10.1145/29933.275639. URL https://doi.org/10.1145/29933.275639.

[768] M. L. J. Søndergaard, M. Ciolfi Felice, and M. Balaam. Designing menstrual technologies with adolescents. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, CHI '21, New York, NY, USA, 2021. Association for Computing Machinery. ISBN 9781450380966. doi: 10.1145/3411764.3445471. URL https://doi.org/10.1145/3411764.3445471.

[769] R. W. Soukoreff and I. S. MacKenzie. Towards a standard for pointing device evaluation, perspectives on 27 years of fitts' law research in hci. *International journal of human-computer studies*, 61(6):751–789, 2004.

[770] B. Sparrow, J. Liu, and D. M. Wegner. Google effects on memory: Cognitive consequences of having information at our fingertips. *science*, 333(6043):776–778, 2011.

[771] R. Spencer. The streamlined cognitive walkthrough method, working around social constraints encountered in a software development company. In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems*, pages 353–359, 2000.

[772] J. P. Spradley. *Participant observation*. Waveland Press, 2016.

[773] L. R. Squire. Memory systems of the brain: a brief history and current perspective. *Neurobiology of learning and memory*, 82(3):171–177, 2004.

[774] S. Srinivasa Ragavan, A. Sarkar, and A. D. Gordon. Spreadsheet comprehension: Guesswork, giving up and going back to the author. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, pages 1–21, 2021.

[775] G. Stahl. Group cognition, 2006.

[776] S. L. Star. The structure of ill-structured solutions: Boundary objects and heterogeneous distributed problem solving. In *Distributed artificial intelligence*, pages 37–54. Elsevier, 1989.

[777] F. Steinberger, R. Schroeter, M. Foth, and D. Johnson. Designing gamified applications that make safe driving more engaging. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, CHI '17, page 2826–2839, New York, NY, USA, 2017. Association for Computing Machinery. ISBN 9781450346559. doi: 10.1145/3025453.3025511. URL `https://doi.org/10.1145/3025453.3025511`.

[778] S. S. Stevens. On the psychophysical law. *Psychological review*, 64(3):153, 1957.

[779] J. Stewart, B. B. Bederson, and A. Druin. Single display groupware: a model for co-present collaboration. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 286–293, 1999.

[780] J. W. Stigler. "mental abacus": The effect of abacus training on chinese children's mental calculation. *Cognitive Psychology*, 16(2):145–176, 1984.

[781] E. Stolterman. The nature of design practice and implications for interaction design research. *International Journal of Design*, 2(1), 2008.

[782] E. Stolterman and J. Pierce. Design tools in practice: studying the designer-tool relationship in interaction design. In *Proceedings of the designing interactive systems conference*, pages 25–28, 2012.

[783] N. Streitz and P. Nixon. The disappearing computer. *Communications-ACM*, 48 (3):32–35, 2005.

[784] P. Streli and C. Holz. Capcontact: Super-resolution contact areas from capacitive touchscreens. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, CHI '21, New York, NY, USA, 2021. Association for Computing Machinery. ISBN 9781450380966. doi: 10.1145/3411764.3445621. URL `https://doi.org/10.1145/3411764.3445621`.

[785] M. Sturdee and J. Lindley. Sketching & drawing as future inquiry in hci. In *Proceedings of the Halfway to the Future Symposium 2019*, pages 1–10, 2019.

[786] K.-W. Su and C.-L. Liu. A mobile nursing information system based on human-computer interaction design for improving quality of nursing. *Journal of Medical Systems*, 36(3):1139–1153, 2012.

[787] L. Suchman. Making work visible. *Communications of the ACM*, 38(9):56–64, 1995.

[788] L. A. Suchman. *Plans and situated actions: The problem of human-machine communication.* Cambridge university press, 1987.

[789] H. Suh, N. Shahriaree, E. B. Hekler, and J. A. Kientz. Developing and validating the user burden scale: A tool for assessing user burden in computing systems. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, CHI '16, page 3988–3999, New York, NY, USA, 2016. Association for Computing Machinery. ISBN 9781450333627. doi: 10.1145/2858036.2858448. URL `https://doi.org/10.1145/2858036.2858448`.

[790] H. Suh, N. Shahriaree, E. B. Hekler, and J. A. Kientz. Developing and validating the user burden scale: A tool for assessing user burden in computing systems. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, CHI '16, page 3988–3999, New York, NY, USA, 2016. Association for Computing Machinery. ISBN 9781450333627. doi: 10.1145/2858036.2858448. URL `https://doi.org/10.1145/2858036.2858448`.

[791] H. Suh, N. Shahriaree, E. B. Hekler, and J. A. Kientz. Developing and validating the user burden scale: A tool for assessing user burden in computing systems. In *Proceedings of the 2016 CHI conference on human factors in computing systems*, pages 3988–3999, 2016.

[792] I. Sutherland. The ultimate display. 1965.

[793] I. E. Sutherland. Sketchpad a man-machine graphical communication system. *Simulation*, 2(5):R–3, 1964.

[794] I. E. Sutherland. A head-mounted three dimensional display. In *Proceedings of the December 9-11, 1968, fall joint computer conference, part I*, pages 757–764, 1968.

[795] P. Sutter, J. Iatridis, and N. Thakor. Response to reflected-force feedback to fingers in teleoperations. In *Proceedings of the NASA Conference on Space Telerobotics*, 1989.

[796] C. Swann. Action Research and the Practice of Design. *Design Issues*, 18(1): 49–61, 01 2002. ISSN 0747-9360. doi: 10.1162/07479360252756287. URL `https://doi.org/10.1162/07479360252756287`.

[797] Systems, S. E. S. Committee, et al. Ieee standard model process for addressing ethical concerns during system design: Ieee standard 7000-2021. 2021.

[798] S. K. Tadeja, P. Seshadri, and P. O. Kristensson. Aerovr: An immersive visualisation system for aerospace design and digital twinning in virtual reality. *The Aeronautical Journal*, 124(1280):1615–1635, 2020.

[799] R. Tamas, W. O'Brien, and M. S. Quintero. Residential thermostat usability: Comparing manual, programmable, and smart devices. *Building and Environment*, 203:108104, 2021.

[800] R. S. Taylor. The process of asking questions. *American documentation*, 13(4): 391–396, 1962.

[801] J. Teevan, E. Cutrell, D. Fisher, S. M. Drucker, G. Ramos, P. André, and C. Hu. Visual snippets: summarizing web pages for search and revisitation. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 2023–2032, 2009.

[802] M. Teyssier, M. Koelle, P. Strohmeier, B. Fruchard, and J. Steimle. Eyecam: Revealing relations between humans and sensing devices through an anthropomorphic webcam. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, pages 1–13, 2021.

[803] R. H. Thaler and C. R. Sunstein. *Nudge: Improving decisions about health, wealth, and happiness*. Penguin, 2009.

[804] H. Thimbleby. Safer user interfaces: A case study in improving number entry. *IEEE Transactions on Software Engineering*, 41(7):711–729, 2014.

[805] J. Tidwell. A pattern language for human-computer interface design. *DIALOG*, 1997.

[806] K. Tiippana. What is the mcgurk effect? *Frontiers in psychology*, 5:725, 2014.

[807] E. Tiong, O. Seow, B. Camburn, K. Teo, A. Silva, K. L. Wood, D. D. Jensen, and M. C. Yang. The economies and dimensionality of design prototyping: Value, time, cost, and fidelity. *Journal of Mechanical Design*, 141(3):031105, 2019.

[808] P. Tolmie, J. Pycock, T. Diggins, A. MacLean, and A. Karsenty. Unremarkable computing. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 399–406, 2002.

[809] G. F. Tondello, D. L. Kappen, E. D. Mekler, M. Ganaba, and L. E. Nacke. Heuristic evaluation for gameful design. In *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts*, CHI PLAY Companion '16, page 315–323, New York, NY, USA, 2016. Association for Computing Machinery. ISBN 9781450344586. doi: 10.1145/2968120.2987729. URL `https://doi.org/10.1145/2968120.2987729`.

[810] N. Tractinsky, A. S. Katz, and D. Ikar. What is beautiful is usable. *Interacting with computers*, 13(2):127–145, 2000.

[811] G. Travis. How the boeing 737 max disaster looks to a software developer. *IEEE Spectrum*, 18, 2019.

[812] H. M. Treasury. Cox review of creativity in business: building on the uk's strengths. *London: HM Treasury*, 2005.

[813] A. M. Treisman and G. Gelade. A feature-integration theory of attention. *Cognitive psychology*, 12(1):97–136, 1980.

[814] S. Trepte and L. Reinecke. Avatar creation and video game enjoyment: Effects of life-satisfaction, game competitiveness, and identification with the avatar. *Journal of Media Psychology: Theories, Methods, and Applications*, 22(4):171, 2010.

[815] A. N. Tuch, R. Trusell, and K. Hornbæk. Analyzing users' narratives to understand experience with interactive products. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 2079–2088, 2013.

[816] T. Tullis and L. Wood. How many users are enough for a card-sorting study. In *Proceedings UPA*, volume 2004. Usability Professionals Association (UPA) Minneapolis (EUA), 2004.

[817] B. Tversky and A. Jamalian. Thinking tools: Gestures change thought about time. *Topics in Cognitive Science*, 13(4):750–776, 2021.

[818] J. M. Twenge. Increases in depression, self-harm, and suicide among us adolescents after 2012 and links to technology use: possible mechanisms. *Psychiatric Research and Clinical Practice*, 2(1):19–25, 2020.

[819] A. Tyack and E. D. Mekler. Self-determination theory in hci games research: current uses and open questions. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, pages 1–22, 2020.

[820] A. Tychsen and A. Canossa. Defining personas in games using metrics. In *Proceedings of the 2008 Conference on Future Play: Research, Play, Share*, Future Play '08, page

73–80, New York, NY, USA, 2008. Association for Computing Machinery. ISBN 9781605582184. doi: 10.1145/1496984.1496997. URL https://doi.org/10.1145/1496984.1496997.

[821] B. Ullmer and H. Ishii. Emerging frameworks for tangible user interfaces. *IBM systems journal*, 39(3.4):915–931, 2000.

[822] K. Ulrich. The role of product architecture in the manufacturing firm. *Research policy*, 24(3):419–440, 1995.

[823] K. T. Ulrich. *Product design and development*. Tata McGraw-Hill Education, 2003.

[824] J. Underkoffler and H. Ishii. Urp: a luminous-tangible workbench for urban planning and design. In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems*, pages 386–393, 1999.

[825] L. Van Boven and T. Gilovich. To do or to have? that is the question. *Journal of personality and social psychology*, 85(6):1193, 2003.

[826] S. Van Buuren and K. Groothuis-Oudshoorn. mice: Multivariate imputation by chained equations in r. *Journal of statistical software*, 45:1–67, 2011.

[827] A. Van Dam. Hypertext'87: keynote address. *Communications of the ACM*, 31(7): 887–895, 1988.

[828] T. Van der Geest. Conducting usability studies with users who are elderly or have disabilities. *Technical Communication*, 53(1):23–31, 2006.

[829] P. Van Schaik, M. Hassenzahl, and J. Ling. User-experience from an inference perspective. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 19(2): 1–25, 2012.

[830] K. Vaniea and Y. Rashidi. Tales of software updates: The process of updating software. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, CHI '16, page 3215–3226, New York, NY, USA, 2016. Association for Computing Machinery. ISBN 9781450333627. doi: 10.1145/2858036.2858303. URL https://doi.org/10.1145/2858036.2858303.

[831] V. Venkatesh and F. D. Davis. A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management science*, 46(2):186–204, 2000.

[832] I. M. Verstijnen, C. van Leeuwen, G. Goldschmidt, R. Hamel, and J. Hennessey. Creative discovery in imagery and perception: Combining is relatively easy, restructuring takes a sketch. *Acta Psychologica*, 99(2):177–200, 1998.

[833] K. Vertanen and P. O. Kristensson. On the benefits of confidence visualization in speech recognition. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 1497–1500, 2008.

[834] K. Vertanen and P. O. Kristensson. Parakeet: A continuous speech recognition system for mobile touch-screen devices. In *Proceedings of the 14th international conference on Intelligent user interfaces*, pages 237–246, 2009.

[835] R. Vertegaal, I. Weevers, C. Sohn, and C. Cheung. Gaze-2: Conveying eye contact in group video conferencing using eye-controlled camera direction. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '03, page 521–528, New York, NY, USA, 2003. Association for Computing Machinery. ISBN 1581136307. doi: 10.1145/642611.642702. URL `https://doi.org/10.1145/642611.642702`.

[836] F. B. Viegas and J. S. Donath. Chat circles. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 9–16, 1999.

[837] S. Vieweg, A. L. Hughes, K. Starbird, and L. Palen. Microblogging during two natural hazards events: What twitter may contribute to situational awareness. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '10, page 1079–1088, New York, NY, USA, 2010. Association for Computing Machinery. ISBN 9781605589299. doi: 10.1145/1753326.1753486. URL `https://doi.org/10.1145/1753326.1753486`.

[838] G. Villalobos-Zúñiga and M. Cherubini. Apps that motivate: A taxonomy of app features based on self-determination theory. *International Journal of Human-Computer Studies*, 140:102449, 2020.

[839] J. Vines, R. McNaney, S. Lindsay, J. Wallace, and J. McCarthy. Special topic: Designing for and with vulnerable people. *Interactions*, 21(1):44–46, jan 2014. ISSN 1072-5520. doi: 10.1145/2543490. URL `https://doi.org/10.1145/2543490`.

[840] J. Vines, G. Pritchard, P. Wright, P. Olivier, and K. Brittain. An age-old problem: Examining the discourses of ageing in hci and strategies for future research. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 22(1):1–27, 2015.

[841] F. Vitale, J. McGrenere, A. Tabard, M. Beaudouin-Lafon, and W. E. Mackay. High costs and small benefits: A field study of how users experience operating system upgrades. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, CHI '17, page 4242–4253, New York, NY, USA, 2017. Association for Computing Machinery. ISBN 9781450346559. doi: 10.1145/3025453.3025509. URL `https://doi.org/10.1145/3025453.3025509`.

[842] P. Viviani and T. Flash. Minimum-jerk, two-thirds power law, and isochrony: converging approaches to movement planning. *Journal of Experimental Psychology: Human Perception and Performance*, 21(1):32, 1995.

[843] D. Vogel and R. Balakrishnan. Interactive public ambient displays: transitioning from implicit to explicit, public to personal, interaction with multiple users. In *Proceedings of the 17th annual ACM symposium on User interface software and technology*, pages 137–146, 2004.

[844] D. Vogel and P. Baudisch. Shift: a technique for operating pen-based interfaces using touch. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 657–666, 2007.

[845] L. Von Ahn and L. Dabbish. Labeling images with a computer game. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 319–326, 2004.

[846] K. Vredenburg, J.-Y. Mao, P. W. Smith, and T. Carey. A survey of user-centered design practice. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 471–478, 2002.

[847] C. Wacharamanotham, L. Eisenring, S. Haroz, and F. Echtler. Transparency of chi research artifacts: Results of a self-reported survey. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, CHI '20, page 1–14, New York, NY, USA, 2020. Association for Computing Machinery. ISBN 9781450367080. doi: 10.1145/3313831.3376448. URL `https://doi.org/10.1145/3313831.3376448`.

[848] J. Wagemans, J. H. Elder, M. Kubovy, S. E. Palmer, M. A. Peterson, M. Singh, and R. von der Heydt. A century of gestalt psychology in visual perception: I. perceptual grouping and figure–ground organization. *Psychological bulletin*, 138(6): 1172, 2012.

[849] M. Wahlström, A. Salovaara, L. Salo, and A. Oulasvirta. Resolving safety-critical incidents in a rally control center. *Human–Computer Interaction*, 26(1-2):9–37, 2011.

[850] J. B. Walther. Social information processing theory. *Engaging theories in interpersonal communication: Multiple perspectives*, 391, 2008.

[851] J. B. Walther. Theories of computer-mediated communication and interpersonal relations. *The handbook of interpersonal communication*, 4:443–479, 2011.

[852] D. Wang, Q. Yang, A. Abdul, and B. Y. Lim. Designing theory-driven user-centric explainable ai. In *Proceedings of the 2019 CHI conference on human factors in computing systems*, pages 1–15, 2019.

[853] D. Wang, P. Maes, X. Ren, B. Shneiderman, Y. Shi, and Q. Wang. Designing ai to work with or for people? In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems*, CHI EA '21, New York, NY, USA, 2021. Association for Computing Machinery. ISBN 9781450380959. doi: 10.1145/3411763.3450394. URL `https://doi.org/10.1145/3411763.3450394`.

[854] G. Wang, X. Zhang, S. Tang, H. Zheng, and B. Y. Zhao. Unsupervised clickstream clustering for user behavior analysis. In *Proceedings of the 2016 CHI conference on human factors in computing systems*, pages 225–236, 2016.

[855] R. Want, A. Hopper, V. Falcao, and J. Gibbons. The active badge location system. *ACM Transactions on Information Systems (TOIS)*, 10(1):91–102, 1992.

[856] R. Want, B. N. Schilit, N. I. Adams, R. Gold, K. Petersen, D. Goldberg, J. R. Ellis, and M. Weiser. The parctab ubiquitous computing experiment. In *Mobile computing*, pages 45–101. Springer, 1996.

[857] D. J. Ward and D. J. MacKay. Fast hands-free writing by gaze direction. *Nature*, 418(6900):838–838, 2002.

[858] D. J. Ward, A. F. Blackwell, and D. J. MacKay. Dasher—a data entry interface using continuous gestures and language models. In *Proceedings of the 13th annual ACM symposium on User interface software and technology*, pages 129–137. ACM, 2000.

[859] D. J. Ward, A. F. Blackwell, and D. J. MacKay. Dasher: A gesture-driven data entry interface for mobile computing. *Human–Computer Interaction*, 17(2-3):199–228, 2002.

[860] C. Ware. *Information visualization: perception for design.* Morgan Kaufmann, 2019.

[861] E. J. Webb, D. T. Campbell, R. D. Schwartz, and L. Sechrest. *Unobtrusive measures*, volume 2. Sage Publications, 1999.

[862] M. Weigel, T. Lu, G. Bailly, A. Oulasvirta, C. Majidi, and J. Steimle. Iskin: flexible, stretchable and visually customizable on-body touch sensors for mobile computing. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, pages 2991–3000, 2015.

[863] M. Weiser. The computer of the 21st century. *Scientific American*, 265(3):94–104, 1991.

[864] M. Weiser and J. S. Brown. The coming age of calm technology. In *Beyond calculation*, pages 75–85. Springer, 1997.

[865] M. Weiss, F. Schwarz, S. Jakubowski, and J. Borchers. Madgets: actuating widgets on interactive tabletops. In *Proceedings of the 23nd annual ACM symposium on User interface software and technology*, pages 293–302, 2010.

[866] P. Wellner, W. Mackay, and R. Gold. Back to the real world. *Commun. ACM*, 36(7):24–26, July 1993. ISSN 0001-0782. doi: 10.1145/159544.159555. URL `https://doi.org/10.1145/159544.159555`.

[867] E. Wenger. Communities of practice: A brief introduction. 2011.

[868] C. Wharton, J. Rieman, C. Lewis, and P. Polson. The cognitive walkthrough method: A practitioner's guide. In *Usability inspection methods*, pages 105–140. 1994.

[869] M. D. White and E. E. Marsh. Content analysis: A flexible methodology. *Library trends*, 55(1):22–45, 2006.

[870] J. Whiteside, J. Bennett, and K. Holtzblatt. Usability engineering: Our experience and evolution. In *Handbook of human-computer interaction*, pages 791–817. Elsevier, 1988.

[871] A. Whitten and J. D. Tygar. Why johnny can't encrypt: A usability evaluation of pgp 5.0.

[872] C. D. Wickens. Multiple resources and performance prediction. *Theoretical issues in ergonomics science*, 3(2):159–177, 2002.

[873] D. A. Wiegmann and S. A. Shappell. *A human error approach to aviation accident analysis: The human factors analysis and classification system*. Routledge, 2017.

[874] N. Wiener. *Cybernetics or Control and Communication in the Animal and the Machine*. MIT press, 2019.

[875] S. Wiggins. Talking about taste: Using a discursive psychological approach to examine challenges to food evaluations. *Appetite*, 43(1):29–38, 2004.

[876] W. Willett, B. A. Aseniero, S. Carpendale, P. Dragicevic, Y. Jansen, L. Oehlberg, and P. Isenberg. Perception! immersion! empowerment! superpowers as inspiration for visualization. *IEEE Transactions on Visualization and Computer Graphics*, 28 (1):22–32, 2021.

[877] W. Willett, B. A. Aseniero, S. Carpendale, P. Dragicevic, Y. Jansen, L. Oehlberg, and P. Isenberg. Superpowers as inspiration for visualization. *IEEE TVCG*, 2021, 2021.

[878] R. Williams. *The non-designer's design book: Design and typographic principles for the visual novice*. Pearson Education, 2015.

[879] A. D. Wilson. Robust computer vision-based detection of pinching for one and two-handed gesture input. In *Proceedings of the 19th annual ACM symposium on User interface software and technology*, pages 255–258, 2006.

[880] G. Wilson, S. Brewster, M. Halvey, and S. Hughes. Thermal icons: Evaluating structured thermal feedback for mobile interaction. In *Proceedings of the 14th International Conference on Human-Computer Interaction with Mobile Devices and Services*, MobileHCI '12, page 309–312, New York, NY, USA, 2012. Association for Computing Machinery. ISBN 9781450311052. doi: 10.1145/2371574.2371621. URL https://doi.org/10.1145/2371574.2371621.

[881] S. Wilson, M. Bekker, P. Johnson, and H. Johnson. Helping and hindering user involvement—a tale of everyday design. In *Proceedings of the ACM SIGCHI Conference on Human factors in computing systems*, pages 178–185, 1997.

[882] T. Winograd. What can we teach about human-computer interaction? (plenary address). In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '90, page 443–448, New York, NY, USA, 1990. Association for Computing Machinery. ISBN 0201509326. doi: 10.1145/97243.97322. URL `https://doi.org/10.1145/97243.97322`.

[883] T. Winograd. *Bringing design to software.* ACM, 1996.

[884] T. Winograd, F. Flores, and F. F. Flores. *Understanding computers and cognition: A new foundation for design.* Intellect Books, 1986.

[885] D. Wirtz, J. Kruger, C. N. Scollon, and E. Diener. What to do on spring break? the role of predicted, on-line, and remembered experience in future choice. *Psychological Science*, 14(5):520–524, 2003.

[886] I. H. Witten, R. M. Neal, and J. G. Cleary. Arithmetic coding for data compression. *Communications of the ACM*, 30(6):520–540, 1987.

[887] J. T. Wixted and L. Mickes. A continuous dual-process model of remember/know judgments. *Psychological review*, 117(4):1025, 2010.

[888] J. O. Wobbrock and J. A. Kientz. Research contributions in human-computer interaction. *interactions*, 23(3):38–44, 2016.

[889] J. O. Wobbrock, M. R. Morris, and A. D. Wilson. User-defined gestures for surface computing. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 1083–1092, 2009.

[890] J. O. Wobbrock, S. K. Kane, K. Z. Gajos, S. Harada, and J. Froehlich. Ability-based design: Concept, principles and examples. *ACM Trans. Access. Comput.*, 3(3), Apr. 2011. ISSN 1936-7228. doi: 10.1145/1952383.1952384. URL `https://doi.org/10.1145/1952383.1952384`.

[891] M. S. Wogalter. Communication-human information processing (c-hip) model. In *Forensic Human Factors and Ergonomics*, pages 33–49. CRC Press, 2018.

[892] C. T. Wolf. Explainability scenarios: towards scenario-based xai design. In *Proceedings of the 24th International Conference on Intelligent User Interfaces*, pages 252–257, 2019.

[893] T. V. Wolf, J. A. Rode, J. Sussman, and W. A. Kellogg. Dispelling" design" as the black art of chi. In *Proceedings of the SIGCHI conference on Human Factors in computing systems*, pages 521–530, 2006.

[894] J. M. Wolfe. Guided search 6.0: An updated model of visual search. *Psychonomic Bulletin & Review*, 28(4):1060–1092, 2021.

[895] A. S. Won, J. Bailenson, J. Lee, and J. Lanier. Homuncular flexibility in virtual reality. *Journal of Computer-Mediated Communication*, 20(3):241–259, 2015.

[896] J.-b. Woo and Y.-k. Lim. User experience in do-it-yourself-style smart homes. In *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, UbiComp '15, page 779–790, New York, NY, USA, 2015. Association for Computing Machinery. ISBN 9781450335744. doi: 10.1145/2750858.2806063. URL `https://doi.org/10.1145/2750858.2806063`.

[897] J. R. Wood and L. E. Wood. Card sorting: current practices and beyond. *Journal of Usability Studies*, 4(1):1–6, 2008.

[898] A. Worden, N. Walker, K. Bharat, and S. Hudson. Making computers easier for older adults to use: area cursors and sticky icons. In *Proceedings of the ACM SIGCHI Conference on Human factors in computing systems*, pages 266–271, 1997.

[899] P. Wright and J. McCarthy. Empathy and experience in hci. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 637–646, 2008.

[900] A. Y. Wu and C. Munteanu. Understanding older users' acceptance of wearable interfaces for sensor-based fall risk assessment. In *Proceedings of the 2018 CHI conference on human factors in computing systems*, pages 1–13, 2018.

[901] S. P. Wyche, S. Y. Schoenebeck, and A. Forte. "facebook is a luxury": An exploratory study of social media use in rural kenya. In *Proceedings of the 2013 Conference on Computer Supported Cooperative Work*, CSCW '13, page 33–44, New York, NY, USA, 2013. Association for Computing Machinery. ISBN 9781450313315. doi: 10.1145/2441776.2441783. URL `https://doi.org/10.1145/2441776.2441783`.

[902] M. Yamagami, K. M. Steele, and S. A. Burden. Decoding intent with control theory: comparing muscle versus manual interface performance. In *Proceedings of the 2020 CHI conference on human factors in computing systems*, pages 1–12, 2020.

[903] E. Q. Yan, J. Huang, and G. K. Cheung. Masters of control: Behavioral patterns of simultaneous unit group manipulation in starcraft 2. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, pages 3711–3720, 2015.

[904] A. L. Yarbus. *Eye movements and vision.* Springer, 2013.

[905] X. You and D. Hands. A reflection upon herbert simon's vision of design in the sciences of the artificial. *The Design Journal*, 22(sup1):1345–1356, 2019.

[906] S. Zhai. Characterizing computer input with fitts' law parameters—the information and non-information aspects of pointing. *International Journal of Human-Computer Studies*, 61(6):791–809, 2004.

[907] S. Zhai and P.-O. Kristensson. Shorthand writing on stylus keyboard. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 97–104, 2003.

[908] S. Zhai, P. O. Kristensson, P. Gong, M. Greiner, S. A. Peng, L. M. Liu, and A. Dunnigan. Shapewriter on the iphone: from the laboratory to the real world. In *CHI'09 Extended Abstracts on Human Factors in Computing Systems*, pages 2667–2670. 2009.

[909] M. R. Zhang, H. Wen, and J. O. Wobbrock. Type, then correct: intelligent text correction techniques for mobile text entry using neural networks. In *Proceedings of the 32nd Annual ACM Symposium on User Interface Software and Technology*, pages 843–855, 2019.

[910] S. Zhao and R. Balakrishnan. Simple vs. compound mark hierarchical marking menus. In *Proceedings of the 17th annual ACM symposium on User interface software and technology*, pages 33–42, 2004.

[911] H. Zhu, B. Yu, A. Halfaker, and L. Terveen. Value-sensitive algorithm design: Method, case study, and lessons. *Proceedings of the ACM on human-computer interaction*, 2(CSCW):1–23, 2018.

[912] J. Zimmerman. Designing for the self: Making products that help people become the person they desire to be. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '09, page 395–404, New York, NY, USA, 2009. Association for Computing Machinery. ISBN 9781605582467. doi: 10.1145/1518701.1518765. URL `https://doi.org/10.1145/1518701.1518765`.

[913] J. Zimmerman, J. Forlizzi, and S. Evenson. Research through design as a method for interaction design research in hci. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 493–502, 2007.

[914] T. G. Zimmerman, J. Lanier, C. Blanchard, S. Bryson, and Y. Harvill. A hand gesture interface device. *ACM Sigchi Bulletin*, 18(4):189–192, 1986.

[915] A. Zoran and J. A. Paradiso. Freed: a freehand digital sculpting tool. In *Proceedings of the SIGCHI conference on human factors in computing systems*, pages 2613–2616, 2013.