CHAPTER

Case studies 7

7.1 INTRODUCTION

Research into human-computer interaction (HCI), like most other research, is often a numbers game: the more, the merrier. Whether you are collecting data to help you understand the requirements for a new system, evaluating the usability of a new system, or conducting an empirical study aimed at validating a new theory, more participants are better. It takes more time and effort to run 20 subjects than 10 and it may be harder to find 100 people than 30 for focus groups, but the advantages are significant. When you involve large numbers of people, you get a broader, more representative sample. With a small number of people, your chances of getting outliers—those who are significantly faster or slower, inexperienced or expert—are vastly increased. For empirical studies, results that may be statistically ambiguous with a small group may be much clearer with a larger sample.

Unfortunately, for some research projects, a large sample is extremely difficult, if not completely impossible. Fortunately, this is not a cause for despair. *Case studies*, in which researchers study a small number of participants (possibly as few as one) in depth, can be useful tools for gathering requirements and evaluating interfaces.

A case study is an in-depth study of a specific instance (or a small number of instances) within a specific real-life context. Close examination of individual cases can be used to build understanding, generate theories and hypotheses, present evidence for the existence of certain behavior, or to provide insight that would otherwise be difficult to gather. Case studies often use theoretical frameworks to guide both the collection of data from multiple sources and the analysis of the data (Yin, 2014). However, statistical analyses are not the goal. Instead, case studies use careful analysis of carefully selected subjects to generate interesting and novel insights, ideally with an eye on developing general principles that might facilitate understanding of other cases.

Case studies present a different set of challenges from studies involving larger numbers of participants. The first question you might face is determining whether or not a case study is appropriate. Given the small sample size, identifying appropriate participants may be even more important than it is for larger studies. The duration, content, and format of the study will depend upon your goals and resources. Finally, data analysis and interpretation are particularly important: you may want to be careful about making broad, sweeping claims based on your study of one case.

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In a truly reflective style, we look closely at an example of HCI case study research to understand what is involved. Close examination of this one case will illustrate when case studies are appropriate, how they might be designed, how cases are chosen, how data might be collected, and how the data can be interpreted. Examination of this specific case provides us with a clearer understanding of the application of case study research.

7.2 OBSERVING SARA: A CASE STUDY OF A CASE STUDY

Concerns over the limits of narrowly constructed usability studies led Shinohara and Tenenberg to conduct an in-depth examination of a blind person's use of assistive technologies (Shinohara and Tenenberg, 2007). By examining the use of a range of technologies in the user's home, they were able to address several questions that would have been difficult to consider in a lab-based usability study. Specifically, they looked at types of task that were common across multiple technologies, including both digital and physical objects, in order to identify general strategies and understand the trade-offs involved in hardware and software design.

Shinohara and Tenenberg used a series of semistructured interviews (see Chapter 8) to collect the observations that form the basis of the case study. In a series of 6, 2-hour sessions in her home, Sara (not her real name) demonstrated how she used technologies such as tactile wristwatches and screen readers; discussed early memories of using various objects and her reactions to them; and imagined improved designs for various objects or tasks. Notes, audio recordings, interviewer reactions, and photographs from these sessions provided the raw data for subsequent analysis. Insights and theories based on early observations were shared with the subject for validation and clarification.

Analysis and presentation of the case study data took multiple forms. Twelve tasks were recorded in terms of their intentions/goals, limitations, workarounds, and desires for future improvements (see excerpt in Table 7.1). This table can be used to compare and group seemingly unrelated tasks in search of common themes. Detailed descriptions—complete with representative quotations—of Sara's use of a tactile watch and screen-reader software complement this table with illustrative details. For example, discussion of the tactile watch led to a deeper understanding of the importance that Sara placed on aesthetics and her desire to be unobtrusive, as she preferred the comfortable, silent tactile watch to a talking watch, which was both noisier and larger. Examination of Sara's use of a screen reader led to the observation that she would examine all possible options, possibly even restarting from scratch, in order to achieve a goal (Shinohara and Tenenberg, 2007).

Building upon the insights from the individual tasks, Shinohara and Tenenberg identified several general insights that could guide the design of improved tools. Examples included the importance of designs that would not make users feel self-conscious when interacting with sighted friends or colleagues; the importance of control, efficiency, and portability; the need for tools that ease the process of

Table 7.1 Analysis of Sara's Tasks

Object/ Task	Description	Intentions/ Goals	Limitation (What Exactly is Going on?)	Explanation (Why Does the Limitation Happen?)	Workaround (How is the Limitation Overcome?)	Usability of Workaround (Efficiency, Memorability, Satisfaction)	Wish (Desires for the Future)
Navigating with JAWS	Incorrect key strokes may cause her to lose her bearings	Execute an action through specific hotkeys	JAWS is doing something other than the intended action	Other keys may have been hit by mistake	Keeps trying different key combinations to execute intended action	Satisfactory but not efficient	JAWS could help gather her bearings before executing commands
Searching for A CD to play	Linearly searches all CDs	To select a specific CD to listen to	She cannot quickly read CD covers	CD jewel cases not easily identifiable. Labels do not fit on case spines	Labeled CDs, mentally organized by preference, read one at a time	Slow but satisfactory	None
Organizing CD collection	CD collection is placed on two shelves, in almost no particular order	To distinguish CDs in player, preferred ones from least favorites	Discs are not organized in conventional means	She does not have much time; she has a lot of CDs	Three discs currently in CD player have a special spot on CD shelf	Efficient, quick and straightforward	None

JAWS refers to the assistive screen-reading software used to turn text on the screen into speech (http://www.freedomscientific.com/Products/Blindness/JAWS [accessed 19.03.16]).
Excerpted from Shinohara and Tenenberg (2007). Copyright ACM.

distinguishing between similar items (such as CDs); and the need for flexibility and interoperability.

Although Sara does not provide a comprehensive picture of the needs and concerns of blind people, the investigations of her needs and goals led to valuable insights that might apply to many other blind people.

The remainder of this chapter uses this specific case study to develop a broader understanding of case studies in general.

7.3 WHAT IS A CASE STUDY?

A case study is a detailed examination of one or more specific situations. The case study described above helped the researchers to understand how Sara used a variety of technologies to accomplish multiple tasks. They were specifically interested in understanding "what technologies were most valued and used, when they were used and for what purpose" (Shinohara and Tenenberg, 2007). Conducting the research in Sara's home helped the investigators gain insights into how she actually addressed real challenges, as opposed to the more contrived results that might have been seen in the lab.

Four key aspects of this design can be used to describe case studies:

- in-depth investigation of a small number of cases;
- examination in context;
- multiple data sources;
- emphasis on qualitative data and analysis.

7.3.1 IN-DEPTH INVESTIGATION OF A SMALL NUMBER OF CASES

The substantial effort needed to conduct a thorough investigation of each case leads directly to a practical limit on the number of cases that can be included in any given study. The entire Shinohara and Tenenberg (Shinohara and Tenenberg, 2007) study was focused on a single individual: data was collected in her house over the course of approximately 12 hours, with postmeeting debriefings, transcriptions of audio tapes, and photos compiled for analysis. The substantial effort required to collect and collate this body of data is difficult—if not impossible—to replicate for larger numbers of participants.

In this regard, case studies are quite different from experiments that ask large numbers of participants to perform specific, well-defined tasks, leading to results that can be interpreted as applying to a broad range of users. Case studies use in-depth, broad examinations of a small number of cases in order to discuss issues that might provide insights not available in larger user studies. However, this insight comes at a cost, as the focus on a small number of participants increases the risk that the chosen cases might be somehow unrepresentative, thus limiting the generalizability of the conclusions.

Although case studies are small, they need not be limited to only one case. Involving two or more cases is a highly recommended technique for increasing the

credibility of both analyses and results (Yin, 2014). As we will see, the precise definition of a case is not clear (Section 7.5.2). Was Sara's study an example of a case study with one case—the individual—or with twelve cases—the tasks? Answers to these questions are not necessarily obvious.

Case studies are closely related to ethnographic research (Chapter 9) in that both approaches involve close, qualitative examination of a small number—often only one—of situations. Although case studies often use ethnographic observation techniques, classic ethnographic studies are usually more in-depth, conducted over longer periods of time, and more likely to involve a mix of participation and observation than case studies. As the line between case studies and ethnography is often somewhat blurred, it is often best to focus on the techniques used for data collection and analysis, rather than on the label applied to the study.

7.3.2 EXAMINATION IN CONTEXT

Lab-based usability studies have a huge role to play in HCI research. The controlled environments of usability labs are wonderful for removing undesired external influences, but they do not provide a very realistic picture of how people really work. Computer use generally takes place at homes or offices that have distractions, competing concerns demanding attention, and the stress of multitasking in the hopes of meeting competing deadlines. As these factors do not arise in controlled usability labs, observations made in the lab might not generalize to "real-world" behavior.

Unlike lab-based experiments, case studies focus on observation of phenomena in a meaningful context that is beyond the control of the investigator. By observing and closely watching activities as they occur in the real world, free from the predetermined goals and narrowly defined questions that often accompany usability studies and controlled experiments, researchers can use case studies to develop detailed understandings of interaction techniques and coping strategies—understandings that might be hard (if not impossible) to develop through usability studies. In this sense, case studies can be very similar to ethnographic research (Chapter 9), although case studies generally (although not always) lack the participatory aspect associated with some ethnographic studies. Further comparison between case studies and ethnographies can be found in Chapter 9.

7.3.3 MULTIPLE DATA SOURCES

Case studies often rely upon multiple data collection techniques to act as sources of corroborating evidence. In Shinohara and Tenenberg (Shinohara and Tenenberg, 2007), three types of technology biographies (Blythe et al., 2002) were used: demonstrations of devices (*technology tours*), reflections on memories of early use of and reactions to devices (*personal histories*), and wishful thinking about possible technological innovations (*guided speculation*). More generally, these data sources are examples of three commonly used types of case study data: artifacts, observation, and interviews. The case study of Sara also involved the impressions and subjective responses of the researchers.

These three approaches to technology biography provide opportunities for gathering insights that might be difficult to acquire using only one method. By asking Sara to talk about both past experiences and future aspirations, the research design allowed for the possibility of understanding changes in her relationship to technology. Sara's demonstrations of the tools provided an example of current use of artifacts. The examination of tools (such as the tactile watch and screen-reading software) can be an important source of data for case studies, particularly when you are interested in understanding how users complete tasks.

Multiple data sources can also provide corroborating evidence to increase your confidence in observations. In a case study of workplace information management, you might start your data collection with interviews of employees. These discussions provide useful data but they are limited: participants may have different understandings of practices and habits, they may be unwilling to comment on the details of their work, or they may simply forget important details (Chapter 8). Investigation of the artifacts of their work—computer files, paper records, archives, and e-mail messages—can provide concrete understanding of actual practices, free from the limitations of interviews. This analysis may confirm statements made in interviews, thus increasing your confidence in their validity. The use of multiple sources to provide corroborating evidence is known as *data triangulation*—a reference to the practice of taking measurements relative to multiple known reference points in order to precisely measure location.

Multiple data sources can also help deal with any concerns about the quality of the data provided by any single source. Due to the relatively small number of cases involved, the use of any single data collection technique with a particular case may not give you the data that you really need. For example, if Sara had some residual vision that allowed her to make use of some visual display components on a computer screen she might not be an appropriate participant in the case study. We have more to say about selecting cases in Section 7.7, but for now, we mention that simply asking Sara about her use of technology might not have revealed her use of visual displays. A combination of interviews along with direct observation of her work might provide more appropriate measurements; logs of computer activity—taken when she wasn't being directly observed—might be even more realistic.

Of course, the use of multiple data sources does not guarantee nice, clean corroboration of results—if only it were that easy. Two scenarios may arise that make life more interesting. Your data sources might diverge, with each source of data covering different observations. This is not necessarily a problem, as all of the observations may have some validity. When this happens, your use of multiple data sources has not increased the validity of your analyses—you simply have many observations that fail to support each other. You may need to be cautious about your interpretation, refraining from strong claims until you can find some corroboration.

The possibility of contradiction is a more troubling concern. Suppose one source says that something is true, while another says that it is not? You may need to look carefully at the specific details of the claims and the specific sources, in order to determine which is plausible. Contradictions may also motivate you to dig deeper,

asking additional questions of existing sources or consulting new data sources in order to develop explanations that resolve the inconsistencies.

Case studies often draw upon many data sources. Documents, data archives, direct observation, and participant observation (similar to ethnography—see Chapter 9) are just a few of the possibilities (Yin, 2014).

7.3.4 EMPHASIS ON QUALITATIVE DATA AND ANALYSIS

The researchers were not specifically interested in measuring how quickly Sara completed various tasks, how many errors she made, or how quickly she learned to use an interface. Case studies always contain a substantial qualitative component, focusing on questions that help describe or explain behavior (Yin, 2014). In Sara's case, questions might have included "How did she use technology to achieve various goals?" or "which tools did she use in a given circumstance?" The data needed to answer questions such as these tends to be more qualitative than quantitative.

Case studies can certainly include quantitative components measuring traditional metrics, such as task completion time, but these measures are not usually the sole focus of the investigation. In Sara's case, the investigators might have measured the time it took her to complete certain tasks or how frequently she used the tactile watch. As interesting as these measurements might have been, they would not have been sufficient to meet the goal of the study: a deeper understanding of her use of assistive technology. The qualitative interviews, which provided room for in-depth discussion, elaboration of concerns, and discussion of contextual issues, were crucial for achieving this goal.

Quantitative data might be used as a triangulation tool for corroborating results. In this case, Sara's frequency of use of the tactile watch might be used to provide supporting evidence for interview comments describing her perceptions of how she uses the watch. If you choose to use quantitative data in a case study, you should be acutely aware of its limitations: as your case or cases are unlikely to be representative of a larger class, statistical comparisons are generally not appropriate. Having collected data on the frequency of Sara's use of the tactile watch over a period of weeks, investigators might have sufficient data to investigate how Sara's use of the watch changed over time, but they would not have been able to make any comparison between Sara and other tactile watch wearers, or blind people in general.

7.4 GOALS OF HCI CASE STUDIES

Goals of traditional qualitative case studies generally fall into one of three categories (Yin, 2014):

- *exploration*: understanding novel problems or situations, often with the hopes of informing new designs;
- *explanation*: developing models that can be used to understand a context of technology use; and

- *description*: documenting a system, a context of technology use, or the process that led to a proposed design.

HCI case studies address these and one additional goal:

- *demonstration*: showing how a new tool was successfully used.

7.4.1 EXPLORATION

New research projects—whether in a lab or in a product development environment—often begin with an incomplete or preliminary understanding of a problem and its context. Case studies can provide invaluable feedback when a project team is in the early stages of understanding both the problem and the merits of possible solutions. Such studies would have members of the project team examining the goals and constraints facing likely users. Using processes similar to those used in ethnographic work (see Chapter 9), researchers might observe how potential users currently accomplish tasks, use available tools, and respond to problematic situations. The insights that result from this inquiry can inform both system design and further investigation.

7.4.2 EXPLANATION

Technologies in general, and computer systems in particular, are often used in ways that were not considered in the initial design, often with impacts that are completely unexpected. Case studies of tools in use can provide understanding of these uses and outcomes. An examination of the use of a tool for browsing photo collections on mobile devices provides an example of an explanatory study: in-depth interviews with nine users provided substantial insight into how the tool was used and how specific designs might engage users (Naaman et al., 2008).

The Extreme Cases sidebar describes a case study of the use of GPS location devices for tracking parolees. In addition to explaining how these systems affect—often in surprising ways—the behavior of the individuals required to wear them, this case study provided the basis for reconsideration of broader issues regarding mobility and privacy.

EXTREME CASES

Cases are not always selected because they are representative or typical. *Edge cases*—extreme or unusual examples—often present combinations of characteristics that make them particularly worthy of further study. This strategy is used extensively in medical education, where profiles of individuals with puzzling and unusual symptoms are presented as compelling challenges for budding diagnosticians.

As HCI researchers often use case studies as tools for understanding the technology usage and needs of populations of potential users, these

investigations often focus upon representative users and use cases, omitting extreme cases. As understandable as this strategy might be, a focus on general cases may miss out on some of the insights that might be gained from examining less familiar perspectives.

Geo-location services—tools that combine global positioning system (GPS) facilities with data and communication tools—have spawned numerous computing tools and services. Possibilities include facilities for finding nearby friends or restaurants; games; educational systems based on the location of items of interest in natural environments; and location-based data collection covering entire cities.

A case study based on extremes was used to explore some of the questions regarding perceptions of location and privacy (Troshynski et al., 2008). This investigation examined the habits and perceptions of a group of sex offenders who were required to have their locations tracked via GPS as part of their parole agreements. Building from theories that argue that marginalized groups may possess instructive insights into society, these researchers hoped to use this extreme population to reconsider HCI questions about location-based systems. Data collection involved semistructured focus group sessions with 10 parolees who were already participating in a pilot study on the use of GPS for parole supervision for sex offenders. Although several individuals participated, comments were analyzed as an undifferentiated whole, making this a single-case study of the group of parolees.

Analysis of the focus group data led to the identification of three main themes describing the impact of the system on the participants. The GPS systems structured their perception of space, making them acutely aware of how far they were from home and how close they may have come to forbidden locations such as schools and parks. The systems also constrained their time: the need to regularly charge batteries limited their ability to spend long periods of time away from convenient sources of electricity. The parolees' sense of their bodies was also changed, as the ankle-mounted GPS units both made certain clothing choices (such as short pants) impractical and effectively prohibited swimming, bathing, or other activities that might have exposed the unit to the possibility of water damage. The researchers used these insights to fuel a more general consideration of location-based interfaces in specific social and cultural contexts (Troshynski et al., 2008).

The value of these extreme cases lies in the distance between their perspectives and motivations and those of "typical" users of GPS-based computing systems. Generalization was not the goal of this study—it is hard to see how the concerns of a group of parolees who were required to use these systems might be applied to voluntary users of location-based systems for game playing or locating friends. Instead, the comments of this atypical user group provided a richer understanding that might not have emerged through investigation of the expected case.

7.4.3 DESCRIPTION

A description of a system and its impact can be of interest. In some cases, particularly those involving new design methodologies, the process behind the design may be the focus of a case study. In general, a single-case study describes a problem, the steps that were taken to understand it, the details of the eventual design, and the lessons learned that might be of more general interest. Case studies that describe design processes and results have been written for a wide variety of topics, including interfaces for people with Alzheimer's disease (Cohene et al., 2007) (see sidebar), fire alert services in South Africa (Davies et al., 2008), browsers for a collection of music written by a composer (Hochheiser, 2000), and mobile interfaces for sharing navigation information in cities (Bilandzic et al., 2008).

INTERFACES FOR PEOPLE WITH ALZHEIMER'S DISEASE

The process of developing a novel interface or interaction technique is often as interesting, if not more interesting, than the resulting product. This is particularly true for design efforts that tackle novel problems involving challenging contexts of use.

A University of Toronto project involving the design of an assistive technology tool for people affected by Alzheimer's disease provided the basis for an intriguing case study (Cohene et al., 2007). This project was based on a body of prior work that firmly established the importance of reminiscences for people with Alzheimer's disease. Specifically, the researchers were interested in developing multimedia "life histories" that people with Alzheimer's disease could use to recall and relive old memories. The case described the process of developing a system to be used by a 91-year-old woman named Laura.[1] The participation of Laura and her two daughters formed a crucial part of the study.

The initial phases of the study included exploratory efforts aimed at developing an understanding of the challenges faced by people with Alzheimer's disease and their families. Although the study was focused on developing a tool specifically for Laura, the researchers conducted a variety of inquiries aimed at providing greater understanding of the needs and abilities of individuals with Alzheimer's disease. The researchers conducted a modified ethnographic inquiry (see Chapter 9), interacting with groups of individuals engaged in recreational therapy activities. These observations provided a detailed understanding of the range of abilities and impairments of the participants, leading to a set of design principles. Discussions with caretakers and other experts formed the basis for a set of categories and themes that would assist with reminiscing.

Interviews with Laura's family members informed both the content of the life histories and an understanding of important needs and outcomes. Family members also completed a "family workbook" that contained storyboards describing stories that would be recounted with the tool to be developed.

[1] All names of participants in this study were changed to protect their privacy.

Photographs, home videos, and music were collected that formed the basis for the multimedia components of the tool. This data provided the basis for several generations of prototype, culminating in designs including multimedia DVDs to be controlled by a customized input device and an interactive photo album, with pages that could be displayed on a TV monitor. These descriptive elements in the case study give a detailed picture of how the research was conducted and how it informed the system design.

Elements of explanation and demonstration can be found in the discussion of how the prototypes were evaluated and refined. As with many HCI projects that examine new tools, this effort involved having the participant make frequent use of the tool over an extended period of time—in this case, eight times in 4 weeks.

This led to ideas for refining some designs, including modifying the design of the one-button remote control, while abandoning others, such as the interactive photo album, which was perceived to be too cognitively demanding. Follow-up interviews with family members confirmed initial hypotheses that the system would have multiple benefits for the participants, including providing perspective, sharing experiences, and communicating.

This project as a whole is an exploratory case study. As relatively little work has been done on user interfaces for people with Alzheimer's disease, the description of a successful process is valuable in and of itself. The design ideas presented raise interesting possibilities, but in many ways they raise more questions than they answer. The broad range of cognitive impairments experienced by people with Alzheimer's disease and the varying impacts that their condition has on family members makes generalization very hard: what works well for one individual and their family might not work well for others. Extending the applicability of this work—particularly by scaling the design process—was clearly a goal of the research team, as they describe further efforts involving additional participants and improving the process of designing life histories.

The intensive nature of the research—requiring substantial time commitments both from the individual with Alzheimer's disease and from family members who are dealing with the emotional strain of the decline of a family member—made the work extremely resource intensive. The elaboration of the design process and the completion of one specific design are important contributions, even if the resulting design does not generalize to other users.

The most broadly applicable results from this story lie in the lessons learned. The authors concluded that new design methods and principles were needed for working with individuals affected with Alzheimer's disease that active participation was more stimulating than passive, and that working with both the patients and their family members throughout the entire design process was necessary. Practical concerns included the resource-intensive nature of the research, the emotional commitment required of the family members, the need to make the approach practical for larger numbers of families, and the need for standards for evaluation (Cohene et al., 2007). Although drawn from this particular project, these insights might be extremely valuable to others interested in conducting related research.

7.4.4 DEMONSTRATION

Usually shorter and less in-depth than descriptive case studies, demonstrations are often found in papers describing new designs. Short anecdotes describing how one or more individuals successfully used a new tool to complete one or more appropriate tasks often complement usability studies, controlled experiments, and other data documenting the success of the design.

Demonstration case studies can play an important role in describing the success of a new design or tool, particularly when a controlled user study is inappropriate or impractical. This is often the case with a complete tool, which may have many elements and multiple metrics for evaluation. Demonstration case studies can also be appropriate in cases where the broad scope of the interface may preclude the use of a controlled study.

Demonstration case studies tend to follow a common pattern. The report generally starts with an introduction of the participants and their context of use. Other elements often found in the report include descriptions of how the participants used the system, problems they faced, strengths of the system design, and discussions of subjective responses. See the Interfaces for People with Quadriplegia sidebar for a discussion of such a case study.

INTERFACES FOR PEOPLE WITH QUADRIPLEGIA

Building interfaces for quadriplegic people is a significant challenge: without the use of their hands, fingers, or feet, these individuals may be restricted to using input devices that consist of a single action, such as blowing on a straw or pressing a single switch. Interfaces for such users are generally based on some form of scanning: a graphical window on the computer screen contains a grid of buttons that are scanned—highlighted in some predictable order—with each button being active for a given amount of time. When the desired button is highlighted, the user activates the switch to make a selection.

Steriadis and Constantinou (2003) include a demonstration case study as a partial validation of the proposed design of a new interface architecture. This paper presented widgets for single-switch input devices ("wifsids") that support a model of button selection appropriate for both discrete text input from the keyboard and continuous mouse movement. These widgets were used to build a set of applications that would run in Windows, supporting cursor movement, keyboard entry, selection of applications, macros for common functionality, and other features.

The case study described how the system was used by a 35-year-old man with amyotrophic lateral sclerosis (ALS), which left him bedridden and unable to speak. The paper describes how the participant decided to use a button between his knees to make selections, after having rejected other inputs as being difficult to use, cumbersome, or unattractive. The description of the participant's success in learning how to use the system, and in using

it for communicating with family and the Internet, forms an important part of the description. Details of his use of the various components, along with initial difficulties and their resolutions, are also described (Steriadis and Constantinou, 2003).

This individual's success may not be generalizable: the system might not work so well for others. However, this is not the only evaluation found in the paper. An empirical study of how the typing rates of two additional quadriplegic users varied with word-prediction schemes formed the basis for a discussion of factors that might influence typing rate. Even though this study only involved two users, it provides some insight into the factors that influence success in using the tool to type text. The case study and the empirical study work together in a complementary fashion to demonstrate the strengths and limitations of the proposed system.

The four classes of case study are not mutually exclusive. Sara's case study has elements of both exploration and explanation. The Interfaces for People with Alzheimer's Disease sidebar describes a study involving elements of exploration, description, and demonstration.

7.5 TYPES OF CASE STUDY

7.5.1 INTRINSIC OR INSTRUMENTAL

Case studies are often conducted to shed light on a specific situation. You may be working with a client to design a new organizational website. A case study of the client's work processes, corporate organization, and information-sharing practices and procedures would inform your design process, but the results would be likely to apply only to that client. These *intrinsic* studies (Stake, 1995) describe cases that are of interest to a particular situation.

Case studies can also work towards developing a broader understanding. These *instrumental* case studies ask questions in the hope of generating insights that go beyond the case at hand. They become tools that lead to a broader understanding. Sara's case study involved the instrumental goal of identifying difficulties and workarounds that might be used by many others—not just Sara (Shinohara and Tenenberg, 2007).

Case studies can be both intrinsic and instrumental: it might be argued that Sara's case is both interesting in its own right (intrinsic) and aimed at broader understanding (instrumental).

7.5.2 SINGLE CASE OR MULTIPLE CASES

Although Sara's case study focused on one person's use of technology, case studies are certainly not limited to single cases. The use of multiple cases may initially seem

to be a bit of a contradiction in terms, but there is nothing strange about doing case-study research with two or more cases.

To understand why you might use multiple cases when one might seem to do just as well, we must consider one of the important goals of many instrumental case studies: generalization. An in-depth discussion of one individual (such as Sara) is interesting, but the real value in a study of this sort lies in generating insights that can be applied to a broader class of design challenges. We might be pleased if Sara's case study led to some suggestions for the design of assistive devices that would help Sara with her daily challenges, but we would often like to go further. If the case study led to insights that apply to many blind people, any resulting designs might be useful to a much broader range of blind users.

If our goal is to generalize, we would ideally argue that our cases are somehow representative. They must be similar to the members of the broader group that is the focus of our generalization, at least in ways that are relevant to the study at hand. A single case may or may not be representative, and we may not have any way of evaluating whether or not any single case provides a basis for generalization. From the description of her tasks and challenges, we might infer that Sara is a reasonably representative blind college student, but we really can't say for sure. She may be more (or less) experienced with computers than other blind college students, more (or less) willing to try new technologies, and so on. Casting a broader net, we might wonder if insights gained from interviewing Sara can apply to blind people of different ages or education levels, such as working professionals or elementary school students.

Just as scientific experiments of all sorts rely upon replication to provide increased confidence in observed results, case studies can use multiple cases to provide critical support for confidence in the generality of any results. Suppose another college student had been interviewed, following the same protocol that was used with Sara. If the observations and insights gained from the two studies were similar, we might be more inclined to believe that these results were applicable to blind college students in general. This use of closely comparable cases to demonstrate consistency of results is known as *literal replication* (Yin, 2014).

The analogy between case studies and other scientific experiments can lead us to another useful form of multiple-case studies. Experimentation relies upon contrasts between situations that are similar but differ in specific, controlled ways. When these situations are created correctly, observed differences in experimental outcome can be attributed to the differences between the groups. Multiple-case studies might use cases with specific differences in much the same manner. Imagine an extension of Sara's study that involved a blind executive instead of another student. Differences between Sara and the executive in terms of how they use technology might be due to differences in their occupations.[2] The use of comparable cases to generate results that differ in ways that can be explained by differences between the cases is known as *theoretical replication* (Yin, 2014). The International Children's Digital Library sidebar describes a multiple-case study involving theoretical replication.

[2] Differences in age and economic resources might also play a role. Strictly controlling for differences is difficult with cases involving human participants.

THE INTERNATIONAL CHILDREN'S DIGITAL LIBRARY

The International Children's Digital Library (ICDL, http://www.childrenslibrary.org) is an online repository of thousands of books from around the world. Built "to help young people understand the value of tolerance and respect for diverse cultures, languages and ideas" (Druin et al., 2007), the ICDL provides interfaces specifically designed to support children in searching for and reading books. Search tools support strategies that children might use for finding books (such as the color of the cover, the types of character, or the length of the book) and several reader tools support a variety of reading strategies (Druin et al., 2007).

The ICDL's ambitious goals of serving a diverse group of children from all over the world presented a challenge and an opportunity. By studying how children in different countries with different economic and social backgrounds, used the ICDL, the research team hoped to gain a better understanding of how children in varied settings would interact with the ICDL. As both the interface and content are multilingual, they could examine the use of this single tool in diverse contexts, in order to understand how usage patterns differ across cultural boundaries.

The resulting multiple-case study involved students in four distinct geographical locations: Munich, Germany; Le Ceiba, Honduras; Wellington, New Zealand; and Chicago, USA. Three 8-year-old children participated in each location, along with parents, teachers, and administrators. Data collected over the course of 4 years included open-ended interviews with both children and adult participants, drawings that children made to illustrate their ideas about libraries, and book reviews that the children wrote. Grounded theory and content analysis approaches (see Chapter 11) were used to analyze the 152 interviews, 236 drawings, and 301 book reviews that were collected over the course of the study.

Although there were multiple participants at each site, data analysis focused on understanding how use patterns and responses differ across these varied circumstances. As the individual children were not the units of analysis, this case study can be seen as a holistic case, multiple-case study. The four groups can be seen as theoretical replications, with their varied backgrounds providing opportunities to examine how observed phenomena differ across cultures.

As differences between the groups were largely attributable to preexisting cultural differences, the results of this study demonstrate the likely outcome of theoretical replication. All children seemed to appreciate the digital library and the range of books that they read over time increased. Children in all four locations found books in languages that they did not know to be difficult or frustrating and they all liked the search tools but preferred to read physical books. They all valued libraries and children in all groups became more interested in learning about different cultures. Differences in responses may have been due to specific differences in circumstances. Compared to children

(Continued)

THE INTERNATIONAL CHILDREN'S DIGITAL LIBRARY—CONT'D

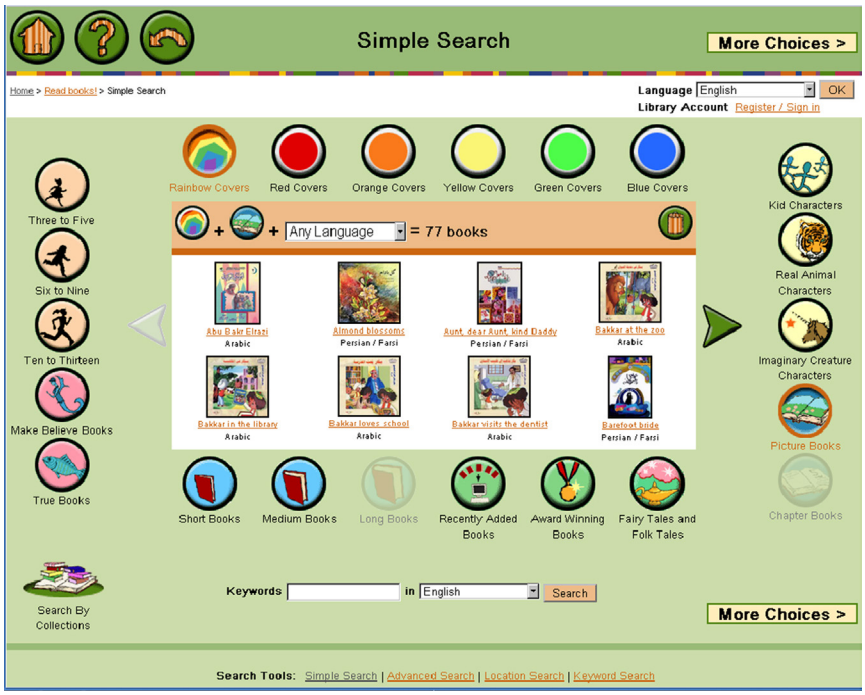

FIGURE 7.1

The search interface for the International Children's Digital Library provides young readers with search tools designed to meet their interests.

From the International Children's Library (http://www.childrenslibrary.org).

in the other countries, German children showed less increase in confidence in their ability to use technology effectively. However, the German children may have started out with higher levels of exposure to technology. Similarly, children in the United States—who live in a relatively homogenous environment—showed greater increase in interest in diverse cultures than children from the other, more diverse cultures (Figure 7.1) (Druin et al., 2007).

Increased confidence in the results may be a compelling argument for involving multiple cases in your studies. Multiple cases help to combat criticisms that you have chosen a single case that is unrepresentative. Any single case can be idiosyncratic, but multiple cases are much less likely to be unrepresentative in the same ways. "Cherry-picking" a single case to support hypotheses or justify a preexisting model might be possible, but this sort of bias—whether intentional or not—is less likely with multiple-case studies.

Despite the advantages of multiple-case studies, there may be some times when a single case design is the more—or only—appropriate option. If you are studying the use of a custom piece of software in a single workplace, you may be unable to find additional cases. Single-case designs are the only option in such cases (Yin, 2014). Cost—both in terms of financial and human resources—can also play a role in the decision to use a single-case design. Case studies can often be labor intensive, requiring extensive effort for preparation, data collection, and analysis. You may be unable to find the time needed for additional cases, as much as you might want to include them.

The goals of your study may play a role in determining whether you should use a single case or multiple cases. Multiple cases are most useful when you are interested in generalizing your results, but this may not be your goal. Some case studies may describe a unique case that cannot easily be compared to others, making a multiple-case study difficult, if not impossible. Other studies—such as Sara's—may be exploratory in nature, focusing on the generation of ideas and formulation of questions for future research (see Section 7.4.1). These exploratory case studies might lead to in-depth inquiries with broader populations, using surveys or other less expensive data collection approaches.

Although generalization may be appealing, extrapolating from a small set of cases to a larger population is not something that should be done lightly. Even if you do choose to use multiple cases, you should always be very cautious about any claims of generality. Some researchers feel that generalizing from case studies is always inappropriate—without a broad-based sample that can be shown to adequately represent a population, how can you conclude that any of your findings apply to all members of the larger group? Multiple cases can help you identify phenomena that might apply across larger groups, but you would need to conduct further research to truly justify claims of generality. By all means, look for these trends, and use multiple cases to show that they apply in multiple instances, but steer clear of any claims that imply that they will always apply.

7.5.3 EMBEDDED OR HOLISTIC

Even with only one participant, Sara's case study may be more complex than you might initially think. Although only one individual is involved, this case study discusses 12 tasks. Each of these tasks is a *unit of analysis*—a distinct subject of investigation. The inclusion of multiple units of analysis within a single case is referred to as an *embedded* case study, in contrast to *holistic* studies that address only one unit in each case (Yin, 2014).

This distinction arises at least in part from the nature of the questions being asked: as Sara uses multiple tools in different ways to address daily activities, any investigation of her use of technology should discuss these differences. A case study that did not address these differences might miss many interesting insights. Other examples of embedded designs might include academic departments in a university or designers on a product team.

Integration of the multiple units of analysis is an important aspect of embedded case study design. In Sara's case, insights from the various tasks were combined in a classification of challenges that she faced, including control, efficiency, portability, and interoperability. Just as these categories provide additional understanding of the individual tasks, individual units of analysis in an embedded design might be grouped or viewed from common perspectives.

The inclusion of multiple participants in a case does not necessarily imply an embedded case study. If participants are not discussed individually, with analyses identifying similarities and differences between them, they are not distinct units of analysis. In this case, the group is the unit of analysis in a holistic study. A study of virtual collaboration in a school in Finland provides an illustration (Lakkala et al., 2007). Although the class involved 14 students and seven teachers, the case study does not discuss students and teachers in any detail. Specific comments from both teachers and students are cited in the paper, but there is no attempt to discuss any of the participants as individuals, making this a single-case, holistic study. The sidebar on the International Children's Library presents an example of a case study involving a theoretical replication across four comparable groups, each of which is a single unit of analysis.

A paper discussing strategies for sustaining a "community computing infrastructure" provides an interesting example of an embedded case study (Farooq et al., 2007b). This single-case study examined an online community aimed at supporting professional development for teachers. Four "design interventions"—contact and bug forms, "needed features" group, task list, and help desk—were chosen as the units of analysis, due to their differences in terms of goals, primary mode of communication, participants, and implications for use. Separate discussions of each of these interventions complemented a general examination of how they worked together to support the continuing success of the community.

Although the distinction between holistic and embedded analysis might ideally be made before the study is conducted, the need for multiple units of analysis may not be clear until after data collection has started. A study of the use of a groupware tool in a corporate setting might start out as a holistic study of the tool's use in a given group, only to evolve with time to include embedded analyses of the differing tasks for which the tool would be used, the roles of the various members in the group, or the types of project for which it might be used.

7.6 RESEARCH QUESTIONS AND HYPOTHESES

As with almost any other form of research, a good case study is built on the foundations of a theoretical model. Although these theories might not be cleanly testable hypotheses that can be easily disproved, they can be used to describe what you are looking for, what you think you might find, and how you will use your data to support your theories.

Roughly speaking, there are four components of a case study design[3]:

- questions;
- hypotheses or propositions;
- units of analysis; and
- a data analysis plan.

Research *questions* describe the goals of your study—what you are interested in understanding.

Hypotheses or propositions are statements of what you expect to find. The *unit of analysis* defines the granularity of your study—what exactly you are focusing on. Are you studying an organization, a group of people, an individual, or individual activities? These questions will guide your data collection. The final component—a *data analysis plan*—is described in Section 7.8.

Just as in other forms of research, your research questions and hypotheses guide your efforts. You may be interested in understanding how users accomplish certain goals or tools, how the introduction of a new tool changes the workflows and patterns in an organization, or what a team needs from a new collaboration tool. Even if your case study is exploratory or descriptive, you should try to make your research questions and propositions explicit.

Taken together, your research questions and hypotheses form a preliminary model that will guide your development of the case study. By mapping out your interests and the range of concerns that you are trying to address, you will gain greater understanding of the criteria that you will use to choose your cases, the data sources that you might need to include, and how you will conduct your analysis. The approach of ignoring theory in favor of simply collecting data indiscriminately can be a recipe for failure (Yin, 2014).

In Sara's case study, the researchers were interested in understanding how a blind person might use a variety of assistive technologies to accomplish tasks and to recover from task failures using workarounds. These questions led to several propositions. The investigators expected to see common types of failures and workaround strategies. They also expected that the choice of implementing features in hardware or software might influence user interactions, including failures and responses to those failures.

A different set of research questions might have led the researchers to a very different case study. If, for example, a preliminary study had led them to believe that education or socioeconomic status might play an important role in determining how blind people use technology, they might have chosen a multiple-case design, including participants with backgrounds that differed in these relevant respects. They might also have asked a broader range of questions about background and included consideration about other aspects of their participants' lives.

[3] This list is based on Robert K. Yin's list of five components. His list divides the “data analysis plan” into two components: the logic linking the data to the propositions and the criteria for interpreting the findings (Yin, 2014).

A study of sociability in massive, multiplayer, online games provides another example of the important role of theory in case study design. In Ducheneaut et al. (2007), the researchers were interested in asking whether social spaces in these games acted as "third spaces," where players would socialize, just as coffee shops and other spaces support socializing in the real world. This question led them to choose a particular online game that provided strong support for social spaces, a data collection strategy involving active participation in these spaces in the game, and an analysis strategy that combined analysis of observations from their participation with quantitative analysis of activity in the game.

Once you have defined your questions and hypotheses, you can move on to consider other questions of case study design, including the type of case study, selection of cases, data collection, and data analysis.

7.7 CHOOSING CASES

Single-case studies may present little, if any, difficulty in case selection. Case studies often involve cases that are somehow unique or incomparable to others. Intrinsic case studies limit you to consideration of the specific instance of interest. Convenience can also be a factor—you may choose a specific case "because it's there." This is often the case when you are not particularly concerned about generalizing: when conducting an exploratory case study aimed at building initial understandings of a situation, any case might work (see Section 7.11). In all of these instances, selection is straightforward: you work with what you have available. Otherwise, you will want to put careful consideration into your criteria for selecting cases.

There are a few general guidelines that apply to almost any sort of case study. Like ethnographic investigations (Chapter 9), case studies require a great deal of time, careful preparation, and often close cooperation with one or more individuals or organizations. Given these challenges, the individuals, groups, organizations, or systems that you choose should be chosen carefully. You will want to try to identify case study participants who have an interest in committing some of their own resources to work with you to make the research successful. You should also try to maximize convenience, working with geographically convenient participants whenever possible.

Further considerations in your choice of cases will be driven by the details of your research design. If you are conducting an instrumental case study aimed at developing generalizable models of classes of users or contexts, you should aim for cases that are representative in the appropriate aspects. Although the analysis tools may be different, this is the same problem faced by quantitative user studies (see Chapter 2): if the participants in your study are sufficiently different from the group to which you are generalizing, your findings may not hold up, no matter how strong the analysis. Thus, if you are doing a case study to understand how technically unsophisticated users interact with antispyware and antivirus tools, you probably don't want to ask computer science undergraduates, who are likely to be more technically savvy than most

users. The additional credibility that comes from having appropriate participants is referred to as *external validity* (Yin, 2014).

Multiple-case studies reduce concerns about external validity somewhat, as consistent findings across your cases can be used to counter the argument that you are describing some idiosyncrasy of your specific participants. However, these problems reappear if you are attempting theoretical replication—members of each group must both represent that group appropriately while differing from other groups in the appropriate dimensions.

Sara's case study provides an instructive example of case selection. When reading the paper, all we are told about Sara is that she is a blind college student. We are not given any other details about her age, background, or socioeconomic status. However, we can infer from the list of tasks—which includes activities such as organizing CDs, cooking, and receiving text messages by cell phone—that she is fairly active and self-reliant. In other words, as far as we know, she may be an appropriate participant for a study of the workaround strategies used by people who are blind. We might not be able to make generalizations that apply her results to other people, but that would be true of any single participant. Furthermore, as the study was described as descriptive and explanatory (Yin, 2014), the authors do not make any claims of generality.

Some case studies specifically seek out unusual, distinctive, or "edge" cases. When studying antispyware or antivirus tools, you might argue that computer science undergraduates are worth studying because you would look for an understanding of how their domain expertise helped them approach challenges that would stop less knowledgeable users. The Finnish study of virtual collaboration in a school setting was conducted in a school that was chosen specifically because "the pedagogical setting had several features that may be described as innovative" (Lakkala et al., 2007). See the Extreme Cases sidebar for a description of a case study that specifically sought out an atypical set of participants in order to get a fresh perspective on an established problem.

Some studies use *critical cases*—cases that are somehow particularly distinctive or notable with respect to the problem that is being considered (Flyvbjerg, 2006). For example, a case study examining the use of antivirus software by employees of a large company might focus on a firm that required all staff members to complete extensive training in the use of the tools in question. This required training makes the firm a strong candidate for success: if antivirus software isn't used there, it might not be used anywhere. Thus, the company becomes a critical case.

Still other strategies for identifying cases are possible. You might search for cases that are most or least likely to exhibit behavior that you are interested in investigating (Flyvbjerg, 2006).

If you find yourself trying to choose from a large pool of potential cases, consider expanding your research agenda to include a screening survey (Yin, 2011). A carefully constructed survey of potential participants can provide data that informs your selection process. Such surveys might assess both the fit between the participants and your criteria and the willingness of the participants to commit their time and energy to the success of the study. Ideally, screening surveys stand

on their own as research results, providing insights into the larger group of respondents not selected for closer examination in your case study (Yin, 2011). See Chapter 5 for advice on conducting surveys.

7.8 DATA COLLECTION

Having defined your research questions, chosen the number of cases and the units of analysis, and determined whether your study is embedded or holistic, you are ready to plan your data collection. Specifically, you need to define the types of data you will collect and the specific procedures you will follow for collecting those data.

7.8.1 DATA SOURCES AND QUESTIONS

As described in Section 7.2, case studies often, if not always, rely on multiple data sources. Data sources for case studies in other fields include documentation, archival records, interviews, direct observation, participant observation (similar to ethnography), and physical artifacts (Yin, 2014). For HCI research, you may find yourself adapting and adding to this list as appropriate. If you are trying to understand someone's use of existing computer tools, e-mail messages, web history logs, and related data sources may be considered archival. Logs of specific activities with applications of interest might be available or you might be able to use a variety of technical approaches for collecting such data (see Chapter 12).

Your research questions and hypotheses will play a significant role in determining which of the available data sources you will use. Documentation and archival records are likely to be most interesting if you want to understand past and current practices and use of existing software tools. Interviews are helpful for understanding perceptions, concerns, needs, and other user reactions. Direct observation can help you understand what people do in circumstances of interest, while participant observation can be a powerful tool for understanding complex organizational dynamics. For HCI researchers, artifacts can be used to provide valuable examples of how people bridge the gap between computer work and the rest of their lives. Classic examples include paper notes stuck to the edge of computer monitors.

Your choice of the types of data that you will collect should be guided by the goal of using multiple sources that address your questions from different perspectives. Sara's case study took this approach, combining interviews about early technology use, demonstrations of various physical and software artifacts, and speculation about desired designs.

By using your research goals to guide a careful selection of data sources and specific questions, you will increase your chance of generating the multiple sources of evidence that form the backbone of data triangulation. A design that makes clear and explicit links between each of the data sources and your research questions will help you understand which questions are addressed by multiple data sources, and which are not. If you find that you have questions that are only represented in one of the

data sources, you might want to rethink your design, adding additional data sources or questions.

7.8.2 COLLECTING DATA

Once you have identified your data sources, you need to develop protocols for how you will use each of them to collect data. For interviews, this will include the type of interview, questions, and an interview guide (see Chapter 8). Similar approaches can be used for examination of artifacts. Observations require you to specify the structure of the tasks that will be performed and the questions that will be asked. Each data source, in effect, becomes a mini-experiment within the larger case study, all tied to the common goals of the study as a whole.

You should also develop a protocol for the case study as a whole. In addition to the specific data sources and the procedures that you will use in examining each of these sources, the protocol includes important details that are needed to conduct the case study from start to finish. The case study protocol should start with an introduction, including the questions and hypotheses. It should continue with details of data collection procedures, including criteria for choosing cases, contact information for relevant individuals; and logistical plans for each case, including time requirements, materials, and other necessary preparations. Specific questions and methods for each of the data sources should be included in the protocol. Finally, the protocol should include an outline of the report that will be one of the products of the case study (Yin, 2014).

Although this may seem like an excessive amount of overhead, effort spent on careful development of a protocol is rarely wasted. The process of developing a clear and explicit explanation of your research plan will help clarify your thinking, leading to a better understanding of possible shortcomings and challenges that may arise during the study. Any problems that you identify can stimulate reconsideration and redesign, leading to a stronger research plan.

A draft outline of your report serves a similar purpose. Constructing a report before you collect any data may seem strange, but it's actually quite constructive. Many of the sections of your report are easy to enumerate: your report will always contain an introduction to the problem, a description of your questions and hypotheses; an explanation of your design and how it addresses those questions; informative presentations of data and analysis; and discussions of results. Within each of these components there is substantial room for adaptation to meet the needs of each project. An outline that is as specific as possible—even down to the level of describing charts, tables, and figures to be used for presentation of data and analysis—will help guide your design of the questions and methods that you will use to generate the necessary data.

A case study protocol can be a powerful tool for establishing reliability (Yin, 2014). If your protocol is sufficiently detailed, you should be able to use it to conduct directly comparable investigations of multiple cases—the protocol guarantees that differences in procedures are not the cause of differences in your observations or

results. Ideally, a research protocol will be clear enough that it can be used by other researchers to replicate your results.

Consider running a pilot case study. Pilot tests will help you debug your research protocols, identifying questions that you may have initially omitted while potentially exposing flaws in your analysis plans. For some studies, a pilot may not be possible or desirable. If you have a unique case, this may not be possible. If your study is exploratory, you may find that a single case will provide you with sufficient data to generate an informative analysis.

7.9 ANALYSIS AND INTERPRETATION

As qualitative data is a key component of case study research, your analysis will use many of the techniques and strategies discussed in Chapter 11. You should start planning your data analysis early in the process, before you collect any data. Grounded theory, content analysis, and other techniques from Chapter 11 are commonly used to analyze case study data.

Perhaps the largest challenge in the analysis of case study data involves the limited range of data samples. Unlike controlled quantitative experiments, which use large numbers of participants to generate statistically significant results, case studies rely on a few samples, which may be idiosyncratic. This may present challenges if you are interested in building general models: how can you be confident that conclusions drawn from experience with your cases generalize to others?

To some extent, these validity concerns are inherent in case study research. No matter how carefully you choose your cases, collect your data, or conduct your analysis, your case study may lead to interpretations that are not valid or do not generalize to other cases. You should always keep in mind that case study results may not generalize. Even if yours seems to point to trends that hold in all cases, you should avoid assuming that those trends are truly general.

Careful attention to the strategies described in Chapter 11 can help increase the rigor of your analysis and confidence in your conclusion. Triangulation, documentation of chains of evidence, and consideration of rival theories are all appropriate tools for case study analysis.

Case study analysis generally proceeds in a bottom-up fashion, using techniques from grounded theory to code and categorize data (see Chapter 11). In Sara's case, the analysis might have involved examining all of her descriptions of previous interactions with technology, her current approaches and speculative desires for solving a specific task. Any conclusions that were supported by all three of these approaches might be seen as being reasonably valid. These analyses could then be used to form an integrated description of the unit of analysis—the specific task.

After analyzing individual units of interest, you are likely to want to push your analysis to help you understand larger trends that describe your case as a whole and (for multiple-case studies) can be used to support comparison of similar cases. The goal here is not necessarily to make everything agree: there may be fundamental

differences between individual units of analysis or cases. That's fine. The point is to facilitate understanding of the differences and similarities between the individual elements.

The multiplicity of data sources used in case study research can support data source triangulation (Chapter 11). If you can use artifact, interview, and observation data together to provide a consistent interpretation of certain aspects of the case under examination, you will have a strong argument in favor of the validity of your interpretation.

Appropriate data displays can prove invaluable in this process. If you have multiple units of analysis that can be described in many ways, you may create a matrix display (Miles and Huberman, 1994) that lays out the data in a tabular format. With one unit of analysis per row and a specific aspect of the analysis in each column, these displays can easily be used to understand an individual unit (reading along a row) or to compare some aspect of each unit (reading down a column), see Table 7.1.

The relationship between the theory behind the case study design and the analysis of Sara's individual tasks provides an opportunity for the use of an important case study analysis technique—pattern matching. In this approach, case study observations can be matched to predictions from the theory behind the design. Matches between the observations and the theory provide support for the theory (Yin, 2014). The specific pattern that is being matched in Sara's study can be found in the researchers' discussion of their study: they initially believed that Sara would use a wide range of technological approaches and creative workarounds to solving problems, and that these practices would help provide a greater understanding of factors influencing the success or failure of tool designs. The description of each task in terms of the situation that led to the difficulty and the characteristics of the individual workarounds allowed each task to be matched directly to the theoretically proposed model.

A final level of analysis takes the comparisons between the units or cases and combines them to develop a model or framework that communicates the results of your case study and the over-arching themes that emerged from your analysis. As you analyze the individual pieces and their relationships, you may identify higher-level patterns, common concerns, or recurring ideas that may help explain, categorize, or organize your results. These explanations might cut across individual units of analysis or multiple cases, forming the basis of a case description (Yin, 2014), which might organize your case study into specific areas of interest. In Sara's case study, the researchers identified several criteria that technologies must meet to satisfy her needs, including efficiency, portability, distinguishability of similar items, and suitability for socially appropriate use in a sighted community (Shinohara and Tenenberg, 2007). As always, you should be very careful to consider rival explanations (see Chapter 11).

Although case studies may rely heavily on qualitative data, quantitative data is often vitally important. A study of massive, multiplayer, online games (Ducheneaut et al., 2007) used quantitative analysis to address questions left unresolved in the qualitative analysis. By defining measures of activity such as the

number, frequency, and length of visits to social places, the researchers were able to conduct a quantitative analysis that provided a much richer description of the interaction dynamic than would have been possible with the qualitative data on its own.

7.10 WRITING UP THE STUDY

Documenting a case study can be challenging. More so than many other presentations of research results, case studies often read like descriptive discussions. Instead of presenting quantitative data or statistical results, you may find yourself trying to construct a narrative argument that uses the strength of the organization and writing to construct a convincing argument. In other words, your case study may live or die on the strength of your writing.

Starting your write-up early helps. Documenting your theory and your design in detail as soon as possible aids in clarifying your thinking; you have these artifacts to go back to. You do not want to be in the position of having to reconstruct these important details from memory or incomplete notes long after the fact.

You should make your theories, data, methodologies, analytic steps, and models as explicit as possible. Clear presentation of these important components help readers to understand where you have come from and how you got to any particular conclusions that you may have derived.

Presentation of data and analysis may take many forms. You might present summaries of your data followed by detailed analysis or you might intersperse data with interpretation. Case study reports often use analyses of individual observations or incidents to draw attention to noteworthy details. These analyses set the stage for discussions of broader themes that arise from the analysis. Case study data are usually presented in one of two forms—either thematically (Shinohara and Tenenberg, 2007) or chronologically (Farooq et al., 2007a). Chronological presentation is particularly useful for case studies that describe a project or process.

Story-telling is often an important component of a case study report. Carefully chosen anecdotes bring concrete details to your discussion, supporting your analytic results. These stories are particularly useful—and often required—in cases of direct interpretation (Stake, 1995). If you have chosen a specific incident as warranting detailed interpretation, you should relate all of the relevant details. Stories can also be used to introduce discussions of various components of your analysis. Short *vignettes* (Stake, 1995; Yin, 2011) that illustrate factors that you discuss in your analysis can make your subsequent analysis more concrete. These stories need not be narrative descriptions of specific incidents: direct quotes from interviews describing behaviors (Shinohara and Tenenberg, 2007) or individual perceptions (Troshynski et al., 2008) work very well in this regard.

A case study of the use of participatory design in support of a community organization developing a website (Farooq et al., 2007a) provides an example of a compelling and readable case study report. After introducing the problem and reviewing

the literature, this report introduces the methodological approach of combining traditional participatory design methods with measures aimed at encouraging the learning that would need to happen for the project to continue to succeed after the research team ceased to be actively involved. The report continues by providing detailed background of the organization, including its context, goals, and staff resources. The data collection methods and analytic methods were then discussed. The case study data were discussed chronologically, with analysis interspersed, leading to a discussion of implications of the results. The resulting report has details that might be of interest to a wide range of users, including HCI researchers, technology experts, and community organizers.

When appropriate, your case study report should also discuss rival explanations. Having taken the time to consider alternative explanations for any of your analytic results, you should document the results of this effort. Introducing the rival theories and explaining why the available evidence better supports your conclusions can bolster the credibility of your report. If you do not find any evidence in favor of the alternatives say so (Yin, 2011, 2014).

Your write-up of your case study should reflect the limitations of case study research. Any discussions of observations that may apply to the community as a whole should be phrased so as to avoid claims of generality. If you make the same observation for several cases, you might say that your observation appears to apply to a broader population, but you should not claim that your conclusion is definitively general. You might also say that these recurring trends merit further investigation, implying the need for a more rigorously sampled study that would determine whether the findings were generally applicable. Proper attention to the validity of the claims that you are making will help defend you from critics who may feel that you are being overly broad in your interpretation.

Once you have written a draft of your report, you might consider letting your participants read it. This can be a valuable reality check—if your participants believe that you have the facts wrong, you may have a problem that needs to be revisited. If this happens, you may need to collect some more evidence to clarify the situation (Yin, 2014). Participants may also provide alternative viewpoints on the data, possibly including explanations or theories that might (or might not) complement yours. You may not agree with all of the comments that your participants make, particularly with regards to interpretation of the data, but you should do your best to be receptive to constructive criticisms from your participants. Having taken the time to work with you, they are likely to have some interest in helping make your work and your report as accurate as possible.

Case study write-ups often face the troubling question of anonymity. When you're dealing with an individual or a specific group, concerns about privacy are very real: particularly for unique cases, your write-up may be too revealing for comfort. In some cases, protocols for the protection of human research subjects (see Chapter 15) might require that you do not identify the participants in a research study. A good rule of thumb might be to be conservative—when in doubt, protect your participants.

7.11 INFORMAL CASE STUDIES

Although careful planning and design are never completely inappropriate in HCI research, there may be times when the construction of a fully fledged case study is overkill. You may be starting a completely new project, without any understanding of the application domain or the needs of the users. Or, you might be interested in getting some initial response to a proposed design for a new feature that you've designed for a software tool. Yet another possibility involves validation: can you collect some data to document the success of your completed design?

In situations like these, your goal is not to develop a general model or to construct a rigorous argument. Rather, you are more interested in feedback that will help you understand a new situation or a "sanity check" that will indicate whether a new idea is worth pursuing. Informal case studies with a small number (as few as one) of carefully chosen participants can be very valuable sources of feedback. Informal case studies are frequently used by HCI researchers to describe the successful use of a tool—see the Interfaces for people with quadriplegia sidebar for an example.

These case studies are "informal" in the sense that some of the guidelines and procedures might be relaxed in favor of expediency. As you're not looking to make broad, generally applicable claims, you do not need the rigorous planning and record-keeping that is necessary to establish chains of evidence. You might forego a theoretical background or defined analytical framework in favor of simple note-taking and observation.

Imagine a foray into designing a tool for an unfamiliar domain. You might consider running a fully fledged case study, asking several experts in the domain what they do, how they do it, and what they might want in a tool. The potential utility of this study might be significant, but you might need some initial background to plan the details. An informal case study with one potential user might help you gather the initial understanding that is necessary for designing the complete case study. Sometimes, you may find that limits on available resources (time and personnel) make it impossible for you to conduct a complete study. If this happens, informal case studies may be your best option for understanding the problem.

If you are looking for feedback on a proposed design or constructed interface, an informal case study can be an attractive alternative to user studies or observation sessions. Particularly if you can work with a participant who will use your tool on a problem that interests him or her, you can use an informal session to document an instance of the successful use of your tool in the intended domain. A negative result can be informative here as well: if it turns out that your design is fundamentally flawed, your single case can help you identify the error early, saving you the trouble of designing a more thorough summative evaluation.

Even if your case study is informal, your criteria for selecting participants should not be. Although the lesser time commitments of these shorter studies may make them more appealing to many participants, the relatively loose and informal nature may be troublesome to some. You probably don't want to do an informal, preliminary study of a proposed interface with a critical participant who won't be able to handle a few glitches along the way. People who have invested in the success of your project

and willing to try out new ideas often make the best participants in informal case studies. It is not uncommon to rely upon such individuals for repeated sessions at different stages in a project: in such cases, these individuals become informants (see Chapters 8 and 9), providing a detailed understanding of the problem and regular feedback that (ideally) helps keep your project on track.

Although informal case studies may appear to be somewhat simpler than fully realized studies, you should still strive to be as rigorous as possible. An informal study conducted during an hour-long session can still involve multiple methods of data collection, a theoretical basis, and careful definition of the units of analysis. Although your data collection procedures might be relatively simple, you still want to keep careful notes and document your analysis appropriately.

Informal case studies trade scientific rigor for ease of data collection. By foregoing the use of multiple data sources, triangulation, and analytic techniques that give full-blown case studies scientific rigor, informal studies provide for the possibility of "quick-and-dirty" study and insights. Effective use of this approach and appropriate communication of results requires a clear understanding of the limits of this approach.

The example of Sara's use of technology provides a clear picture of the difference between formal and informal case studies. In studying Sara, the research team made multiple visits to Sara's home, using several techniques to examine technologies from differing perspectives. Building from a theoretical grounding in theories of interaction with devices in the home and the importance of failures and workarounds, the analysis of observations from these sessions led to a number of insights that point to potentially generalizable insights that might be addressed by designers of technologies for blind people (Shinohara and Tenenberg, 2007).

Imagine, instead, an informal case study of the same situation, involving a single, hour-long visit, using only observational techniques, and lacking a theoretical basis. This study might yield some interesting observations, but you would be hard pressed to gather the data that would inform the insights identified in the full case study. The abbreviated nature of the data collection session might limit your use of multiple sources, leaving you with less confidence in any particular result. As trends and themes that might arise during a longer session might not be apparent in the single visit, generalization of insights would be difficult, if not impossible. You might be able to use the session to generate some discussion that would be part of a longer report, but this informal case study would not stand very well on its own.

Reports of informal case studies should take these limitations into account. If your investigation is truly informal, you may wish to avoid the term "case study" altogether. This will help you avoid the possibility of creating a false impression of a rigorous study. Instead, you might talk about the lessons learned from observations of one or more individuals. Appropriately cautious statements about the significance of your observations and candid admission that more study is needed can help you avoid criticisms that the informality of your procedures does not justify the claims that you are making.

Informal case studies are often most effective as intermediate steps in larger research processes. This can be true of studies that are used as pilot investigations of user needs prior to more formal study with multiple cases or as initial investigations of a tool in use before conducting larger summative evaluations (Chapter 10). Descriptions of these case studies and how they influence the subsequent investigations can be valuable pieces of your eventual write-up.

7.12 SUMMARY

As every individual who uses computing tools does so in a unique context, with specific goals, backgrounds, and abilities, every use of a computer interface is, in some sense, an HCI case study. Close examination of these contextual factors can give researchers a rich, detailed understanding of the factors that influence system requirements and determine the success or failure of proposed designs. Unlike controlled experiments, which attempt to find general answers to fairly narrow questions, case studies are deep and narrow, focusing on thorough exploration of a small set of cases.

If your research leads you to a situation that seems to be in some sense notable or perhaps unique, you might find yourself considering a case study. Possibilities include studying a domain expert's information management techniques in order to inform the design of a new system; comparing two installations of a new collaborative tool in different contexts; or describing your use of a new participatory design technique in the development of a new tool. Regardless of the context, you should be clear about your goals, as they impact how you design and conduct your study. If you are interested in generalizing from your cases to make broader claims, you should be particularly careful about your research design and analysis, making sure that the data favor your arguments over alternative explanations. Open-ended explorations aimed at generating ideas and descriptions of a unique or unusual situation may not make any broader claims, but they will still benefit from a clearly thought-out design and analysis plan.

Case study research is harder than it may look. Although the small number of participants and the lack of quantitative analysis may be appealing, the studies present substantial analytical and logistical challenges. Selecting cases is often difficult, whether you are identifying the most promising participants from a large pool or worrying about the representativeness of the sole case that you have been able to find. Collecting multiple, corroborating pieces of data may be difficult and teasing interesting insights out of potentially messy and inconsistent data can be tricky. Scheduling the appropriate meetings and working around the needs of your participants can often be a real chore.

The case study's focus on deep, narrow investigation leads to inevitable concerns about validity. How can we learn anything general from the study of a small set—sometimes only having one member—of instances of a given phenomenon? With rigorous evaluation involving multiple participants and (very often) statistically analyzed quantitative results playing such a pivotal role in recent HCI research, it may

be hard to convince some critical readers that case study research is worthwhile. "This study only includes one participant," they might say, "so how can we apply it to others?"

Case studies that make broad claims of generality are particularly likely to infuriate these critics, who may feel that any generalization from case studies is inappropriate. When conducting and describing case study research, always take care to remember the limits of this approach, and try to avoid making claims that cannot be sustained by a small number of cases.

Although concerns about validity and reliability are certainly appropriate, critics of case studies risk the loss of a valuable research tool. In digging deep into concrete situations, they can help researchers identify design particulars that are likely to go unnoticed by research in usability labs. In focusing on specific situations, they provide concrete illustrations of needs, motivations, and successes or failures. As explanatory tools, they take requirements from the abstract to the specific. Particularly when presented alongside complementary user studies that provide broader-based data, case studies can paint rich pictures that deepen our understanding of complex phenomena.

Case studies succeed when they build upon the fundamental human activity of learning through story-telling. If your case study can use the details of a specific situation to tell the story behind some HCI research question, it will succeed in its ultimate goal of increasing understanding and communicating that understanding to a broader audience.

DISCUSSION QUESTIONS

1. Case studies can be useful tools for exploring user requirements for software tools, but they present challenges: given a small number of cases, your results may not be generally applicable. Some user requirements from a case study might be easy to implement with minimal impact on a design—these might be included even if they are not of broad interest. Other requirements might require fundamental changes to system design. How can you be confident that you have gained a thorough, general understanding that is suitable for designing an application of broader interest? If additional cases are not available, how might you use other HCI research techniques to bolster your confidence in the results of your case study?

2. Case studies involve working closely with individuals who may have a substantial interest in the results of your work. This might lead some participants to put "spin" on their interactions with you, framing their activities and responses to questions to increase the likelihood of achieving their desired outcomes. How might you design your study and choose your data sources to account for this concern?

3. Although the case study of Sara's use of technology is a good example of case-study research, our discussion of it represents a different type of case study:

case study for educational purposes. Based on the discussion and analysis found in this chapter, how does an educational case study differ from a research case study? Consider questions such as the type of study, the number of cases, the data sources, and the analysis.

RESEARCH DESIGN EXERCISES

1. Sara's case study is an embedded, single-case study, with the individual tasks as units of analysis. Suppose you wanted to conduct a literal replication of this study with another blind person. Keeping in mind the potential differences in living arrangements, lifestyles, and personal habits that might distinguish Sara from other blind college students, describe the challenges that you might face in conducting this replication. If you could ask the authors of the paper about Sara for access to their notes and records, which items would be of particular interest? How would these challenges differ if you were to do a theoretical replication with another blind individual who was different from Sara in some potentially important regard, such as a retired person?
2. Case studies often focus on groups or organizations as their units of analysis. As specific details of group dynamics can influence the success or failure of software tools, these studies can be very helpful for understanding the use of tools for collaboration or other organizational goals. Design a case study aimed at understanding the information sharing and management processes of your research group. What would your underlying questions be? What hypotheses would you wish to explore? Describe your units of analyses, data sources, and analytic approach.

REFERENCES

Bilandzic, M., Foth, M., De Luca, A., 2008. CityFlocks: designing social navigation for urban mobile information systems. In: Proceedings of the 7th ACM Conference on Designing Interactive Systems. ACM, Cape Town.

Blythe, M., Monk, A., Park, J., 2002. Technology biographies: field study techniques for home use product development. In: CHI '02 Extended Abstracts on Human Factors in Computing Systems. ACM, Minneapolis, MN.

Cohene, T., Baecker, R., Marziali, E., Mindy, S., 2007. Memories of a life: a design case study for Alzheimer's disease. In: Lazar, J. (Ed.), Universal Usability: Designing Computer Interfaces for Diverse User Populations. John Wiley and Sons, London.

Davies, D.K., Vosloo, H.F., Vannan, S.S., Frost, P.E., 2008. Near real-time fire alert system in South Africa: from desktop to mobile service. In: Proceedings of the 7th ACM Conference on Designing Interactive Systems. ACM, Cape Town.

Druin, A., Weeks, A., Massey, S., Bederson, B.B., 2007. Children's interests and concerns when using the international children's digital library: a four-country case study. In: Proceedings of the 7th ACM/IEEE-CS Joint Conference on Digital Libraries. ACM, Vancouver, BC.

Ducheneaut, N., Moore, R., Nickell, E., 2007. Virtual "third places": a case study of sociability in massively multiplayer games. Computer Supported Cooperative Work 16 (1), 129–166.
Farooq, U., Ganoe, C.H., Xiao, L., Merkel, C.B., Rosson, M.B., Carroll, J.M., 2007a. Supporting community-based learning: case study of a geographical community organization designing its website. Behaviour & Information Technology 26 (1), 5–21.
Farooq, U., Schank, P., Harris, A., Fusco, J., Schlager, M., 2007b. Sustaining a community computing infrastructure for online teacher professional development: a case study of designing tapped in. Computer Supported Cooperative Work 16 (4), 397–429.
Flyvbjerg, B., 2006. Five misunderstandings about case-study research. Qualitative Inquiry 12 (2), 219–245.
Hochheiser, H., 2000. Browsers with changing parts: a catalog explorer for Philip Glass' website. In: Proceedings of the 3rd Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques. ACM, New York, NY.
Lakkala, M., Ilomäki, L., Palonen, T., 2007. Implementing virtual collaborative inquiry practises in a middle-school context. Behaviour & Information Technology 26 (1), 37–53.
Miles, M.B., Huberman, A.M., 1994. Qualitative Data Analysis. Sage, Thousand Oaks, CA.
Naaman, M., Nair, R., Kaplun, V., 2008. Photos on the go: a mobile application case study. In: Proceeding of the Twenty-Sixth Annual SIGCHI Conference on Human Factors in Computing Systems. ACM, Florence.
Shinohara, K., Tenenberg, J., 2007. Observing Sara: a case study of a blind person's interactions with technology. In: Proceedings of the 9th International ACM SIGACCESS Conference on Computers and Accessibility. ACM, Tempe, AZ.
Stake, R.E., 1995. The Art of Case Study Research. Sage Publications, Thousand Oaks, CA.
Steriadis, C.E., Constantinou, P., 2003. Designing human-computer interfaces for quadriplegic people. ACM Transactions on Computer-Human Interaction 10 (2), 87–118.
Troshynski, E., Lee, C., Dourish, P., 2008. Accountabilities of presence: reframing location-based systems. In: Proceeding of the Twenty-Sixth Annual SIGCHI Conference on Human Factors in Computing Systems. ACM, Florence.
Yin, R.K., 2011. Applications of Case Study Research. Sage Publications, Thousand Oaks, CA.
Yin, R.K., 2014. Case Study Research: Design and Methods. Sage Publications, Thousand Oaks, CA.