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Observation of Work Practices in Natural Settings

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Introduction

Expertise is not just about inference applied to facts and heuristics, but about being a social actor. Observation of natural settings begins not with laboratory behavioral tasks—problems fed to a "subject"—but with how work methods are adapted and evaluated by experts themselves, as situations are experienced as problematic and formulated as defined tasks and plans. My focus in this chapter is on socially and physically located behaviors, especially those involving conversations, tools, and informal (ad hoc) interactions. How an observer engages with practitioners in a work setting itself requires expertise, including concepts, tools, and methods for understanding other people's motives and problems, often coupled with methods for work systems design.

By watching people at work in everyday settings (Rogoff & Lave 1984) and observing activities over time in different circumstances, we can study and document *work practices*, including those of proficient domain practitioners. This chapter introduces and illustrates a theoretical framework as well as methods for observing work practices in everyday (or natural) settings in a manner that enables understanding and possibly improving how the work is done.

In the first part of this chapter, I explain the notion of work practices and the historical development of observation in natural settings. In the middle part, I elaborate the perspective of ethnomethodology, including contrasting ways of viewing people and workplaces, and different units of analysis for representing work observations. In the final part, I present methods for observation in some detail and conclude with trends and open issues.

What are Work Practices in a Natural Setting?

Every setting is "natural" for the people who frequent it. A laboratory is a natural work setting for some scientists, whereas expedition base camps are natural for others. The framework provided here is intended to be applicable to any setting, including school playgrounds, churches, interstate highways, and so on. But we focus on workplaces, where people are attempting to get some work done, for which they have been prepared, and have sufficient experience to be acknowledged as experts by other people with whom they interact. This can be contrasted with studies of everyday people being expert at everyday things (e.g., jumping rope, car driving) or events purposely arranged by a researcher in a laboratory.

In studying natural settings, one views them broadly: Consider a teacher in a school within a community, not just a classroom. Seek to grasp an entire place, with its nested contexts: Rather than focusing on a physician in a patient exam room, study the clinic, including the waiting room.

Heuristically, one can view an expert's performance as a play, identifying the stage, the "acts," roles, and the audience. But also view the play as having a history, whose nature is changing in today's performance: What are the actors' long-term motives? How is this performance challenging or influenced by the broader *community of practice* (Wenger 1998) (e.g., other clinics and nurses)?

Also inquire more locally about the chronology and flow of a performance: How do people prepare, who assists them (think of actors), how do they get information about today's work, when and where do they review and plan their work, how are events scheduled? Look for informal places and off-stage roles—backrooms and preparation areas, dispatchers, janitors, and support personnel. All of this is part of the expertise of getting a job done, and multiple parts and contributions need to be identified if the fundamental question about work is to be answered: What affects the quality of this performance? What accounts for its success? As a heuristic, to capture these contextual effects, one might frame a study as being "a day in the life" of the people—and that means 24 hours, not the nominal work day.

Thus, a study of work practices is actually a study of a setting; this context makes the observed behavior understandable. For example, consider understanding clowns:

> If we had a film of a clown doing somersaults, and nothing else (i.e., we knew nothing about circuses, about the history of clowns and so on), then the film would not tell us what we need to know to make sense of what the clown was doing.… One would need to know something about how they are part and parcel of circuses, and how their somersaulting is viewed [by many observers] as a kind of

> sentimental self-mockery. (Harper 2000, pp. 244-5; attributed to Gilbert Ryle)

To understand a setting, it is useful to view all workers (not just performers on stage) as social actors. When we say that work is *socially recognized* as "requiring special skills or knowledge derived from extensive experience" (Hoffman 1998, p.86), we mean that people are visibly demonstrating competency, in how they make interpretations, conduct business, and produce results that are "recognizably accountable" (of agreeable quality) to institutional and public audiences (Heritage 1984; Dourish & Button 1998). This perspective has the dual effect for expertise studies of considering the worker as an agent who, with other agents, coconstructs what constitutes a problem to be solved and how the product will be evaluated. Methods for applying this theoretical perspective, called *ethnomethodology*, are presented in this chapter.

Observing people in a natural setting is commonly called *fieldwork*. Besides watching and recording and asking questions, fieldwork may include interviewing, studying documents, and meeting with the people being studied to analyze data together and present findings (Forsythe 1999, p. 128). Fieldwork is most often associated with the broader method of study called *ethnography* (Spradley 1979; Fetterman 1998 Harper 2000, p. 239), literally, the written study of a people or culture. Neither fieldwork nor ethnography are specific to any discipline. Originally associated most strongly with anthropology, the methods today are commonly used by linguists, sociologists, computer scientists, and educational psychologists.

The actual methods of observation—spending time in a natural setting and recording what occurs—may at first appear as the defining characteristic of an ethnographic study, but the difficult and less obvious part is being able to understand work practice. For example, outsiders are often unaware of the inherent conflicts of a work setting (e.g., to physicians, dying people are

a source of money; to police, crime statistics a source of political trouble), which limit what can be done, making it necessary to creatively interpret procedures and regulations.

This chapter focuses on how to see what is happening, how to apply ethnomethodology concepts to analyzing everyday actions. Starting the other way around—with camera at hand and a poor theoretical background—could be like bringing an aquarium fish net to the deep sea, collecting a hodgepodge of anecdotes, narratives, and interesting photographs, with little understanding of people's practices (Button & Harper 1996, p. 267). Furthermore, a planned *analytic program* is important when studying work practice for design, "otherwise observations can be merely invoked at will for particular purposes such as, for example, to legitimize design decisions already made" (p. 267).

An observational study is itself modulated by the observer's purpose and relation to the organizational setting. Intending to transform the setting (e.g., as a consultant) requires engaging as an observer in a particular way, not merely recording and note taking. A helpful, reflective activity called *participatory design* (Greenbaum & Kyng 1991, p. 7; Beyer & Holtzblatt 1998) involves negotiating and codiscovering with the workers what is to be investigated (e.g., setting up a "task force group"; Engeström 1999, pp. 71-73). In settings such as hospitals and business offices, this developmental perspective commonly focuses on software engineering and organizational change.

Historical and Contemporary Perspectives

This section reviews how observation in natural settings developed and was shaped, especially by photographic tools, and how it relates to the psychological study of expertise.

Scientific Observation in Natural Settings

In studies of culture, surveying "informants" on site goes back to the earliest days of 19th-century anthropology (Bernard 1998, p. 12). Several articles and books provide excellent summaries of the theoretical background and methods for observation in natural settings, including especially *Direct Systematic Observation of Behavior* (Johnson & Sackett 1998) and *Participant Observation* (Spradley 1980; Dewalt & Dewalt 2002).

As the ethnomethodologist stresses, observation in natural settings is inherent in social life, for it is what people themselves are doing to organize and advance their own concerns. But perhaps the tacit, uncontrollable, and mundane aspect of everyday life led psychologists to set up experiments in laboratories and anthropologists to set up camp in exotic third-world villages. Moving studies of knowledge and expertise to modern work settings developed over a long period of time, starting with cognitive anthropologists and socio-technical analysts (Emery 1959), and progressing to the "Scandinavian approach" to information system design (Ehn 1988; Greenbaum & Kyng 1991). But today's methods of observation began with the invention of—and motivations for—photography.

Visual Anthropology

Photographs and video are indispensable for recording behavior for later study. The visual record allows studying how people structure their environment, providing clues about how they are relating to each other and structuring their work life. Using photography for close observation dates to the late 19th century. Eadweard Muybridge's famous early motion pictures (*Galloping Horse* [1878], *Ascending Stairs* [1884]) demonstrate the early motivation of using film to study animal and human movements whose speed or structure elude direct observation.

Margaret Mead and Gregory Bateson pioneered the use of film for capturing nonverbal behavior. Their work was influential in treating photography as primary data, rather than as only illustrations (El Guindi 1998, p. 472). Today the use of photographic methods is fundamental in observation of natural settings, and is termed video ethnography or *interaction analysis* (Jordan & Henderson 1995).

An integral part of any observational study in a natural setting considers how physical space, including furniture and designed facilities, is used "as a specialized elaboration of culture" (Hall 1966), called *proxemics*. This study broadly relates ethology (Lorenz 1952) to analyses of physical-perceptual experience (e.g., *kinesics*, Birdwhistell 1952), including "body language" (Scheflen 1972), personal and public kinds of space, nonverbal communication (Hall 1959), and culture differences. Using time-lapse video, Whyte (1980; PPS 2004) studied how people used public plazas at lunchtime, a striking everyday application of proxemics for architectural design.

Visual analysis considers posture, gestures, distance and orientation of bodies, territoriality, habitual use of space (e.g., movement during the day), relation of recreational and work areas, preferences for privacy or indirect involvement (open doors), and so on. For example, referring to Figure 1, how would you group the people, given their posture and behavior? What activities occur in this space? What do body positions reveal about people's sense of timing or urgency? Even a single image can reveal a great deal, and will provide evidence for broader hypotheses about relationships, complemented by living with these people for several weeks.

Figure 1. "The area between the tents" at the Haughton-Mars Base Camp 1999.

The Development of Natural Observation in Expertise Studies

Analysts seeking improved efficiency in procedures and designing automation studied workplaces throughout the 20th century. Developmental psychology primarily focused on schools, whereas organizational learning (Senge 1990) chose business settings. Computer scientists brought domain specialists into their labs to develop expert systems in the model-building process called *knowledge acquisition* (Buchanan & Shortliffe 1984). Human factors psychologists took up the same analytic concepts for decomposing work into formal diagrams of goals and methods, called *cognitive task analysis* (Vicente 1999), and characterized decision making as probabilistic analyses of situations and judgmental rules (Chi et al. 1988). At the same time, social scientists were being drawn by colleagues designing computer systems, motivated largely by labor forces in Europe (Ehn 1988), forming subfields such as business anthropology and workplace studies (Luff et al. 2000).

By the 1990s, industrial engineers and social scientists already in the workplace were joined by computer scientists and psychologists, who had transitioned from laboratory interviews and experiments to "design in the context of use" (Greenbaum & Kyng 1991). The work of studying knowledge and learning moved to everyday settings such as supermarkets (Lave 1988), insurance offices, and weather bureaus (Hoffman et al. 2000). The discipline of human-computer interaction (HCI) became a large, specialized subfield, a consortium of graphics artists, social theorists, psychology modelers, and software engineers (Nardi 1996; Blum 1996; Kling & Star 1998).

Broadly speaking, HCI research has progressed from viewing people as computer *users*—that is, asking questions like "What happens if people are in the loop?"—to viewing people, computers, documents, facilities, and so on as a *total system*, and understanding the processes holistically. In some respects, this approach began with socio-technical systems analysis in the 1950s-1970s (Corbet et al. 1991, p. 9ff). Hutchins (1995) provides especially well-developed examples of how tools, interfaces, and distributed group interactions constitute a work system.

Expertise in Context: Learning to See

Observing and systematically studying a work place is sometimes treated as easy by non-social-scientists, who might perform the work sketchily or not actually analyze practices (Forsythe 1999). The spread of the anthropological and social perspectives to cognitive science was at first limited, at best shifting the analysis to include the social context. For example, only one chapter in *Expertise in Context* (Feltovich et al. 1997) explicitly involved an observational study of a natural setting (Shalin's video analysis in a hospital). Ericsson and Charness used diaries for studying violinists, without investigating their home setting. Other researchers

considered experts as socially selected (Agnew et al.) and more broadly serving and part of market, organization, or community networks (Stern); or viewed expertise as part of cultural construction (Collins, Clancey).

An edited volume from a decade earlier, *The Nature of Expertise* by Chi et al. (1988), focused even more narrowly on mental processing of text: Documents were provided to subjects to read, to judge, to type, or learn from. Expertise was viewed not about competence in settings (i.e., situated action), but decision making, reasoning, memory retrieval, pattern matching—predominantly aspects of the assumed internal, mental activity occurring in the brain. For example, a study of restaurant waiters (p. 27) was reduced to a study of memory, not the "lived work" of being a waiter. A study of typing concerned timing of finger movements, nothing about office work. Of the twelve studies of experts, only one included "naturalistic observation" to "fashion a relatively naturalistic task" (Lesgold 1988; p. 313), namely, dictating X-ray interpretations.

This said, one of the most influential analyses of the contextual aspects of behavior, Suchman's (1987) *Plans and Situated Actions*, also did not involve the study of practice. Suchman studied two people working together who had never used a photocopier before (p. 115)—a form of puzzle solving in which a predefined task is presented in "the real world" (p. 114). Suchman's study is an example of *ethnomethodological analysis* because it focuses on mutual, visible construction of understanding and methods, but it is not carried out using the *ethnographic method* (Dourish & Button 1998, p. 406) because this was not a study of established practices in a familiar setting.

In summary, a participatory design project uses ethnography to study work practice, which may be analyzed from an ethnomethodological perspective (Heritage 1984). More

generally, ethnography may involve many other analytic orientations, emphasizing different phenomena, topics, and issues (Dourish & Button 1998, p. 404). Ethnographic observation involves a rigorous commitment to confronting the worlds of people as they experience everyday life, to understand how problematic situations actually arise and are managed. Workplace studies, contrasted with the study of knowledge and experts in the 1970s and 1980s (Chi et al. 1988), signify a dramatic change in how expertise is viewed and studied, often with entirely different motivations, methods, and partnerships, and having a significant affect on the design of new technologies.

Work Systems Design Project Examples

Here I present two representative examples of work systems design projects to illustrate the relation of methods and the results achieved.

A three-year ethnographic study of a reprographics store was conducted to improve customer service (Whalen et al. 2004)[1]. The data was collected in three phases. First, the researchers made ethnographic observations, shadowing and interviewing employees as they worked. Second, the team collected over 400 hours of video recordings in the store from multiple simultaneously recording cameras. The videotapes were digitized and divided into distinct episodes, consisting of more than 500 customer-employee interactions, some of which were transcribed and analyzed. Finally, three research team members became participant observers in the stores, working as employees, serving customers, and operating the printing and copying equipment.

[1] The description of this project has been provided by Peggy Szymanski at PARC.

The study resulted in the development of a "customer service skill set," a set of web-based instructional modules designed to raise employees' awareness of the organization of customer-employee interactions. Topics include how to listen to what the customer wants during initial order taking, how to talk about price, and the importance of taking the time to review the completed job with the customer. The modules were co-developed by the research team and six store employees who met once a week for two months. For example, the common question "When do you need it?" is practically unanswerable by the customer because they don't know the work load and scheduling constraints of the store, so they reply, "When can you have it?" The employees were asked to experiment with ways of opening up the discussion about due time (e.g., "Is this an urgent job?" or "Would you like to pick this up tomorrow afternoon?"), and they noticed a useful change in customer responses. These analyses inform further reconsideration of the burden placed on customers in justifying the need for "full service" and the delicate balance of providing assistance to "self-service" customers.

The second example illustrates systematic design and adaptation to most aspects of a work system—organization, facilities, processes, schedules, documents, and computer tools. For three-and-a-half years, NASA Ames' researchers worked closely with the Mars Exploration Rover (MER) science and operations support teams at the Jet Propulsion Laboratory, in Pasadena, CA. The project included the design and training phase of the mission (starting January 2001), as well as the surface operations phase that began after the successful landing of two rovers on the Martian surface (January 2004). Observation focused on the interactions between the scientists, computer systems, communication network (e.g., relay via Mars satellites), and the rovers, using ethnography to understand the successes, gaps, and problem areas in work flows, information flows, and tool design in operations systems.

Research data included field notes, mission documents and reports, photographs, video, and audiotape of the work of mission participants. Two to four researchers were present during all of the premission tests (2001 – 2003), all but one of the science team twice-yearly meetings (2001 – 2003), and the majority of the science team's weekly conference calls. Learning the intricacies of the rover instruments and their operation was necessary to understand the telerobotic work. Ongoing findings in the form of "lessons learned" with recommendations for improving mission work processes were presented to operations teams several times each year. Data analysis focused on the learning of the science team as a work practice developed that moved the daily rover-operations plan from team to team across the three-shift mission timeline. The researchers identified and categorized types of information and working groups, and defined work flows, communication exchanges, scientists' work practice and scientific reasoning process, and the interactions of work practice between scientists and rover engineers. Over time many scientists and managers became informally involved in assisting the observation and documentation process and refining design recommendations.

The researchers developed a naming convention and ontology for objects on Mars, a prioritization scheme for planning rover activities, and a method of documenting the scientific intent of telerobotic operations to facilitate communication between operations shifts and mission disciplines. They trained MER scientists in these procedures and associated tools during simulated missions. During the mission in 2004, two researchers moved to Pasadena; six researchers rotated to cover the shifts that moved forty minutes later each day in synchrony with local Mars time. The team then developed operations concepts for an "extended mission phase," during which scientists worked from their home cities, and rover planning was compressed and simplified to reduce work on nights and weekends.

Overall, this work systems design project helped define and enhance the telerobotic scientific process and related mission surface operations, including design of facilities for science meetings. Researchers contributed to the design of four computer systems used for rover planning and scientific collaboration that were being developed simultaneously by NASA Ames colleagues and JPL. The MER work systems design and the methods employed are influencing operations concepts and system architectures for subsequent missions.

Ethnomethodology's Analytic Perspective

In this section, I explain how the "methodology" being studied in a workplace is not just a technical process for accomplishing a task, but incorporates social values and criteria for judging the quality of the work. This idea originated in Garfinkel's discovery in the mid-1950s of jurors' "methodological" issues:

> …such as the distinction between "fact" and "opinion," between "what we're entitled to say," "what the evidence shows," and "what can be demonstrated"…. These distinctions were handled in coherently organized and "agree-able" ways and the jurors assumed and counted on one another's abilities to use them, draw appropriate inferences from them and see the sense of them…common-sense considerations that "anyone could see." (Heritage 1984, p. 4)

Ethnomethodology thus emphasizes the commonsense knowledge and practices of ordinary members of society, as they "make sense of, find their way about in, and act on the circumstances in which they find themselves" (p. 4). However, formalizing these assumptions, values, and resulting procedures is not necessarily easy for people without training (Forsythe 1999).

Ethnomethodology has led researchers to reconceive how knowledge and action are framed, "wresting… preoccupation with the phenomenon of error" prevalent in human factors research (Heritage 1984). The focus shifts to how people succeed, how they construct the "inherent intelligibility and accountability" of social activity, placing new emphasis on the knowledge people use "in devising or recognizing conduct" (p. 5). Button and Harper (1996) provide a cogent example about how "Decisions about what crimes are reported by police are intimately tied up with questions of what is *practical* for the reporting officer and what is in the *interests* of the police organization as a whole" (p. 275).

Contrasted with technical knowledge (Schön 1987), this aspect of work methods is reflective and social, concerning how one's behavior will be viewed, through understood norms and social consequences. Ethnomethodology thus provides a kind of logical, systemic underpinning to how activity becomes coordinated—"how the actors come to share a common appraisal of their empirical circumstances" (Heritage 1984, p. 305)—that is, the process by which they come to cooperate and their methods for resolving conflicts.

The idea of "intelligibility and accountability" means that the work activity is "organized so that it can be rationalized" (Dourish & Button 1998, p. 415), that is, so that it appears rational. For example, the Mars Exploration Rover's (MER) operations (Squyres et al. 2004) were planned and orchestrated by the science team so the exploration could be recognizable to others in perpetuity as being science, especially through the method of justifying instrument applications in terms of hypothesis testing. In practice, geologists will often just strike a rock to see what is inside. In MER, the application of the rock abrasion tool was often explained within the group and to the public as looking for something specific. As the mission continued on for many months, the need for such rationalization diminished, but as the scientists were bound at

the hip, with one rover to command (at each site), they continued to justify to each other why they would hit a particular rock and not another—something that would be inconceivable in their activity of physically walking through such a site with a hammer and hand lens. Thus, the practice of geology changed during the MER mission to adapt to the circumstances of a collective, historical, public, time-pressured activity; and production of accounts of what should be demonstrably scientific action were adapted to fit this situation (cf. Dourish & Button 1998, p. 416).

One must avoid a misconception that technical knowledge is just being selectively applied in social ways. Rather, what counts as expertise—the knowledge required to identify and solve problems—reflectively develops *within the setting*, which Collins calls "the mutual constitution of the social and conceptual" (Feltovich et al. 1997, p. 296). During the MER mission, a cadre of scientists and engineers capable of doing science with rovers has developed new expertise and methods of working across disciplines in a time-pressured way.

In summary, expertise is more than facts, theories, and procedures (e.g., how to be a geologist or policeman); it includes practical, setting-determined know-how in being a recognizably competent social actor. Ethnomethodology reveals the reflective work of constructing *observable* (nonprivate) categorizations (e.g., deciding which Mars rocks to investigate). Thus, an essential task for the outside observer is to learn to see the ordered world of the community of practice: "Human activity exhibits a methodical orderliness…that the co-participants can and do realize, procedurally, at each and every moment…. The task for the analyst is to demonstrate just how they do this" (Whalen et al. 2004, p 6). The following section provides some useful frameworks.

What People Do: Contrasting Frameworks

Social-analytic concepts for understanding human behavior in natural settings are contrasted here with information processing concepts that heretofore framed the study of knowledge and expertise (Newell & Simon 1972).

Practice vs. Process

Practice concerns "work as experienced by those who engage in it" (Button & Harper 1996, p. 264), especially, how "recognizable categories of work are assembled in the real-time actions and interactions of workers" (p. 264), memorably described by Wynn (1991):

> The person who works with information deals with an 'object' that is more difficult to define and capture than information flow charts would have us imagine. These show 'information' in little blocks or triangles moving along arrows to encounter specific transformations and directions along the diagram. In reality, it seems, all along the arrows, as well as at the nodes, that there are people helping this block to be what it needs to be —to name it, put it under the heading where it will be seen as a recognizable variant, deciding whether to leave it in or take it out, whom to convey it to. (pp. 56-57)

Button and Harper (1996, p. 265) give the example of people analyzing interviews: "The coders would resort to a variety of *practices* to decide what the coding rules actually required of them and whether what they were doing was actually (or virtually) in correspondence with those rules."

Practice is also called "lived work"—"what work consists of as it is lived as part of organizational life by those who do it" (Button & Harper 1996, p. 272). Practice is to be

contrasted with formal *process specification* of what work is to be done. In the workplace itself, processes are often idealized and constitute shared values—"crimes should be reported to the bureau as soon as possible" (p. 277). Narratives that people record or present to authorities cater to these avowed policies or preferences, creating an *inherent conflict* in the work system between what people do and what they say they do. The point is not just that the documents and behavior may disagree, but rather, for example, the records may reveal workers' understanding of how their practices must be represented to appear rational.

Two fundamental concepts related to the practice–process distinction are behavior–function and activity–task. Process models (e.g., information processing diagrams) are idealized functional representations of the tasks that people in certain roles are expected to do. Practice concerns chronological, located behaviors, in terms of everyday activities, for example, "reading email," "meeting with a client," and "sorting through papers." Activities are how people "chunk" their day, how they would naturally describe "what I am doing now." Tasks are discovered, formulated, and carried out within activities, which occur on multiple levels in parallel (Clancey 2002).

Putting these ideas together, one must beware of identifying a formalized *scenario* (cf. Feltovich et al. 1997, p. 117) with the physical, interactive, social context in which work occurs. The work context is fundamentally conceptual (i.e., it cannot be exhaustively inventoried in descriptions or diagrams) and dynamically interpreted, in which the actor relates constraints of location, timing, responsibility, role, changing organization, and so on. Scenarios used for studying expertise often represent an experimenter's idealized notion of the "inputs," and thus working a scenario may be more like solving a contrived puzzle than interacting with the flow of events that an actor naturally experiences.

Invisible vs. Overt Work

Observing work is not necessarily as easy as watching an assembly line. Work may be invisible (Nardi & Engeström 1999, p. 2) to an observer because of biases, because it occurs "back stage," or because it is tacit, even to the practitioners. These three aspects are discussed here.

First, preconceptions and biased methods may prevent the ethnographer from seeing what workers accomplish. For example, in a study of telephone directory operators, the researchers' a priori "notion of the 'canonical call' rendered the variability of actual calls invisible and led to a poor design for a partially automated directory assistance system" (p. 3). A related presumption is that people with authority are the experts (Jordan 1992). For example, the Mycin program (Buchanan & Shortliffe 1984) was designed in the 1970s to capture the expertise of physicians, but no effort was made to understand the role of nurses and their needs; in the study of medical expertise, nurses were "non-persons" (Goffman 1969; Star & Strauss 1999, p. 15).

The second aspect of invisibility arises because "many performers – athletes, musicians, actors, and arguably, scientists – keep the arduous process of preparation for public display well behind the scenes" (Star & Strauss 1999, p. 21), which Goffman called "back stage." One must beware of violating autonomy or not getting useful information because of members' strategic filtering or hiding of behavior (Star & Strauss 1999, p. 22).

The third form of invisible work is tacit "articulation work"—"work that gets things back 'on track' in the face of the unexpected, and modifies action to accommodate unanticipated contingencies" (Star & Strauss 1999, p. 10). These may be steps that people take for granted, such as a phone call to a colleague, which they wouldn't necessarily elevate to being a "method."

Participatory design handles the various forms of invisible work by using ethnography to identify stakeholders and then involving them in the work systems design project (e.g., see the examples in Greenbaum & Kyng 1991).

Members' Documentation vs. Literal Accounts

The production of documentation is part of the lived work of most business, government, and scientific professions. To deal with the nonliteral nature of documentation mentioned previously, one should study the activity of reporting "involved in sustaining an account of the work as a formal sequential operation" (Button & Harper 1996, p. 272) as a situated action with social functions. For example, in Mars habitat simulations (Clancey 2002, in press), one can learn from daily reports what the crew did. But one must also inquire how the reporting was accomplished (e.g., contingencies such as chores, fatigue, power failure, etc. that made reporting problematic), what accountability concerned the crew (e.g., the public image of the Mars Society; hence what was emphasized or omitted), and why reporting was given such priority (e.g., to adhere to scientific norms). What people write may not be what they actually did, and interviews may present yet another perspective on why the reports even exist.

Managing Inherent Conflicts vs. Applying Knowledge

One view of expertise is that people apply knowledge to accomplish goals (Newell & Simon 1972). Yet, goals are not simply the local statement of a task, but relate to long-term social-organizational objectives, such as later "work load and responsibilities" (Button & Harper 1996, p. 277). For example, the chair of NASA's Mission Management Team during the Columbia mission (which was destroyed on re-entry by wing tiles damaged by broken tank insulation foam during launch) didn't classify foam damage on the prior mission, STS-112 in

December 2002, as an "in-flight anomaly"—the established practice. Doing so could have delayed a subsequent mission in February that she would manage (CAIB 2003, p. 138-139). Thus, a recurrent consideration in how work is managed is "what-this-will-mean-for-me-later-on" besides "what-can-I-do-about-it-now." The organizational context of work, not just the facts of the case, affects reporting a mishap event (Button & Harper 1996, p. 277).

In summary, the view of rationality as "applying knowledge" can be adapted to fit natural settings, but the goal of analysis must include broad organizational factors that include role, identity, values, and long-term implications. The expert as agent (actor, someone in a social setting) is more than a problem solver, but also an expert problem finder, avoider, delegator, prioritizer, reformulater, communicator, and so on.

We have now considered several contrasts between information processing and social-analytic concepts for understanding human behavior in natural settings. But how does one apply an analytic perspective systematically?

Unit of Analysis: The Principle of Multiple Perspectives

A fundamental aspect of ethnography is to triangulate information received from different sources at different times, including reinterpreting one's own notes in light of later events, explicitly related to previous studies and analytic frameworks (Forsythe 1999, pp. 127-128). In conventional terms, to make a study systematic, one gathers data to model the work from several related different perspectives:

- Flows: Information, communication, product
- Independent variables: Time, place, person, document
- Process influences: Tool, organization/role, facility, procedure

To provide a suitable social framing and organization of these data categories, this section suggests the following units of analysis: activity system, temporality, and collectives.

Activity System

Activity theory (Leont'ev 1979) provides essential analytic concepts for understanding what is happening in a natural setting (Lave 1988; Nardi 1996; Engeström 2000). Psychologically, activity theory suggests how motives affect how people conceptually frame situations and choose problem-solving methods (Schön 1979). People broadly understand what they are doing as identity-related activities (e.g., "exploring an Arctic crater as if we were on Mars"). Career, social, or political motives and identities may influence how procedures are interpreted and tasks enacted. Engeström (1999) provides an exemplary activity theory analysis of a hospital setting.

Temporality: Phases, Cycles, Rhythm

A second unit of analysis is temporality: How does the work unfold during the course of a day or a week? Does it vary seasonally? Is a given day typical? One might observe an individual at different times and settings, and look for disparities between interviews and what people say about each other (Forsythe 1999, p. 138). An essential, recurrent organizing conception is the separating of work into categories such as "'someone-now,' 'me-when-I-can,' 'what-is-mine,' and 'everyone's-concern' to prioritise…work" (Button & Harper 1996, p. 276). Thus, expertise transcends how individual tasks are accomplished, to involve how time is made accountably productive.

Collectives

The third unit of analysis is the *collective*, the people who are interacting in a setting, as well as the conceptualized audience of clients, managers, and the community of practice. The collective might consist of people who don't directly know each other: "The occupational community [of photocopy machine technicians] shares few cultural values with the corporation; technicians from all over the country are much more alike than a technician and a salesperson from the same district" (Orr 1996, p. 76).

How is the study of a collective related to individual expertise? Lave (1988) contrasts the view that culture is a collection of value-free factual knowledge with the view that society and culture "shape the particularities of cognition and give it content" (p. 87). Thus, the study of culture is inseparable from a study of how expertise is identified, developed, exploited, organized, and so on. Orr's study reveals that "The technicians are both a community and a collection of individuals, and their stories celebrate their individual acts, their work, and their individual and collective identities" (p. 143), such that storytelling has a social-psychological function with many practical and institutional effects.

Methods for Observation in Natural Settings

In considering methods of observation, one should not rush to the recording paraphernalia, but first focus on how the study is framed, the nature of engagement of the observer in the setting, and the work plan. This section of this chapter surveys useful handbooks, then summarizes key considerations and methods.

Handbooks for Observing Natural Settings

The following handbook-style guides are suggested for learning more about how to observe natural settings. These fall on a spectrum from observational science to rigorous engineering design.

*Handbook of Methods in Cultural Anthropology (*Bernard 1998) provides a balanced treatment of the history and methods of anthropology, with tutorial-style chapters on epistemological grounding, participant observation, systematic observation, structured interviewing, discourse and text analysis, and visual analysis.

Design at Work: *Cooperative Design of Computer Systems* (Greenbaum & Kyng 1991) is a primer of examples, theory, and methods for participatory design. It represents especially well the Scandinavian perspectives that have defined change-oriented observational studies of workplaces as a morally driven, industrially funded, and theoretically grounded activity.

Contextual Design (Beyer & Holtzblatt 1998) may be used as a beginner's guidebook for conducting a "contextual inquiry," including how to observe and work with customers (with unusually detailed advice about how to conduct interviews); how to model work (organizational flow, task sequences, artifacts such as documents, culture/stakeholders, and physical environment); and how to redesign work (including storyboards, paper prototypes).

Cognitive Work Analysis (Vicente 1999) provides another program for designing computer-based information systems, based on detailed mapping of information flows, task constraints, and control processes. This book presents the methodology and perspective of Jens Ransmussen and his colleagues (Ransmussen, Pejtersen, & Goodstein 1994): Work models must be detailed for tool design, and hence observation must be systematically organized to understand the *domain* (see also Jordan 1996). In particular, analysis of fields—the physical-

conceptual spaces for possible action—is generalized from observations of particular trajectories or behaviors in this space (Vicente, 1999, p. 179).

Framing the Study: Purpose, Genre, Timing, and Biases

Every study of expertise occurs in its own context, which shapes the observer's interests, targeted product (a publication? a design document?), and the pace of work. Researchers therefore find it useful to have a variety of different approaches that can be adapted, rather than imposing one rigorous method on every setting.

Observation of expertise in natural settings has been undertaken as a scientific endeavor (studying decision making, creativity, etc.); to develop training strategies; or, typically, to redesign the workplace by automating or facilitating the work processes (Blomberg et al. 1993; Nardi & Engeström 1999; Jordan 1993, 1997; Ross et al. Chapter 23).

Dourish and Button (1998) summarize the relation of ethnography and ethnomethodology to technological design, emphasizing human-computer interaction. Luff, Hindmarsh, and Heath (2000) provide an updated collection of detailed workplace studies related to system design. More generally, workplace studies may be part of a broader interest in organizational development (Engeström 1999; Nardi & Engeström 1999, p. 4).

Before a study begins, one should make explicit one's interests, partly to approach the work systematically, and partly to expose biases so others may better evaluate and use the results (e.g., provide a comparative survey of related studies, Clancey in press). Throughout a study, one should also question conventional metaphors that predefine what is problematic. For example, the term "homelessness" could lead to focusing on housing, rather than studying how such people view and organize their lives (Schön 1979). The underlying nature of a setting may clarify as change is attempted (Engeström 1999, p. 78).

Observer Involvement

For many researchers, participant observation is the ideal way to study people, informally learning by becoming part of the group and learning by watching and asking questions. But participant observation is not necessary and may not be possible, for instance, in highly technical or risky work such as air traffic control (Harper 2000, p. 258).

Observation should be a *programmatic study* (p. 240-241), with demonstrated sincerity and probity (p. 251). Ethnography is not a haphazard hanging around or shadowing, as if anything is of interest (p. 254). Rather, the observational work must be a systematic investigation, with some sequential order (though often dynamically replanned) that covers a related set of roles, places, situations, and timelines. For example, in studying MER rover operations mentioned previously, the researchers were confronted with a 24-hour operation in three floors of a building, involving three shifts of distinct engineering and scientist teams. Given access constraints, the group focused on one room at first, where the scientists met three times during the day, and worked out from that group and place to understand how instructions were prepared for the rover's next-day operations and then how Mars data was received and stored for the scientists to access.

To stimulate inquiry and make learning progressive, the observer should keep a journal and review it periodically for issues to revisit. Another method is to review photographs and ask about every object, "What is that? What is it for? Who owns it? Where is it used and stored?" This can be done effectively via email with colleagues who are not at the study site, encouraging them to ask questions about what they see in the photos.

The ideal in participatory design is to find at least one person in the setting who can be a champion for the inquiry, explaining the study to others, getting access, and making the

observational activity legitimate. By this conception, people in the workplace are partners in a cooperative activity, and not referred to as "subjects," "users," or "operators" (Wynn 1991, p. 54). Probably no other philosophical stance is more fundamental to the observer's success. Data are discussed with the workers (in appropriate forums); report outlines are circulated for comment; related local expertise responsible for modeling the workplace is solicited for advice; documents about the work may even be coauthored with organizational champions.

Program of Work

For an observational study to be systematic, there must be an explicit program or plan for what, where, and how to study the setting (Harper 2000, p. 248). For example:

- Map out the key processes of the organization.
- Understand the diversities of work.
- Understand how different sets of persons depend on one another.
- Determine salient junctures in the information life cycle.

A plan will specify particular kinds of records kept over a certain period, and how they will be created, as described in subsequent sections.

Person, Object, Setting, Activity, Time-oriented Records

To be systematic, the observer must deliberately adopt a perspective and keep records organized accordingly. Jordan (1996) suggests the perspectives person, object (e.g., documents), setting, and task or process. More generally, an activity-oriented record includes any recurrent behavior, including both predefined work tasks (e.g., processing an order) and behaviors that may not be part of a job description (e.g., answering a phone call). Time is an orthogonal dimension. For example, one could check to see what people in a work area are doing every 15

minutes or observe a given setting at the same time every day. Time-lapse video can be used to record when people enter and leave a particular place (Clancey 2001).

Anthropologists make a distinction between two kinds of data: Emic categories (after phon*emic*) are used by participants; etic categories (after phon*etic*) are formal distinctions from an analyst's perspective (Jordan 1996). The basic systematic units mentioned in this section are etic: activities, roles, objects, persons, places, durations, etc.; in Western European and North American business settings these often fit emic distinctions.

Study Duration

Observational studies may last from weeks to years. The duration depends on the logistics and natural rhythm of the setting, technical complexity, and the study's purpose. Generally speaking, long-term involvement is preferable to follow the development of work practice. However, a few months of regular observation can be sufficient; a few weeks of daily participation usually enables a proficient analyst to form an understanding that can be a launching point for more focused interviews and design sessions. Indeed, one aspect of a study is to identify periodicities and historical developments, that is, to locate observations within overarching cycles and trends.

Recording Methods and Logistics

Data from natural settings is recorded using tools varying from paper and pen to electronic tracking devices. The standard media are texts (e.g., field notes, documents found in the setting), video and audio recordings, photographs, and computer models (e.g., the Brahms work practice simulation system, Clancey et al. 1998; Sierhuis 2001). Recording has enabled "repeated and detailed examination of the events of an interaction… permits other research to

have direct access to the data about which claims are being made… can be reused in a variety of investigations and can be re-examined in the context of new findings" (Heritage 1984, p. 238). Having a body of such data is the sine qua non for being a researcher who studies natural settings.

Recordings must be labeled, indicating at least the setting, date, and time. Experienced ethnographers suggest the following procedures: Collect photographs in a computer catalog, where they can be sorted by categories into folders. Transcribe field notes (not necessarily journals) in an electronic form so that they can be shared and searched. Organize computer files in folders, separating preparatory/logistic information, miscellaneous graphics, documents acquired, photographs, field notes, presentations and reports, press stories, email, and so on.

When recording outdoors, wireless microphones can be used to avoid wind interference. An audio mixer with several microphones enables combining different sources (e.g., computer speech output, "ambient" remarks, radio or telephone conversations). Typically, observation reveals settings where interpersonal interaction occurs, from which one chooses "hot spots" (Jordan 1996) for systematic video recording. The following methods are suggested: Use a tripod and wide angle lens, and multiple cameras for different view points if possible. Take systematic photographic records (e.g., the same place each day, such as a whiteboard) or take a rapid sequence to create a "film strip" that captures changing postures and positions as people interact with materials and each other. Interviews can be audio recorded, but video (on a tripod off to the side) provides more information.

Written records can include a pocket notebook (for jotting down phrases or noting things to do), a daily journal (often handwritten) that describes one's personal experience, and field notes (perhaps using an outline-based note-taker), with different sections to elaborate on

observations, raise questions, and interpret what is happening. Surveys given before, during, and after observation are recommended. View a survey as a way to prompt conversations and to encourage people to reflect with you on what is important, including their sense of accountability and how they evaluate their own performance (see Clancey, in press). Finally, if the circumstances of privacy and intellectual property allow, one may learn a great deal from documents found in garbage cans.

Data Analysis

Experienced researchers suggest flexible use of computer tools for representing work (Engeström 1999, pp. 85-90). Analysis methods are detailed in the handbooks cited above. Key pointers are provided here.

First, video data must be inventoried or will probably never be analyzed. Use a spreadsheet or outline to list the general content for each recording, and as you watch loosely transcribe material of special interest. For an extensive video collection of very different settings, create a catalog of illustrative frames. Video to be analyzed should be reformatted if necessary with the time and date displayed.

Social scientists often use some form of *conversational analysis* (CA), including gaze and gestures (Heritage 1984, p. 233). This method has revealed that behavior in "naturally occurring interactions" is strongly organized to great levels of detail. In pure form, CA eschews uses of interviews, field notes, and set-up situations in real world environments (p. 236). CA emphasizes "conversation as social action, rather than as the articulation of internal mental states" (Dourish & Button 1998, p. 402; Whalen et al. 2004).

Video-based *interaction analysis* (Greenbaum & Kyng 1991; Jordan 1996; Jordan & Henderson 1995) is a method for examining data in which scientists from different disciplines may spend hours discussing a carefully chosen, transcribed five to ten minute segment.

Besides narratives and verbal analyses, data may be collected in spreadsheets (e.g., time vs. person/place/activity), flowcharts, concept networks, timelines, and graphs (generated from the spreadsheets) (Clancey 2001, in press). If the data have been gathered systematically, it will be possible to calculate summary statistics (e.g., how long people did various activities in different places). Such information may prompt further questioning and reveal patterns that were not noticed by the ethnographer on site.

Social scientists use a wide variety of metrics. However, some studies never measure or count anything, as statistics are viewed merely as an attempt to quantify everything (Forsythe 1999, p. 139) or as being misleading (Nardi & Engeström 1999, p. 1). Researchers engaged in design projects are more likely to seek a balance. The real issue is whether the measurements are meaningful (Bernard 1998, p. 17). As a stimulus for further inquiry, it may be useful to quantify members' concerns (e.g., "I'm interrupted too much").

Perspective: Improving Ethnographic Practice

Observation in natural settings is a valuable, and some say necessary, way to systematically learn about practical knowledge, that is, to understand how people, places, activities, tools, facilities, procedures, and so on relate. One can learn about technical knowledge from textbooks or lectures, or even get important insights from surveys or by designing experiments in a laboratory. But expertise has a subjective, improvisatory aspect whose form changes with the context, which is always changing. This context includes the workers'

conception of personal and organizational identity (including motives and avowed goals), economic trends, physical environment, and so on.

Observation in natural settings may be arduous because of the time required, equipment maintenance, the amount of data that is often generated, personal involvement with the people being studied, and political and power concerns of the organizational setting. Some conflicts are inherent, with no easy solution:

- Ethics, privacy, and confidentiality
- Distribution and simultaneity of collective work
- Long-cycle phases and off-hours commitments
- Representativeness and systematicity of the data (vs. details of specific situations)
- Exposing invisible work (e.g., practices deviate from legally proscribed routines)
- Point-of-view and authoritative biases

Using ethnography for design of work systems is problematic: One often seeks a large-scale system design, but the study focuses on the "small-scale detail of action" (Dourish & Button 1998, p. 411). Observation naturally focuses on what is; how does one move to what might be? (See Greenbaum & Kyng 1991; Dekker, Nyce, & Hoffman 2003.)

Just like other work, ethnographies in practice do not always measure up to the espoused ideal: "Social scientists have for one reason or another failed to depict the core practices of the occupational worlds which they have studied" (Heritage 1984, p. 300). For example, the MER mission study was limited in practice by the number of observers and their stamina. Outside the defined workflow of mission operations, the scientists were also participating in parallel activities of grant writing, public affairs, paper preparation, and so forth. Some of these

unobserved activities directly affected science operations (e.g., preparing a comparative graph for a conference presentation might require additional data from Mars).

The role of simulation for driving observation and formalizing data is unclear (Sierhuis 2001; Seah et al. 2005). As one delves into individual behaviors of specialists, are approaches recurrent or just idiosyncratic? To what extent does a collective have uniform methods? Should a simulation be broad (e.g., several weeks) or deep (e.g., modeling computer system interfaces)?

Finally, social scientists, like other workers, may find it difficult to articulate their own methods: There is "no stable lore of tried and trusted procedures through which, for example, taped records… can be brought to routine social scientific description" (Heritage 1984, p. 301). Researchers often have different disciplinary interests, so a group of ethnographers at one site might not collaborate until they write a report for the host organization. At this point, the problem of indexing and sharing data becomes visible, both within the group and to others seeking to better understand a study. Effectively, in documenting observational studies, the work practice researcher is caught up in all the familiar issues of lived work, accountability, and contingent methods.

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