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Temporality in Medical Work: Time also Matters

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Abstract. CSCW has long been concerned with the distribution of activities in time and in space, but the problems of distributed work have often taken analytic and technical precedence. In this paper, we are interested in the issue of temporality in collaborative work. In particular, we want to examine how the temporal organization of action is experienced by those who are involved in it. To investigate this phenomenon, we conducted a field study of medical workers in a surgical intensive care unit. Through this study, we highlight the temporal organization of the work. In particular, we introduce and describe three temporal features – temporal trajectories, temporal rhythms, and temporal horizons – that emerge from and influence the work of healthcare providers as they attempt to seek, provide, and manage information during the course of their daily work.

Key words: collaborative work, medical work, information seeking, temporality

1. Introduction

One of CSCW's primary concerns is the achievement of concerted action – how individual activities are organized to achieve collective ends. Collective action is, to borrow a metaphor from Jean Lave (1988), "stretched over, not divided among" the physical, social, and cultural settings in which it emerges. Consequently, much research in CSCW has examined the ways in which activity is stretched across two dimensions in particular – one of space and one of time. The canonical four-way categorization of collaborative contexts, according to whether they occur at same/different places/times (Johansen, 1988), was used as an orienting mechanism by early CSCW research but by now has largely been abandoned, recognized as overly simplistic. However, the themes of space and time as dimensions across which work must be coordinated remains a central theme in current research into distributed teams, computer-mediated communication, the management of working schedules, and virtual organizations.

The problems of spatial distribution have tended to dominate in the CSCW literature. As one extensive empirical investigation concludes, "distance

matters'' when attempting to conduct collaborative work (Olson and Olson, 2000). An extensive collection of research investigations surrounds such topics as distributed teams (Olson and Teasley, 1996; Grinter et al., 1999; Mark et al., 2003), computer-mediated communication (Galegher and Kraut, 1990; Markus, 1994; Bos et al., 2002), and more recent phenomena such as distributed gaming (Ducheneaut and Moore, 2004). A wide range of tools, such as multimedia communication systems (Gaver et al., 1992; Bly et al., 1993), collaborative workspaces (Bently et al., 1997) and tools for synchronous collaboration (Begole et al., 2001; Sun and Chen, 2002), have attempted to overcome the problems of distribution by simulating aspects of co-presence. For instance, facilities for distributed work are now incorporated into personal computer operating systems as a matter of course. Spatial distribution has been a major topic for empirical, analytic, and technological investigation, and when people talk of ''collaboration technologies,'' they refer primarily to tools designed to support distributed action.

At the same time, there has been growing interest in dealing with issues of coordination and collaboration from a temporal perspective (McGrath, 1990; Egger and Wagner, 1992; Bardram, 2000; Begole et al., 2002; Hudson et al., 2002; Reddy and Dourish, 2002; McGrath and Tschan, 2003). Despite their formulation as twin dimensions across which work is distributed, time and space are fundamentally different aspects of the everyday environment within which we live. Space can be ''bridged'' using telecommunication technologies, but time remains fixed. Where space is available for examination and navigation, time proceeds, inexorably, at a fixed rate. Activities unfold in real-time, and cannot be undone or replayed. Time is experienced as a continual movement; as Alfred North Whitehead (1920) commented, ''What we experience as the present is the vivid fringe of memory, tinged with anticipation.'' Many who investigate distributed working evaluate it in comparison to co-present interaction. However, when thinking about the temporal distribution of work, clearly it makes no sense to imagine activities taking place all in the same moment. Similarly, while we have developed a range of empirical and analytic understandings of the impact of spatial distribution on collaborative work, our understandings of its temporal organization are considerably less formalized.

When looking at collaborative settings, it is critical to recognize that the experience of time also has a social component. Sorokin and Merton (1937) explore the notion of ''social time,'' observing that, while time proceeds unremittingly and uniformly, our experience of time reflects cultural and social patterns that give it meaning. Seconds follow seconds, but our experience of the passing of time is structured by social patterns – the cycle of weeks and seasons, the organization of the school year, the ''seven ages of Man,'' religious and cultural festivals, decades that take on their own identity, etc. A fascinating analysis of the radical, ''rational'' French revolutionary calendar

(organized primarily into 12 fixed-size months, each of three ten-day "weeks" or cycles) suggests that the failure of the calendar was rooted in its disruption of people's long-held temporal beliefs (Zerubavel, 1977). Like space, then, our encounters with time, and with the temporal organization of activities and events, shapes and is shaped by social and cultural meanings. Attempts to incorporate a notion of temporality into the construction of collaborative technologies must, accordingly, provide for the social nature of the temporal texture of everyday activity, and focus not simply on how activities are organized in time, but how they are experienced in time.

The focus of our research is conceptual in nature. Our goal in this paper is to contribute to the body of empirical and analytic investigations of the temporal organization of collaborative work. We draw upon ethnographic fieldwork to present a framework for understanding the temporal experience of collective action. By focusing on the production and negotiation of temporal order, we approach the temporal organization of activity as a practical accomplishment of social actors. Although this research is not linked to any particular design proposals, we discuss some design implications that focus on ways in which effective temporal interpretations of information and activity can be achieved.

In particular, we are concerned with the issue of temporality and information seeking in the context of medical care. We have been investigating the temporal organization of work in a surgical intensive care unit (SICU) of a major urban teaching hospital. A hospital is an almost paradigmatic example of an information-rich environment because of the wide array of information sources in the environment (Bardram, 1997; Reddy et al., 2001, 2002). It is also a natural site for investigation because workers have to continuously and extensively collaborate to provide appropriate patient care (Reddy and Dourish, 2002). In the SICU, we have been examining the experience of temporality in the context of workers' searching for, managing, and providing information. We view information seeking as an integral aspect of the work practices of hospital staff and do not distinguish "information work" (Strauss et al., 1985) from other working activities. Rather, we are interested in how medical workers seamlessly incorporate information seeking into their practical everyday work. By taking this perspective, we focus our attention on the details of people's work that affect their collaborative information seeking practices. Through this perspective, we highlight the temporal organization of the work. In particular, we introduce and describe three temporal features – temporal trajectories, temporal rhythms, and temporal horizons – that emerge from and influence the work of healthcare providers as they attempt to seek, provide, and manage information during the course of their daily work.

The paper is organized as follows: in the next section, we discuss information seeking and temporality in greater detail. In Section 3, we present

details of our field site. Next, we discuss the three major temporal features of work – temporal trajectories, temporal rhythms, and temporal horizons. In Section 5, we discuss how the three temporal features are related and potential benefits and challenges organizations face in more explicitly dealing with temporality as a feature of work. Finally, we conclude with some thoughts on information seeking, collaboration, and temporality.

2. Information seeking and temporality

Because of our interest in exploring temporality in the context of people's information seeking and management activities, we will briefly provide some background on both information seeking in collaborative work and temporality in organizational settings.

2.1. INFORMATION SEEKING IN COLLABORATIVE WORK

Traditional models of information seeking are focused on the individual information seeker. These models background understandings of collaboration and the broader context of work into which information-seeking activities are incorporated (Wilson, 1996; Twidale et al., 1997). For instance, Kuhlthau (1988) and Ellis' (1989) information-seeking models highlight the different stages and behaviors of an *individual* seeking information. Neither model incorporates collaboration in the process. In his discussion studies of user needs and of information seeking behavior, Wilson (1981) states, ''Information seeking behavior results from the recognition of some need perceived by the *user*.'' Information seeking is conceptualized by most information-seeking models as an intrinsically individual activity because of the emphasis on the individual not collaborative work.

Researchers studying collaborative work have acknowledged the important role that information seeking plays (Cicourel, 1990; Forsythe et al., 1992; Paepcke, 1996). However, only a few researchers have focused on actual collaborative information-seeking practices. One of the largest-scale studies exploring this problem was undertaken at the University of Washington (Fidel et al., 2000), where researchers investigated the information-seeking behavior of teams from two different companies, Boeing and Microsoft (Poltrock et al., 2003). They found that each team had different communication and information-seeking practices, and that current information systems are oriented toward individual rather than collaborative information-seeking activities. In practice, though, information seeking is often embedded in collaboration. For instance, in a study of a military command and control environment, Sonnenwald and Pierce (2000) describe information seeking as a dynamic activity in which ''individuals must work together to seek, synthesize and disseminate information.'' They describe the

importance of sharing information between team members during the information-seeking process. Reddy et al. (2002) describe the different information sources that patient-care team members use when collaborative looking for information. In these and other studies (e.g. Allen, 1977; McDonald and Ackerman, 1998; Sonnenwald and Pierce, 2000), the conventional view of the individual as *the* information seeker is challenged. As Twidale et al. (1997) state, "It is our belief that collaborative actions are central to the information search process."

Traditional approaches to information processing present "information" as given, well-defined and stable. This reduces the problem space to access and retrieval; the key becomes the design of better technologies to provide easier access to the information. Studies of information practice, however, reveal a more complex picture. Information seekers do not simply gather information from some external sources; instead information is created by interaction between individuals. Dervin (1999) describes information as an interactionally created artifact, encouraging us to turn our analytic attention away from problems of "access" and towards the ways in which information is created in the course of collaborative work. An aspect of work that plays an important role in the creation and use of information is temporality.

2.2. TEMPORALITY IN ORGANIZATIONS

We noted at the outset that temporality – the experience of time and the temporal organization of activities around us – is a central element of our experience of the world. Phenomena such as the passage of time, the cycle of the seasons, and the trajectory of aging are so integral to human experience that they are enmeshed in ancient myths and religious practices. Similarly, just as temporality is central to our experience of the world, it is also central to our interactions with each other. In organizational settings, people use their knowledge of the temporal features of the work to plan, organize, and coordinate their work activities (Barley, 1988; Egger and Wagner, 1992; Bardram, 2000). Much cooperative activity is built around the temporal organization of the world, from conversational turn-taking to large project planning.

The coordination of work is intrinsically tied to temporality because "the vast subdivision of labor which characterizes our technology requires coordination in time and space – neither axis alone is adequate." (Cottrell, 1939) Temporal logics emerge on individual and collective levels (Roy, 1959), and lend an interpretive structure to the work of the organization. As Strauss et al. (1985) note, "Anyone who works in organizations thinks – has to think – of his or her work, and of the organization itself, in temporal terms."

Orlikowski and Yates (2002) observe that researchers have studied temporality from two diametrically opposite perspectives – objective and

subjective. The objective perspective views time as ''independent of man''; time is linear, mechanistic, and absolute. The subjective perspective views time as ''a product of norms, beliefs, and customs of individuals.'' Orlikowski and Yates propose a practice-based perspective that bridges the objective–subjective dichotomy. From this perspective, people experience time through *temporal structures* that they reify through recurrent use in their everyday practices. Time is both independent of and dependent on human actions. The practice-perspective allows us to examine temporality from the perspective of people doing the work and their interactions with temporal features of the work.

Like Orlikowski and Yates, we are particularly concerned with the relationship between temporality and practice, with the ways in which a negotiated temporal order arises within, and lends meaning to, individual activities coordinated in concert. We believe that a detailed understanding of the relationship between temporality and practice provides a basis for both a more detailed analytic understanding of the temporality of collaboration, but also for technological and representational advances in support of cooperative activity. We approach this topic through an empirical investigation of temporality and information seeking in one particular cooperative domain – hospital work.

3. Surgical intensive care unit

Our fieldwork was conducted in the surgical intensive care unit (SICU) of a large metropolitan teaching hospital. The first author observed work in the unit for approximately 7 months during 2000–2001. He collected data through 30 formal interviews, as well as a number of informal interviews, and observations. The formal interviews were taped and transcribed. He also had access to internal communications, including written policies, procedures, and meeting notes.

3.1. RESEARCH SITE

The SICU is one of nine intensive care units in the hospital. In comparison to regular hospital wards, intensive care units have a higher nurse/patient ratio (1:2 rather than a more usual 1:6), allowing for more intensive patient monitoring and medical care, more comprehensive electronic monitoring of the patient, and stronger collaboration among healthcare providers to respond quickly to rapid changes in the patient's condition.

Specifically, the SICU is a 20-bed unit that treats the most seriously ill surgical patients, including those who have suffered major trauma, or undergone liver transplant or other major elective surgery. It is extremely busy, with 19 of the 20 beds occupied on a daily basis. Patients usually stay in

the unit for 5–6 days and are treated by a team of health-care workers (see below). The SICU is equipped with sophisticated equipment including digital physiological monitors, web-based applications (Duncan and Shabot, 2000), and a fully computerized patient record system (Reddy et al., 2001). In most cases, patients are in such critical condition that any minor change in their condition could have rapid and severe implications. The specialized equipment and staff in the SICU allows early detection of even small changes in a patient's condition, thus permitting rapid changes in treatment to prevent problems from developing.

3.2. SICU STAFF

Patient treatment in the SICU is highly collaborative. The SICU staff includes surgical critical care nurses, pharmacists, physical therapists, social workers, respiratory therapists, surgical residents, critical care fellows, and faculty. In addition, in the ''open'' treatment model followed in the SICU, the patient's primary care physician and other specialists will also be involved in patient care. In our work, we focus on three groups from the SICU staff: physicians, nurses, and pharmacists, who carry out the majority of collaborative work activities in the unit.

The physician staff plays a central role in making medical and organizational decisions in the unit. The physician staff consists of three rotating surgical residents, two critical care fellows, and four attending physicians. The physician staff is responsible for the patient from the minute the patient is admitted to the unit until the patient is discharged from the unit.

The nursing staff consists of more than 50 registered nurses certified in critical care, supervised by a SICU nurse manager. The nurses work 12-hour shifts (7 am–7 pm/7 pm–7 am). Unlike individual physicians who are responsible for a particular patient during that patient's entire stay, a nurse only deals with any specific patient for the duration of one shift at a time. On her next shift, depending on the staffing needs in the SICU, she may be assigned to another patient.

The SICU also has a pharmacist assigned to it on a permanent basis. The medical staff, especially the residents, relies heavily on her knowledge to help them make the appropriate medication decisions.

3.3. INFORMATION SOURCES

One immediately striking feature of the SICU is the large number of information sources that the staff members use in the course of their daily work. The SICU information space includes patient medical information and organizational information stored across various electronic, non-electronic, and human information sources.

The electronic resources include HealthStat, an ICU-specific electronic patient record system. HealthStat allows the SICU staff to follow the patient on an hour-by-hour as well as minute-by-minute basis. The other major electronic resource is WebView, a hospital-wide web-based system. It is used in the SICU to view digital images (e.g., MRIs, CAT scans). The unit also contains digital bedside physiological monitors and digital X-ray workstations.

The non-electronic resources are just as numerous. For instance, a central whiteboard contains most current patient-bed information and on-call information, updated at the beginning of each nursing shift. Outside each patient's room, a paper copy of the patient's record is stored in a color-coded folder. Within the record are time-stamped notes written by the patient's primary physician and consultants and any therapies or treatment plans ordered by outside physicians. Books, charts, and other paper-based records provide sources of information about not only patients but also about hospital activities and procedures, and general medical information.

The human resources include consultants, ancillary services, SICU staff, and patients. Consultants are physicians who are called in to see a patient because of their specialized knowledge. Ancillary services include respiratory therapists, physical therapists, and social workers. They provide information on the patient's response to therapy (e.g., breathing improving) and social issues (e.g., family is/is not supportive). The SICU staff also serves as in important information resource to each other. Finally, the patient is an important source of information. Patients provide information impossible to otherwise gather such as how comfortable/uncomfortable they are, and identifying locations of pain in their bodies.

4. Temporal organization of work

The wide range of skills and activities represented by the staff, and the large number of heterogeneous information sources distributed through the workplace raise obvious questions of precisely what role the information plays in the work being conducted, and how that work is coordinated across a range of people and sites.

Our initial investigations focused on the ways in which questions were asked or answered, and various information sources employed in order to answer specific questions that arose in the course of administering medical care (Reddy et al., 2001, 2002). However, this focus – on where questions and answers arose – neglects the considerable importance of the temporal nature of information flows through the organization. The various activities at work – of staff members, of medical actions, of patient movements, etc. – gain their intelligibility through a collective organization that allows various parties to interpret and anticipate information needs.

In what follows, we present this in more detail, and illustrate the role of temporality in coordinating medical practice. Our analysis of work in the SICU centers on three temporal features – trajectories, rhythms, and horizons. These three concepts point to different levels of work in the unit.

Temporal trajectories focus our attention on the individual patient and activities related to that patient occurring over a period of time. As we move from examining the work needed to take care of one patient to what happens over time when taking care of multiple patients, we move to temporal rhythms; rhythms focus our attention on collective behavior in the unit. Finally, temporal horizons point to how an individual responds in her daily work to temporal rhythms and trajectories. So, temporal trajectories and horizons highlight temporal issues at an individual level; temporal rhythms highlight temporal issues at a collective level.

4.1. TEMPORAL TRAJECTORIES

Anselm Strauss[1] and colleagues (Glaser and Strauss, 1968; Strauss et al., 1985) developed the concept of illness trajectories in their studies of work in medical settings. Strauss et al. (1985) use illness trajectories to refer to:

> Not only the physiological unfolding of a patient's disease but to the total organization of work done over that course, plus the impact on those involved with that work and its organization. (p. 8)

Illness trajectories are a conceptual device to examine the work (people, places, activities) surrounding a particular patient as the patient progresses through a particular illness. The focus of illness trajectories is on the work over time for a given patient. By describing work as it unfolds over time, illness trajectories focus on the *sequence* of work activities. For instance, a patient progresses through various stages of an illness that follow each other. For each stage, there are sets of activities associated with that stage. Illness trajectories point to this sequencing of activities. As the illness unfolds, the work of managing that illness also unfolds. Illness trajectories present us a way of examining this management from a number of different perspectives: the patient, nurses, physicians, family, and other health-care providers.

A patient's particular illness trajectory also creates a structured "timeline" of activities, events, and occurrences – a *temporal trajectory*. We use this term to focus on the fact that illness trajectories have not only a spatial but also a temporal logic by which they proceed. The temporal aspect of a trajectory concerns the way in which it unfolds and the forces that move it to completion. Temporal trajectories shift our focus from the sequential ordering of work to a broader temporal orientation of the patient's *progress* through the illness or treatment regime (in turn, allowing that progress to be evaluated). A sequential ordering focuses our attention on the one-to-one relationship

that an activity has with the activity preceding it and following it; in contrast, the temporal orientation emphasizes how these activities relate to all other activities and to the broader patterns of work, embedding an illness trajectory within the larger temporal structure surrounding the patient. The salience of temporal trajectories is evidenced in the way that healthcare workers, especially physicians, talk about their patients and focus on such questions as:

- Where is the patient in her recovery?
- Where *should* the patient be in her recovery?
- What do we have to do to ensure that the patient is at the right point of her recovery?
- What has happened to the patient during her recovery?

These questions point to a need to understand a patient's progress through an illness from a temporal perspective. The value of temporal trajectories as an analytic tool lies in demonstrating how SICU staff orient their immediate actions towards both past and future actions and expectations. Staff members are aware of a patient's temporal trajectory and use this knowledge to provide appropriate care for the patient.

4.1.1. *Temporal Trajectories in the SICU*

A patient's particular temporal trajectory depends on a variety of issues including type of illness, possible complications, and plan of care. The combination of these different conditions shapes a patient's temporal trajectory. Within the SICU, the staff especially the physicians and nurses are concerned with the *overall* temporal trajectory of the patient because they are responsible for the patient from the minute that the patient is admitted into the unit until she is stable enough to be released. Physicians want to know on a constant basis what has been happening (looking backwards) and what is planned (looking forward) for the patient. They are continuously trying to find past information and think about future information that they will need. One way that team members know about a patient's temporal trajectory is through explicit verbal statements. For instance, during rounds, the presenting resident explicitly states how long the patient has been in the unit.

> A resident is presenting a patient who is recovering from a surgery to repair gunshot damage from an attempted suicide. He starts the presentation by stating "the patient is recovering from a gunshot wound to the face." However, before he can continue his presentation, the attending, Jack, stops him. He didn't like the way that the resident presented the patient. Jack tells the resident that he should present the information, as "patient is post-op 3 days from a gunshot procedure arising out of an attempted suicide."

This statement of time – "*post-op 3 days*" – serves multiple purposes. It situates the patient within a temporal trajectory that has an entrance event

(admission to the unit) and an exit event (discharge from the unit). It also cues team members on where the patient is in her recovery; based on this information, team members can place the other patient status information (e.g., vitals, speed of recovery) within the patient's temporal trajectory to help them determine whether the patient's recovery is on-schedule. The relevance here is not simply that the patient has arrived in the SICU out of the operating room, as is quite common, but rather that the patient is being explicitly located within a sequence of events which will play out according to broadly understood patterns.

Although physicians pay close attention to a patient's temporal trajectory, nurses are also broadly interested in a patient's temporal trajectory, and, in particular, how it relates to their own trajectories, as defined by their shiftwork. Since nurses are assigned to patients on a shift basis, rather than being associated with them through their stay in the SICU (as are the physicians), they often need to be able to form an understanding of the patient's history and trajectory in order to provide appropriate patient care. In the following quote, Theresa describes problems that current technologies in the unit have in providing this past history.

> Theresa: Some times what I want in the HealthStat, is to have a flow sheet where there would be some kind of chronological events that happened. For instance you come back to the unit, you have been gone for a month and here you come and you get a 15-minute report for that patient. That will not tell you a lot about that patient. It tells you about what is going on today or during the past 72 hours. For the whole picture, you cannot really see what went on. I have told my nurse manager, that maybe, you need to create a form, for instance like September 1, patient came in, use data like that, September 2 – patient had an episode of an arrest, September 3 – went to CAT scan. Those are significant events that could have been put in, because sometimes you come in and really it is like groping in the dark, like you really know what went on and if the went into a Brady, yeah, you can really like look back but some times you basically look back for a day's report. But if we have like a quick look form where you can just put the patient had an episode of v-tach on September 3.
>
> Interviewer: Something in a chronological order.
>
> Theresa: Yeah, chronologically. I think that would be great. Just like a summary report for the day, in one clean sentence, like for instance today, if there is really no significant event, you can just say, *status quo* from the previous day. Like if my patient today was started on dopamine, then you

> can put that it was started on this day or for tomorrow the patient will go for a MRI, that sort of thing that is significant. Even for us nurses we do know when they went for the MRI and when was the last time and we always like, look to each other when you are rounds and some one says when was the last CAT scan and then it is really hard to trace that, when was the last central line placed, we do not know that. In this way we will always know where to check for this information.

Theresa's responses highlighted the type of temporal information that nurses find useful. The information contained in the information system is not sufficient in itself; the temporal context within which it can be placed, organized according to the trajectory, helps makes sense of it. This is particularly significant because of the details of nurses' working schedules. Full-time nurses in the SICU work three days and then do not work for four days. So, when they come back to work after those four days, there are usually gaps in their knowledge concerning their assigned patients. Therefore, they are interested in making sure that they understand what has happened to the patient; this allows them to situate the patient within a temporal trajectory. Physicians and nurses are interested in what has happened, what is happening, and what is going to happen to the patients in the SICU.

Temporal trajectories help to contextualize both information and actions by emphasizing the temporal context of patient treatment and care administration.

4.2. TEMPORAL RHYTHMS

Temporal trajectories focus our attention on temporal aspects of work in the SICU associated with the individual patient. However, a significant feature of hospital work (and indeed, of most working activities) is the ways in which activities are repeated. The unit and the staff have to deal with many patients at once and over time. The temporal trajectory begins to show how an individual patient's progress can be linked to others through an understanding of conventional patterns of treatment and recovery, but it provides us with little help in understanding how multiple activities are knitted together to create a collective whole. Our data suggests that the pattern of activities across many patients and across many people creates, itself, a temporal structure towards which staff members can orient themselves and through which they can coordinate their work. An analytical approach that highlights a temporal characteristic of work at a collective level is the concept of *temporal rhythms*. The concept of rhythms directs our attention to the re-occurring patterns of work and how people use their knowledge of these re-occurring patterns during their patient care and organizational activities in the unit.

In his classical study of social rhythms in a hospital, Zerubavel (1979) described the cyclical nature of work to highlight the role of temporality in work. Similarly, Peter and Trudy Johnson-Lenz (1991) described how daily activities occur in regular patterns or rhythms in our lives. We use the concept of rhythms in a slightly different manner. Our interest is not only in the fact that medical work exhibits these patterns, but in the detail of how these patterns provide people with a resource for seeking, providing, and managing information in the course of their work.

Rhythms arise from the broad temporal pattern of the work iterated over time. Critically, the unit's work is characterized not by a single rhythm, but by many; the rhythms associated with different people, activities, tasks, and interactions that collectively form a complex temporal fabric. It is precisely the characterization of, and orientation to, these different component rhythms that concerns us here.

The broad pattern of work in the unit is governed by sets of large-scale and finer-grained rhythms. Examples of large-scale rhythms include nursing shifts, rounds, movement of patients through the SICU, bed management meetings, arrival of patients from the operating room, and SICU residents' work. Examples of much finer-grained rhythms include lab results, medication administration, and drug responses.

4.2.1. *Nursing Shifts (large-scale)*

Nurses work 12-hour shifts, with shift changes at 7 am and 7 pm. These shift changes set a broad temporal pattern for the work of the unit. Within those shifts, there are generally three major periods of intensive activities. These periods are spread throughout the nurse's 12-hour shift but are fairly predictable. The first period of intense activity is at the beginning of the shift. The nurse going off duty "gives report" to the incoming nurse taking over for her. During this information exchange, which usually lasts for 30 minutes, the incoming nurse must rapidly assimilate all the information about the patient and the daily plan of care for the patient. Immediately after shift report, the nurse ensures that all the medications are available and checks on the patient. The next intense period of activities follows the SICU team morning rounds; the nurse implements or helps the physicians implement the plan of care decisions made during the rounds. The final intense period of activity occurs at the end of the shift. The nurse makes sure that all her work for the shift is done and gathers all the information that she will have to give her replacement. Obviously, how busy a nurse will be during a shift is affected by the condition of her patient.

There are major differences between the rhythms of the day shift and night shift nurses (Zerubavel, 1979). During the day, the nurses deal with admissions, discharges, and procedures ordered for the patient. Day shift nurses have access to more varied information sources because of the

availability of physicians and other healthcare providers but the night shift nurses do not have the same access to these information sources. Night shift nurses also perform basic patient care functions that cannot be done during the day, e.g., bathing the patient.

4.2.2. *Lab Results (finer-grained)*

A key monitoring feature of the SICU is the various tests performed on the patient. For instance, a common occurrence in the SICU is patient infection. A common lab test to check for infection is measuring the white blood count; a high count indicates that the body is fighting an infection. There are two ways to get this count. A ''stat'' lab means that the medical staff will receive the information within a half-hour, and a ''regular'' lab will return a result within a few hours. Therefore, the staff knows depending on the type of lab test, when the results should be ready.

Rhythms manifest themselves in various ways in the SICU. Individuals use the information that rhythms provide to help them accomplish their work and guide them in their future activities. However, temporal rhythms describe broad patterns of work in the unit at a collective level. What we observe in the unit are not the rhythms themselves but how an individual respond to the rhythms in their daily work. We turn our attention to how rhythms manifest themselves in the details of an individual's work through a set of temporal horizons.

4.3. TEMPORAL HORIZONS

Rhythms serve as a resource for people seeking, providing, and managing their information during the course of their daily work. People's knowledge of rhythms allows them to anticipate when information will be needed and when it will be available. However, rhythms themselves do not do any work; rather, it is people who in the course of their work are responding to the rhythms. This raises an important question: *how do people respond to rhythms?*

Rhythms describe broad patterns of activities for the SICU as a whole (such as the rhythms of patient movement through the unit.) For individuals, these broad patterns arise in practical concerns – what work must be done and when must it be carried out. Generic aspects of the work give rise to specific components and courses of action. We characterize the manifestations of rhythms in work practice as an emergence of a set of *temporal horizons*. People, in the course of their daily work, use their knowledge of likely future activities to organize their current activities. Through this organization, people create a sense of ''orderliness'' to the work. Orderliness does not imply a rigid, sequential ordering of activities. Temporal horizons do not describe a schedule of activities that people follow in ''lock step'' nor

attempt to describe how people closely manage their work. Rather, they refer to how people broadly arrange their activities to ensure that they accomplish their work in a timely and appropriate manner. For instance, a nurse has to carry out multiple activities (e.g., medication administration, patient transportation, and vital collection) in order to provide appropriate care for a patient. Temporal horizons describe how she organizes these jobs based on her knowledge of when she has to finish them in order to prepare for upcoming activities.

Two important properties of temporal horizons help us better understand this concept. First, temporal horizons are people-based, not activity-based. We associate a temporal horizon with the person doing the work, not with a particular activity. An individual has a general understanding of her activities and when these activities have to be done. For instance, during her workday, a professor knows that she has to teach a class at 10:00 am, meet with students early in the afternoon, and call a co-writer between 4:00 and 4:30 pm. Temporal horizons reflect this broad temporal structure to the person's day. Some of the activities have fixed deadlines such as teaching class at 10:00 am while others such as meeting students early in the afternoon are more vague. Temporal horizons point to how an individual's personnel view of her activities is temporally organized. Second, an individual doing her work often has to deal with multiple temporal horizons. Rarely, will she have only one activity to focus on. In the course of her work, she is constantly shifting activities and putting one activity in front of another. She has to organize her multiple activities with an eye towards the effect that this organization will have on her upcoming work. Multiple temporal horizons characterize how an individual organizes a re-occurring activity. For instance, after a nurse administers a medication to a patient, she has to then plan when the patient must next receive the medication – is it in an hour? In two hours? In a day? Individuals in the course of their work must organize multiple jobs and re-occurring activities as they prepare for future work.

People organize their work with an orientation to the future (e.g., work that is waiting for them, information that is needed). In the SICU, team members' different approaches to accomplishing their goals are characterized by different temporal horizons.

4.3.1. *Temporal Horizons in the SICU*

In the SICU, different temporal horizons characterize the different ways that team members go about completing their activities. These temporal horizons describe two important aspects of team members' work in the unit – flexibility and urgency. In this section, we will discuss how temporal horizons characterize team members' flexibility and urgency in the SICU.

Flexible vs. Inflexible Horizons. Clearly, an individual does not carry out all her activities at the same time. Instead, during her work, she often knows the "window" of time that she has to complete an activity. If she has a large window of time, she has more flexibility on when the activity has to get done. Conversely, if she has a short window of time, she has less flexibility on when the activity has to be completed. We characterize a temporal horizon as *flexible* or *inflexible* when describing an individual's flexibility on when she has to get her work done. A situation in which an individual has flexibility concerning when an activity has to be finished, we describe as a flexible temporal horizon. If the person does not have much flexibility on when the work needs to done, we describe as an inflexible temporal horizon. Individuals who have less flexibility have to follow the actual "scheduling" of the work much more closely than individuals who have greater flexibility.

The following two vignettes describe the same activity. However, in one case, a flexible temporal horizon characterizes the situation and in the other case, an inflexible temporal horizon characterizes the situation.

> A nurse, Sharon, is accepting the new values for respiratory data for patient 1 in HealthStat. The values are automatically transmitted to HealthStat from the bedside monitors. However, before they are considered valid, the nurse must accept the data. To ensure that the data is correct, Sharon looks at the bedside monitor to compare those values with the values in HealthStat. Interestingly, for 9 am data collection (data is collected every hour for this patient), she is accepting the data at 8:30. When asked why she is accepting the data earlier than when they should be collected, she responded that it was o.k. because the vitals do not change that often for patient who are stable.

Patient data is regularly collected every hour (i.e., 6 am, 7 am, 8 am, etc.) So, Sharon should accept the patient vitals on an hourly basis. Yet, what she actually did was to accept the data a full half-hour before it was needed to be done. This flexibility allowed her to focus on other activities such as checking on the patient's medications. In this instance, due to the patient's stable condition, Sharon had a considerable leeway on when to accept the data. She could have accepted the data anytime between 8:30 and 9:00 am. Sharon is following a particular schedule for data collection (i.e. data is accepted on an hourly basis) but had greater flexibility on when to collect the data because of the patient's stability. Contrast this situation with one where Sharon had less flexibility on when to accept the patient's vitals.

> In the morning, Sharon is accepting data for a patient and talking on the phone at the same time. As she was talking on the phone, she stopped accepting the data and moved away from the HealthStat workstation. Another nurse who saw that she was busy walked over the workstation

> and finished accepting the data for her. This activity is not unusual – nurses often help each other out in this way. The nurse finished accepting all the data for the 10:00 am vitals at 9:30 am. In most circumstances, this would not be a problem. However, this particular patient was receiving dopamine. Over time, dopamine can greatly change the vitals. Therefore, the actual 10:00 am vitals would be very different than the 9:30 am vitals. At 10:00 am, Sharon had to insert a comment that there was mistake and manually enters the data at that time for the patient.

In this case, the patient was receiving a specific medication, dopamine, that affects the patient's vitals (e.g., raising blood pressure). Because dopamine could change the patient's condition significantly in as little time as a half-hour, his vitals at 9:30 am will be different then at 10:00 am. Therefore, Sharon had to accept the vitals at 10:00 am (when it should be done) rather than at 9:30 to ensure that she accepted the correct vitals. She had less flexibility on when this activity needed to be done because the patient's condition was unstable. The temporal horizon characterized by this situation was much tighter because the patient's instability prevented Sharon from having the flexibility of accepting the data earlier.

These two examples illustrate different ways that temporal horizons may affect the organization of work particularly a person's flexibility in carrying out her activities. Although both patients' vitals were monitored on an hourly basis (i.e., the rhythm for the monitoring was the same), Sharon did not have the same flexibility on when she has to accept the vitals for both patients. For the first patient, the temporal horizon was flexible because Sharon had greater flexibility on when she had to do the work. However, she had less flexibility with the second patient and the temporal horizon was inflexible.

Close vs. Distant. In the course of her daily work, a person must deal with a wide variety of activities that can easily overwhelm her. Therefore, she must have some idea of what activities are coming up and when they are going to occur because that will affect her ability to finish her immediate work. Temporal horizons allow people to situate their work with respect to other anticipated needs and activities. So, for instance, the proximity (immediacy) of the next activity affects the work currently being done (e.g., increases the sense of urgency). We characterize a temporal horizon as *close* or *distant* when describing a situation where people use their knowledge of what's coming up – through their understanding of rhythms – to determine how quickly they must work to finish their current activities. This knowledge manifests itself in a variety of ways. While a close temporal horizon might necessitate a scramble to get things finished, a distant temporal horizon allows for work to be carried out at a more leisurely pace or postponed

altogether. An imminent nursing shift change provides a perfect example of a rhythmic activity that quickens the pace of the nurses' work.

> At 6:30 pm, the unit is starting to get really busy because the nurses will change shift at 7 pm. Karen, the charge nurse, for 7SICU is sitting down and filling out a patient summary sheet that she will give to the night shift charge nurse. At the same time, another nurse, Lisa, is filling her in about one of Lisa's patients. Lisa is telling Karen about the patient's medications, procedures, and problems. She than tells Karen about her other patient. Most of the other nurses are sitting at the various workstations entering data into HealthStat. Everybody is looking real busy. When I asked Lisa about shift change, she said, "Oh yeah, it always gets really swamped around now. We are trying to get everything done before we leave." The primary resource nurse (she is in charge of both 7&8SICU) for the shift then walks into the unit and Karen tells her the patient assignments that she made for the night nurses. Around 6:45 pm, night shift nurses start coming into the unit and preparing for their shift.

The nurses are trying to get everything done by shift change to ensure that, first, they can go home; and second, that the night-shift nurses will have the necessary information to carry out their work. So, at 6:30 pm, the nurses started to work faster to finish by 7 pm – shift change. Their work highlights how as a rhythm changes (i.e., from day to night shift) the nurses' activities are pushed closer together and the pace is picked up in order to finish all the work activities before shift change. From a temporal perspective, upcoming events push current activities nearer together creating a close temporal horizon. In this situation, the temporal horizons were pushed closer together because shift change was about to happen. However, when shift change is not looming, a nurse may not feel the need to pick up the pace in order to finish her work in the same way that she would right before shift change.

> At the start of a day shift, one of the nurses, Kelly, is showing me the different forms that they have to fill out. One of the forms is labeled "Multi-disciplinary Plan of Care." I ask her what she has to do with this form. She tells me that the nurses fill out the form with the plan of care for the patient and with the different people (i.e., respiratory therapists, social workers, etc.) who have seen the patient during the day. She does not fill out the form until the near the end of her shift because she does not have all the information until then. Also, she says that it only has to be done by the end of the shift.

Because it is the start and not the end of the shift, Kelly did not worry about completing the multi-disciplinary plan of care form. She does not have to speed up her work pace to fill this form because it was not needed until the

end of the shift. Her lack of urgency to do the work points to a distant temporal horizon.

A close temporal horizon characterizes a work situation where upcoming events push current activities closer together creating a sense of urgency to finish these activities. An individual's reaction to this urgency is to quicken the pace of her work. Conversely, a distant temporal horizon characterizes a work situation where future events are distant enough that an individual does not perceive a sense of urgency to finish her current work; hence, she does not quicken her pace of work in this situation.

Temporal horizons, unlike rhythms, focus on individual rather than collective work. Their relevance is that temporal horizons describe how an individual decides when to do the work – what she has to do *now* to prepare for what is coming up; temporal horizons describe how an individual temporally organizes their activities with respect to rhythms and trajectories. In the SICU, temporal horizons – flexible, inflexible, close, and distant – characterize important aspects of team member's work. These different temporal horizons characterize two important features of an individual's work: (1) the flexibility an individual has in organizing her work and (2) the urgency an individual has for carrying out the work.

5. Temporality and collaboration technology

We have discussed the significance of temporality as a facet of collaborative work, both in broad terms (concerning the relationship between temporality and social practice) and in specific terms (drawing on our fieldwork in healthcare). In particular, drawing on this fieldwork, we have proposed a set of interlocking concepts – trajectories, rhythms, and horizons – which provide an initial characterization of relevant aspects of the temporal organization of working activity and its impact on coordination and collaboration. These concepts emerged from the analysis of our field materials, but provide a useful framework for understanding the rich temporal texture of working activities.

While we have presented these broadly as ways of understanding collaborative work mediated by information technology, we want here to consider some broader potential considerations in the design of information systems revealed by the framework.

5.1. INFORMATION FLOWS

Temporality plays a key role in the organization of work and is as important to the social structure as "spatial or hierarchical organization" (Fine, 1990). In the SICU, it is not just information, but the temporal context of

information, that allows people to coordinate their actions and successfully accomplish their work.

What we find when we look at temporality and information is that, while traditional information seeking often characterizes information in terms of individual artifacts or answers, information in organizational life is often organized into flows. Flows of information connect the units of the hospital (the OR, SICU, the labs, external physicians) and the members of each unit (nurses, physicians, pharmacists, therapists). Where individual information needs and information artifacts are short-term phenomena, information flows change much more slowly; they tend to persist in organizational settings. When we characterize work in terms of trajectories, rhythms, and horizons and information in terms of flows, our attention is called to the ways in which they allow for people to anticipate both information needs and working consequences. Temporality and flows lead to *expectations* about the future based on past events. Temporality and flows are ways of imposing a structure on the past that we believe will persist and carry forward into the future. As such, they allow people to anticipate and plan for future events.

Critical to the appropriate interpretation of information, then, is how it is situated within a temporal structure and within (or between) flows of information. Although conventional system analysis techniques focus on information storage, access, and retrieval, with patterns of information movement only secondary, we believe that in many cases the flows of information through an organization – and the temporal organization of those flows – is critical to the interpretation and meaningfulness of that information. By presenting information in a temporal context – in terms of, for example, trajectories, rhythms, and horizons, although potentially too according to other metaphors such as timelines – we can provide tools for more effectively making sense of information and its consequences (Reddy et al., 2001)

5.2. AWARENESS

In CSCW, awareness technologies have often been used to integrate information spaces and representations of activity. Some, such as Schmidt (2002), have noted the broad ambiguity inherent in discussions of awareness, and in particular the fact that, by focusing on awareness as a form of knowledge rather than a form of practice, the term provides little analytic leverage. However, in our fieldwork, we find the processes of interpretation surrounding the temporal structure of activity suggest mechanisms by which an understanding of the relationship between individual and collective activities is being maintained.

Our research highlights the opportunities for incorporating cyclic and temporal information – to show not only current activities, but also patterns of former actions, and expectations about future activities. In other words,

not only do we want to use awareness approaches to ''populate'' information spaces, but also to give a sense of how current activities are related to the past and to the future. The information that Begole et al. (2002) generate describing regularly occurring work rhythms can support information displays that exploit the temporal patterns of activity that surround information. Some researchers, such as Hill et al. (1992) have suggested visualizations that can extend beyond the purely synchronous, and social navigation approaches (Munro et al., 1999) have created information spaces enriched by the temporal aggregation of activities. However, the specifically cyclical nature of many working activities opens up new areas in the design space that can provide for more detailed coordination. The cycle of work helps to render information meaningful because of its very connection to past events and future expectations. We believe that this approach can provide a valuable enrichment of information spaces, and especially to support the interweaving of information use with other forms of work.

6. Conclusions

The work of the surgical intensive care unit is complex and deeply collaborative. Practitioners of different professional backgrounds and training must delicately coordinate their work in order to design, administer and monitor coherent and effective treatments of care. They do so within an environment with myriad tools and technologies each with different characteristics. At the same time, they must coordinate their work not only with each other, but with various external entities, including other parts of the same organization (the hospital) as well as other groups such as professional communities, families, and more.

As we have presented our field data, we have drawn particular attention to the role of the temporal structure of work, and how it provides to SICU staff a set of resources for managing, integrating, and coordinating their individual actions in order to achieve concerted outcomes. In the course of their work, they oriented towards the temporal patterns of organizational life and individual activity as a means to predict upcoming events, anticipate needs, juggle tasks, interpret settings, understand requirements, demonstrate alignment, and negotiate needs. We have pointed, in particular, to three features of the temporal fabric of life in the SICU that seem particularly relevant to the work of the unit. Temporal trajectories describe the ''arcs'' of expected events and are integral to planning treatment and interpreting everyday events. Temporal rhythms describe the broad patterns of repetition and recurrence against which particular activities are experienced; like musical rhythms, these working rhythms create a sense of tension and release as the events of the day, week, or year unfold. Temporal horizons are

individual manifestations of the trajectories and rhythms, and are a primary resource for the coordination of multiple activities.

Collectively, these point to the centrality of temporality in cooperative work. Working activities are not simply carried out, but experienced; and they are experienced as things that unfold in real time. Everyday life is irremediably situated in a temporal structure, and takes its character from aspects of that structure. Any account of work inherently provides an account of temporality, and our model of the temporal nature of working activity must go beyond the ''same time/different time'' model of early CSCW explorations.

Space has been a primary analytic concern for CSCW researchers, and has manifest itself in many ways – from comparisons of collocated and distributed work (e.g. Hinds and Kiesler, 2002) to explorations of the use of spatial models of awareness (Benford and Fahlen, 1993) to studies of the use of immersive technologies for telepresence (Hindmarsh et al., 1998; Fussell et al., 2000). Although temporality is of growing interest to CSCW researchers, we have paid less attention to it than we have to issues of space. Our experiences in the SICU show how central the temporal aspects of collaborative working are, and suggest that this may be a fruitful area for further research investigation. While distance is certainly important, time also matters.

Note

1. Anselm Strauss has done pioneering work in the sociology of medical work. His book *The Social Organization of Medical Work* is an essential reading for any researcher interested in understanding the intricate nature of medical work and its effects on patients.

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