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# Coordination in Fast-Response Organizations

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Organizational coordination has traditionally been viewed from an organizational-design perspective where rules, modalities, and structures are used to meet the information-processing demands of the environment. Fast-response organizations face unique coordination challenges as they operate under conditions of high uncertainty and fast decision making, where mistakes can be catastrophic. Based on an in-depth investigation of the coordination practices of a medical trauma center where fast-response and error-free activities are essential requirements, we develop a coordination-practice perspective that emphasizes expertise coordination and dialogic coordination. We argue that expertise coordination practices (reliance on protocols, community of practice structuring, plug-and-play teaming, and knowledge sharing) are essential to manage distributed expertise and ensure the timely application of necessary expertise. We suggest that dialogic coordination practices (epistemic contestation, joint sensemaking, cross-boundary intervention, and protocol breaking) are time-critical responses to novel events and ensure error-free operation. However, dialogic coordination practices are highly contested because of epistemic differences, reputation stakes, and possible blame apportionment.

**Key words:** coordination; teams; high-reliability organization; practice; expertise coordination; communities of practice

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## Introduction

Coordination has been at the center of organization theory ever since March and Simon (1958) suggested that work in organizations could be coordinated through prespecified programs or mutual adjustment. This long-dominant view is based on the information-processing model wherein increasing task demands must be matched to structures capable of higher information processing (Daft and Lengel 1986, Galbraith 1977, Thompson 1967). Studies of coordination in settings as varied as office work units (Van de Ven et al. 1976), hospital emergency departments (Argote 1982), research and development (R&D) teams (Keller 1994), and accounting audit teams (Gupta et al. 1994) have substantiated the core idea that matching increased task uncertainty to less formal modes of coordination leads to better performance.

The importance of coordination is increasing as organizations become reliant on interdisciplinary teams of specialists and distributed operations using communication technology (Child and McGrath 2001, DeSanctis and Monge 1999). More and more organizations face highly volatile environments often characterized by dynamism and discontinuous change

(Bourgeois and Eisenhardt 1989, Brown and Eisenhardt 1997). Furthermore, as knowledge work in organizations principally takes place in work groups, coordination is less dependent on structural arrangements and more contingent on knowledge integration (Argote 1999). A gap exists between the traditional view of coordination as structural arrangements and coordination as an unfolding process of linked know-how and interrelated actions. Work groups themselves have traditionally been portrayed as coordination mechanisms (e.g., Galbraith 1977, Van de Ven et al. 1976) rather than settings where complex and interdependent work gets performed.

In this paper, we focus on the collective performance aspect of coordination and emphasize the temporal unfolding and situated nature of coordinative action. We address how knowledge work is coordinated in organizations where decisions must be made rapidly and where errors can be fatal. We call organizations that face such operating conditions *fast-response organizations*. Such organizations develop structures and risk-mitigation processes that allow them to function reliably under the most demanding of circumstances (Grabowski and Roberts 1999, Weick et al. 1999). Although much has been learned

about the unique structures, decision making, and culture of fast-response organizations, little research has addressed their specific coordination mechanisms and practices.

Based on an 18-month-long investigation of a leading trauma center, we explore how coordination of knowledge work occurs in a fast-response organization. Previous models of this type of coordination have emphasized the management of resources (e.g., technology, personnel) through well-understood administrative coordination mechanisms (e.g., task assignment, resource allocation, input integration) (see Malone and Crowston 1994, March and Simon 1958, Thompson 1967, Van de Ven et al. 1976). Using a practice lens (Brown and Duguid 2001, Orlitzky 2000), we suggest that in settings where work is contextualized and nonroutine, traditional models of coordination are insufficient to explain coordination as it occurs in practice. First, because expertise is distributed and work highly contextualized, expertise coordination is required to manage knowledge and skill interdependencies. Second, to avoid error and to ensure that the patient remains on a recovering trajectory, fast-response cross-boundary coordination practices are enacted. Because of the epistemic distance between specialists organized in communities of practice, these latter coordination practices magnify knowledge differences and are partly contentious. An explanation of how expertise is coordinated and how coordination practices unfold in a fast-response setting is the core contribution of this paper.

## Reframing Coordination

At its core, coordination is about the integration of organizational work under conditions of task interdependence and uncertainty. Early theories of coordination focused on the need to balance differentiation among organizational units, with integration achieved through coordination mechanisms (Galbraith 1977, Lawrence and Lorsch 1967, Thompson 1967). The information-processing paradigm provides a common theme for prior research on coordination. Each coordination mechanism is endowed with a specific information-processing capability and must be matched to the information-processing demands of the environment or needs generated by the interdependence of work units.

Not surprisingly, previous models have emphasized the mode of coordination based on the assumption that certain modes are richer or more interactive and can, therefore, provide higher information-processing capacity. As a result, research findings have emphasized the distinction between formal and informal modes of coordination, along with the need for the latter in uncertain environments. Accordingly, coordination has been measured along various

modal continua, for example, by program or feedback (March and Simon 1958), impersonal versus mutual adjustment (Van de Ven et al. 1976), formal versus informal (Kraut and Streeter 1995), and programmed versus nonprogrammed (Argote 1982).

More recently, Malone and colleagues (Malone and Crowston 1994, Malone et al. 1999) developed a coordination theory that emphasizes the management of interdependencies among resources and activities. By characterizing various interdependencies and focusing on the process level, a variety of coordination mechanisms can be identified and applied. These mechanisms can be used as building blocks to solve coordination problems in organizations or to design novel organization processes. A strength of coordination theory is its recognition of the complexity of interdependencies in organizational work. However, it shares with the information-processing view the assumption that the environment is predictable enough to characterize existing interdependencies and that predefined mechanisms can be designed for various contingencies.

In knowledge work, several related factors suggest the need to reconceptualize coordination. First, it may be just as important to focus on the content of coordination (what is being coordinated) as on the mode of coordination. Traditional coordination theory emphasizes the *how* (i.e., the mode) of coordination as opposed to the *what* (content) and *when* (circumstances) of coordination. This distinction becomes increasingly important in complex knowledge work where there is less reliance on formal structure, interdependence is changing, and work is primarily performed in teams. In fact, complex knowledge work requires the application of specialized skills and knowledge in a timely manner, thus raising difficult coordination issues in dynamic and time-constrained environments (Faraj and Sproull 2000, Gittell 2002).

Second, the traditional concept of interdependence as a property of existing linkages between organizational units is of limited use in work settings already organized in teams, where individual cooperation is essential. Thompson's (1967) highly influential but simple typology of interdependencies may be useful to describe necessary interunit or interorganizational linkages. However, it assumes that predetermined work patterns accurately reflect requisite interdependencies and, thus, is a less compelling frame for explicating interdependent knowledge work performed in interdisciplinary teams.

Third, coordination theories have limited applicability in organizations that face a high-velocity environment and must also operate essentially error free. Contrary to the tenets of coordination theories, in such settings the empirical record shows that formal modes of coordination do not melt away in favor of

more improvised ways of coordinating. To the contrary, the dilemma of coordination in such settings is that, on the one hand, there is a need for tight structuring, formal coordination, and hierarchical decision making to ensure a clear division of responsibilities, prompt decision processes, and timely action; but, on the other hand, because of the need for rapid action and the uncertain environment, there is a competing need to rely on flexible structures, on-the-spot decision making, and informal coordination modes. Thus, such organizations paradoxically emphasize both formal and improvised coordination mechanisms (e.g., Bigley and Roberts 2001, Brown and Eisenhardt 1997, Weick and Roberts 1993).

Finally, the coordination of knowledge work may introduce contingencies and intersubjectivities that undermine the information-processing capacity of a coordination mode. For instance, knowledge work increasingly involves specialists embedded in different epistemic communities of practice (COP) where individuals bring with them significant differences in problem conceptualizations and speak different (technical) languages. One implication is that coordination at the boundary may require reconciliation and transformation of knowledge (Bechky 2003) and, thus, involves the COPs themselves (Brown and Duguid 2001). Furthermore, knowledge tends to be embedded in localized work practice and difficult to decontextualize (Brown and Duguid 2001, Lave 1988). Thus, because of differences in perspectives and interests, it becomes necessary to provide support for cross-boundary knowledge transformation (Carlile 2002).

We propose a reorientation of knowledge coordination away from preidentified interdependences and modes of coordination. This reframing is necessary and timely because of the growing recognition that routine coordination (in the sense of recognizable and repetitive patterns) cannot be specified in sufficient detail to be carried out and is, thus, insufficient to coordinate complex knowledge work (Brown and Duguid 2001, Feldman and Pentland 2003). We suggest that for environments where knowledge work is interdisciplinary and highly contextualized, the relevant lens is one of practice. Practices emerge from an ongoing stream of activities and are enacted through the contextualized actions of individuals (Orlikowski 2000). These practices are driven by a practical logic, that is, a recognition of novel task demands, emergent situations, and the unpredictability of evolving action. Bourdieu (1990, p. 12) defines *practices* as generative formulas reflecting the *modus operandi* (manner of working) in contrast to the *opus operatum* (finished work). These practices are characterized by "an uncertainty and fuzziness resulting from the fact that they have as their principle not a set of conscious, constant

rules, but practical schemes, opaque to their possessors, varying according to the logic of the situation." Finally, a practice view breaks with perspectives that overemphasize the role of rules and structures at the expense of actors in explaining work activities. It emphasizes the contextualized engagement of actors and their capacity to make "practical and normative judgments among alternative possible trajectories of action" (Emirbayer and Mische 1998, p. 971).

Based on a practice view, we suggest the following definition of *coordination*: a temporally unfolding and contextualized process of input regulation and interaction articulation to realize a collective performance. Two important points follow. First, the definition emphasizes the temporal unfolding and contextually situated nature of work processes. It recognizes that coordinated actions are enacted within a specific context, among a specific set of actors, and following a history of previous actions and interactions that necessarily constrain future action. Second, following Strauss (1993), we emphasize trajectories to describe sequences of actions toward a goal with an emphasis on contingencies and interactions among actors. Trajectories differ from routines in their emphasis on progression toward a goal and attention to deviation from that goal. Routines merely emphasize sequences of steps and, thus, are difficult to specify in work situations characterized by novelty, unpredictability, and ever-changing combinations of tasks, actors, and resources. Trajectories emphasize both the unfolding of action as well as the interactions that shape it. A trajectory-centric view of coordination recognizes the stochastic aspect of unfolding events and the possibility that combinations of inputs or interactions can lead to trajectories with dreadful outcomes—the Apollo 13 "Houston, we have a problem" scenario. In such moments, coordination is more about dealing with the "situation" than about formal organizational arrangements.

In this paper, we report on a study of coordination in a leading trauma center. Trauma centers are representative of organizational entities that are faced with unpredictable environmental demands, complex sets of technologies, high coordination loads, and the paradoxical need to achieve high reliability while maintaining efficient operations. Trauma victims require intensive and immediate care to aggressively stabilize the patient in the first hour, known as the "golden hour," to forestall complications and multiorgan failures later. A trauma center has little control over its input environment (the kind, number, and timing of patients being brought in) and must organize its staff and resources effectively to provide the best medical care to any number of arriving victims. The primary goal is patient stabilization and initiating a *treatment trajectory*—a temporally unfolding

sequence of events, actions, and interactions—aimed at ensuring patient medical recovery.

We found that coordination in a trauma setting entails two specific practices. First, there is heavy reliance on *expertise coordination processes* to facilitate the management of skill and knowledge interdependencies in a dynamic and highly situated context. Second, when “situations” arise, that is, when a patient is at risk or already on a deteriorating trajectory, intervention is necessary irrespective of specialization, formal role, and reputation. We call these time-critical cross-boundary responses to treatment trajectories degradation *dialogic coordination practices*. Such practices occur infrequently but are highly significant because of the possibility of medical error and disastrous outcome. They are often contentious because of unclear cause–effect relationships and because they involve players with different viewpoints and epistemologies. The rest of this paper describes our field study and discusses our findings.

## Methodology

### Site

The study site, Trauma Center (TC), is a leading trauma center located in an urban setting in the Mid-Atlantic region of the United States. It was one of the first trauma centers in this country and has pioneered some of the key advances in trauma medicine. According to its 2001 *Resident's Manual* the center considers itself “the world leader in research in trauma medicine” and trains “250 residents and fellows, scores of medical students, and hundreds of nurses, paramedics, and advanced practitioners per year.” TC is self-contained in a six-story building that is physically colocated next to a medical school and its hospital. The TC operates a number of specialized subunits, including the 10-bay trauma resuscitation unit (TRU), an operating room (OR) area with six separate rooms, a post-anesthesia care unit (PACU), and an in-patient ward (82 beds). All supporting functions, such as X-rays, computerized axial tomography (CAT) scans, a hyperbaric chamber, and clinical laboratories, are located within the building. According to the local state health agency, the center has 6,000 admissions per year and is designated as the primary adult trauma center for a metropolitan area of about two million people. The TC has a complement of approximately 250 specialists, including surgeons, anesthesiologists, medical residents, nurses, and associated support staff.

We chose TC as a site for three important reasons. First, the site is widely recognized as one of the leading trauma centers in the country. As several interviewees noted with pride, most other trauma centers

are modeled on this one, and more trauma specialists have trained at this center than at any other in the country. Second, as the primary Level-1 center of a large urban area, TC faces a complex environment and a high volume of admissions. Third, part of our research team had a long history of research in this setting, so that site personnel were familiar with members of the research team, trusted them, and were willing to speak frankly to them. However, the interviews and observations were performed by researchers unaffiliated with the medical school in order to create a psychological buffer and because of concern about history—important considerations when covering sensitive organizational issues.

### Data Collection

We began our investigation aiming to understand the interplay of formal and improvised coordination processes but open to alternative frames. We focused our questions during the semistructured interviews on various aspects of coordination, organizing, teamwork, and failures of coordination. As other constructs emerged, we embraced them with an open mind and frequently revisited our interviewing protocol. For example, we initially looked for evidence of “coordination failures.” However, most respondents could not easily relate to this focus. One charge nurse responded: “We basically don’t have coordination failures: We don’t allow it.” Based on the evidence emerging from the setting, we continuously compared data and theory to gain a deeper understanding of the phenomena (Glaser and Strauss 1967, Strauss and Corbin 1990) and shifted our focus to coordination practices.

We collected data over a period of 11 months between December 1999 and October 2000. We used multiple investigators and a mixture of data collection methods to develop complementary insight, achieve theoretical triangulation, and enhance confidence in our findings (Eisenhardt 1989). These methods included review of archival records, observation, shadowing, and in-depth interviews. Additional follow-up interviews were performed to answer any remaining questions, or if the initial interview had been cut short because of logistical considerations, such as an interviewee’s need to respond to an emergency. During the first three months, we observed TC operations intensively and shadowed some key personnel to immerse ourselves in the setting and deepen our understanding of procedures. During the next stage, we intensified our interviews with representatives of every specialty. The research team then analyzed findings and explored emergent theoretical themes. In the final stage of data collection, we performed some follow-up interviews that focused specifically on coordinative actions and interactions resulting from problematic treatment trajectories.

Overall, we observed patient admissions and treatment for a total of 140 hours (with an average session lasting 3.1 hours). We shadowed nine key personnel in five roles for a total of 28 hours and recorded all their interactions and behaviors. We conducted 56 in-depth interviews and 15 short complementary interviews. Interviews lasted from 20 minutes to 1.5 hours, averaging approximately 45 minutes. The interviews were transcribed and checked for accuracy. Based on successive reviews of the observation, shadowing, and interview data, we arrived at a set of recurring themes.

## Findings

We start with a description of the environment and associated uncertainties under which the trauma center operates. Then, we describe two categories of coordination practices that ensure effective work outcomes. The first category, which we call *expertise coordination practices*, represents processes that make it possible to manage knowledge and skill interdependencies. These processes bring about fast response, superior reconfiguration, efficient knowledge sharing, and expertise vetting. Second, because of the rapidly unfolding tempo of treatment and the stochastic nature of the treatment trajectory, *dialogic coordination practices* are used as contextually and temporally situated responses to occasional trajectory deviation, errors, and general threats to the patient. These dialogic coordination practices are crucial for ensuring effective coordination but often require contentious interactions across communities of practice. Figure 1 presents a coordination-focused model of patient treatment and describes the circumstances under which dialogic coordination practices are called for.

## Input Uncertainty

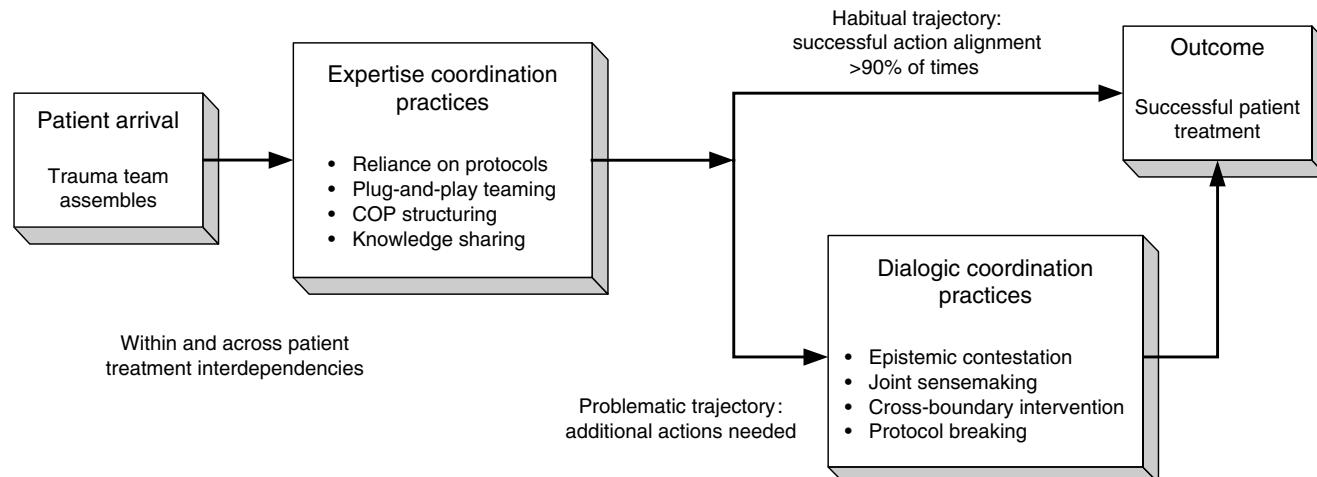
The trauma center receives a large range of trauma injuries. The main categories include penetration trauma (e.g., a gunshot or knife wound) and multisystem trauma patients (e.g., from car crashes and falls). In addition, the center receives patients requiring hyperbaric oxygen therapy (diving accidents, carbon monoxide poisoning) as well as a variety of less-frequent injuries. At any point in the day, it is impossible to predict what the workload will be like. By design, the center needs to be able to handle sudden peaks in demand, such as when a multiple motor vehicle crash produces a large number of admissions at the same time. The demand is not completely random. Traffic rush hours and summer holiday nights generate more admissions.

For the staff, input uncertainty means long periods of waiting without an admission followed by sudden bursts of activity with multiple admissions over a short period of time. As an X-ray technician reported: "I've gone a full shift without getting admissions and also my worst case scenario . . . It was a Friday night, we got 11 admissions in 45 minutes."

Because incoming patients differ in their injury type and severity, TC experiences high levels of input uncertainty (Argote 1982). Using Perrow's (1970) organizational analysis framework, variability of input is high (each patient is different) and analyzability is low (treatment cannot be prespecified and must be customized). Patients in critical condition are routed to TC with just minutes of warning, and treatment must be provided on arrival. TC has no control over the number of patients arriving or their timing and medical conditions.

The treatment process has some uniquely demanding characteristics. TC staff has to establish a diagnosis within minutes and initiate a treatment plan before

Figure 1 Coordination-Focused Model of Trauma Patient Treatment



moving on to the next admission. Because exams are often rushed, the treatment process retains a stochastic quality (Weick 1990). In complicated cases, medical treatment is often described as an educated guess based on limited clues (Gawande 2002). Critical information about the patient (medical history or allergies) is often unavailable (unconscious patient) or unreliable (semiconscious patients). Thus, in its haste to establish a diagnosis, the TC team may miss factors (e.g., internal bleeding, allergy, previous injury or illness) that can interact in unexpected ways with the evolving treatment.

Another characteristic of the process is the need to manage complex interdependences both within and across patient treatments. Working on a patient requires finely tuned activities and interactions among nurses, surgeons, and anesthesiologists. Some of the interdependence is sequential; for example, the patient needs to be anesthetized before the surgeon can perform a surgical intervention. However, the stochastic nature of the treatment process can rapidly impose a reciprocal interdependence (Thompson 1967). For example, depending on how the patient is reacting to surgery, the anesthesiologist may need to intervene multiple times during surgery. At the same time, the team must treat all admitted patients and cannot afford the luxury of focusing exclusively on one patient at a time. Thus, cross-patient interdependence is also a core characteristic of the process.

Because medical expertise is highly specialized and the patient conditions TC faces are very diverse, a necessary organizing principle is that teams must incorporate differentiated expertise.<sup>1</sup> TC's core technology can be summarized as a combination of differentiated expertise (the various specialists) and complex interactions (during treatment). Because the timing of disasters and accidents cannot be planned, TC must organize itself to provide superior care at any time of day and no matter how many patients have already been admitted. Keeping the facility open and trauma teams available on a 24/7 basis is extremely costly during down times. The staffing dilemma is to have the smallest team possible that will not be overwhelmed by the peaks in demand.

### Expertise Coordination Practices

We found evidence of well-developed coordination of expertise practices. Because medical expertise is distributed among the various members of the team, there is a need for team-level processes that support shared cognition and information sharing. Expertise coordination refers to processes that manage knowledge and skill interdependencies (Faraj and Sproull

2000). Expertise coordination processes are important for the team because they facilitate the development of a common mental model of patient condition and treatment options. Such processes also enhance performance by ensuring that crucial knowledge is available to those who need it when they need it.

We found four expertise coordination processes that seemed to enhance performance. First, trauma protocols streamline work and reduce process uncertainty. Second, plug-and-play teaming arrangements allow flexibility to meet contingencies with available personnel. Third, many operational responsibilities for scheduling, training, and control are carried by specialty-based COPs. Fourth, knowledge externalization processes are relied on to reduce information-sharing problems. Table 1 presents evidence in support of the four expertise coordination practices.

**Reliance on Protocols.** A trauma protocol can be viewed as a specification of care procedures integrated within a decision-making flowchart that specifies the treatment of a specific patient condition. Organizationally, it represents a standard operating procedure where roles, decision points, and event sequences are specified. For example, the airway-breathing-circulation (ABC) protocol lays out the specific steps to be taken to ensure that a patient has no obstruction along the airways, is breathing properly, and has effective blood circulation. Protocols serve as organizationally sanctioned standards for best practices. Trauma protocols build on consensus among experts based on reliable experience.

Although routines have generally been portrayed as repetitive and stable performance programs (March and Simon 1958, Nelson and Winter 1982), we found that the trauma protocols serve important coordinative functions even under the most demanding of circumstances in the TC setting. Protocols can be viewed as proven ways to structure interactions and manage the basic resources and expertise interdependencies that emerge around the treatment of a patient. A protocol details what needs to be done, by whom, and in what order, as well as stipulating various actions based on recognized contingencies. Task ambiguity is reduced because everyone knows what needs to be done. Role ambiguity is reduced because roles and actions appropriate to each person and specialty are predefined. Decision making is enhanced because the protocol provides easy-to-follow decision heuristics based on best practices. Finally, because a protocol has beginning and end points and outcome measures, status results can easily be analyzed and communicated to others who have not yet been involved in the treatment.

The strong emphasis on mastering and using treatment protocols at TC may be the result of two principal reasons. First, protocols generate a shared

<sup>1</sup>Narrow specialists (e.g., ophthalmologic surgeons) are available on an on-call basis.

**Table 1 Evidence of Expertise Coordination Practices**

| Reliance on protocol  | Plug-and-play teaming   | Communities of practice  | Knowledge externalization   |
|---|---|--|---|
| Interdependence managed: patient across specialization  | Interdependence managed: Within specialty across patient  | Interdependence managed: Within specialty organizing, identity, and participation  | Interdependence managed: Admission and intercaregiver knowledge dependencies  |
| [Talking about residents] "They do have their medical degrees, and hopefully the nurses will work collaboratively with them in how to take care of the patient but there are certain protocols and certain things that we do because of the level of expectation that we should not miss any injuries at the world famous shock trauma center." (charge nurse)  | "So if you have a multiple accident and have three patients coming in, you don't have the benefit of the full team. For our team, it's fairly automatic to split up an upper and a higher, you don't want to leave two interns admitting a sick patient, you want to put a third year and a first year or a second year and a third year." (chief resident)   | "I don't want to say that we make our own rules, but we govern ourselves a lot, we police ourselves. We don't need someone from three floors up in a suit that's sitting here and making sure we dot our i's and cross our t's." (nurse)   | "Most of the time the information that the surgeon wants, is the same information that the nurses want, which is the same information that I want. So if the team leader or the nurse is extracting information from the patient, I'm listening and so is everyone else." (nurse anesthetist) |
| "To try and get folks to sing from the same hymnal as much as possible is really the key to good organization. Once we decide to do it a certain way and we [the attendings] sit in a room and we'll go, 'Well, you know, we decided.' They're written as policies, for the most part. It depends on how big a deal it is, but we actually do have treatment care plans and books that say: 'Here's how to do protocol X.'" (attending surgeon) | An attending anesthesiologist in the middle of an operation in the OR is paged to the TRU due to a new arrival. He leaves his assistant [a resident] to continue the operation. Ten minutes later, he returns to finish the operation. (observation)  | "Surgery residents want to operate, emergency medicine residents want to 'do stuff.' If we let the residents at the patient, we would kill them with the procedure. They want a particular experience, but his [the attending] goal is to educate them to appreciate injury as a mechanism for illness." (attending surgeon)   | [During a busy time] A nurse at the end of his shift follows the charge nurse updating her with his key information as she moves around performing tasks. (observation)   |
| "We actually teach a lot of residents in terms of procedure here in the TRU, specifically. . . they come in and say: 'OK, I want this lab,' etc. But you know we have a protocol here and I show them, this is what we do as soon as somebody comes in." (nurse)  | "Then as I was walking out [of the operating room], there is another page that a policeman had been injured in a motor vehicle crash, has an ETA of two minutes. But I was due to start the case in Room 4 at that point. When the admission came I said: 'John [another anesthesiologist], you've got to do this admission for me, I'll start the operating room case.' (attending anesthesiologist) | "You can go to the operating room five minutes after you meet somebody and you don't know what kind of skill they have, even though they say they're a fourth year or fifth year. You don't know if they have any ability at all to stop bleeding, or can handle a knife or a needle. Because some people at a fifth year level function as a third year level somewhere else, just depending on the quality of their training." (attending surgeon) | [About lack of knowledge sharing] "It's never a good feeling, but I think the thing to do is not to get upset about it, instead look back at what happened. Who didn't tell whom what? Were you busy doing something else and is that why you missed it?" (surgery fellow)                    |
|   |   |  | "It's important, that turnover of information to the person who is leaving, getting that forward knowledge that they have. All of the knowledge accumulated in the last 12 hours is conveyed." (attending anesthesiologist)   |

cognitive framework of the task, its temporal progression, and what constitutes appropriate patient responses. Because TC team members have learned the various protocols, when to use them, and how they fit into the overall treatment plan; teamwork becomes implicit and the need to communicate is reduced—an important advantage in times of stress. Second, because TC is a teaching institution that annually trains hundreds of medical personnel, the use of protocols controls for the variation in expertise among trauma team members. The TRU core staff is made up of highly experienced attending physicians, nurses, and technicians. In addition, medical residents also participate extensively in the medical care. These are individuals who hold an MD but are still training in trauma medicine. New residents are expected to

quickly learn all 51 protocols used at TC.<sup>2</sup> There is a strong consensus that using protocols helps achieve positive patient results.

**Plug-and-Play Teaming.** A trauma team comprises of approximately 15 to 20 people, including an attending surgeon (formal leader), a surgery fellow (second in charge but still training), three to five residents (MDs specializing in emergency medicine or surgery), two to four medical students, an attending anesthesiologist, two to three trauma nurses, the OR charge nurse (for patients needing immediate surgery), and two technicians. There are three separate teams to ensure 24-hour coverage. Similar to members of temporary work teams in other fields, such as air-

<sup>2</sup> Protocols are described in great detail in a 185-page book that is mandatory reading for new personnel.

craft cockpit crews, individuals on trauma teams do not underscore their trauma team identity. Instead, they view their disciplinary group (e.g., anesthesia, surgery, nursing) as the identity that matters.

Temporary action teams form around patients. Such a team can function regardless of which member of a given specialty serves on it, as long as the requisite expertise is adequate. For example, an attending surgeon may be able to leave the completion of a simple surgical procedure to an experienced resident to focus on an incoming admission that requires advanced expertise. The surgeons thus acted interchangeably, yet team processes and performance seemed unaffected because both of these specialists were highly experienced.

Another interesting aspect of team formation under pressure is the ability of a given group to split up and create two functioning subunits when the situation requires it. This process can frequently be observed in surgery, which is often the most time-consuming trauma activity. We observed situations wherein the trauma team was operating on a patient when one or more new admissions arrived. The surgeons on the team quickly divided into two surgery groups possessing roughly comparable expertise, with the rest of the disciplines on the trauma team following suit. The result was that each new team had the needed variety of expertise and could start working on a different patient in parallel. This process can be further repeated if necessary. When the crisis passes, the team returns to its original form.

The reliance on role-based ad hoc teaming, and the ease with which teams subdivided and reconstituted themselves, leads us to apply the label *plug-and-play teaming* to these unique flexible teaming arrangements. We view plug-and-play teaming as a coordination process enacted to cope with time-critical task demands and input uncertainty. It is an efficient and flexible way to manage across-patient knowledge and skill interdependences that emerge as new patients are brought in.

**Communities of Practice.** We learned from our interviews, shadowing, and observations that most participants saw the ad hoc teams that formed and re-formed around each patient as only temporary occasions for joint action. The key organizational entity that governs these medical providers' lives is the specialty community of practice they belong to, of which there are three main ones: surgery, anesthesiology, and nursing. Contrary to our expectation that the dynamic environment would force flexible and interdisciplinary structures on TC, we found that the specialty communities played a major role in organizing and coordinating TC operations. We found that COPs support work coordination at the trauma center level

by managing staffing interdependences and internally managing the participation (learning) process.

The traditional medical disciplinary divisions within TC are well established and clearly recognized. Each anesthesiologist, surgeon, nurse, and specialist knows his or her role in patient treatment and generally respects these epistemological lines of demarcation. Each discipline has its own hierarchy and, within reason, sets its own policies and manages its own schedule. The COPs structure themselves in shifts in such a way as to cover operations 24 hours a day, seven days a week. The scheduling task is complex because team members have to be scheduled not only for the on-call team but also for the second-call (backup) team. The schedule is planned a month in advance, and it is the sole responsibility of each COP to set its schedule. Individuals are in turn responsible for negotiating coverage of their slots if they are unable to make their shift. This specialty-based mode of scheduling reduces the need for overall managerial intervention and centralized planning. As a nurse reported with pride, the COP structure is cherished: "The [nursing] unit is run by the nurses from scheduling to discipline to evaluations: Nurses run the place."

An advantage of the COP structure is that each specialty can manage the complex processes needed to train new members while ensuring patient outcomes. Incoming patient conditions differ drastically from one admission to the next, so that less-experienced staff may suddenly need to call on people with a higher level of expertise. The COP structure provides flexible coordination and control processes for its members, allowing them to go beyond anything that can be specified in a set of organizational rules or medical routines, such as the trauma protocols. One set of emergent processes integrates and trains peripheral members of the community. For example, residents (who are already physicians) are eager to practice their skills and may often overestimate their ability to handle complex cases.

To safeguard patients, core members of the key medical communities (e.g., surgery) have developed immediate coaching and supervision heuristics and a healthy skepticism regarding the talent at hand. There is a specific ability-based control structure. The attending surgeon (or "attending," usually a professor) is the highest authority. "It is on his credit card," a resident explained, indicating where ultimate responsibility lies. Because the attending is often busy caring for multiple patients (sometimes in different care units), there is a control process that clearly specifies how responsibility devolves within the team: When the attending is not present, the fellow who is apprenticesing to become an attending is in charge. The residents and students have their own pecking order

based on seniority. This leads to a layered responsibility system. Each person is responsible for those more junior. This system provides significant operational flexibility as the attending physician and the fellow may have multiple demands on their time outside the TRU.

Because medical error is potentially fatal, training of new physicians is tightly monitored. As a chief resident said: "You tend to watch them more carefully before you trust them with more responsibility or you test them with responsibility to find out how good they are.... I allow him only to do that, which I trust him to." This self-policing of each individual by senior members of the COP reduces the need for the organization to rely on formal behavior controls for each specialty (such as who can do what procedure). It also facilitates trauma team coordination, because other members are able to quickly size up a new person's ability by observing how much trust and responsibility senior specialty members place in that person.

**Knowledge Sharing.** The high-velocity environment at TC requires the generation and sharing of large amounts of knowledge. At admission, the whole team needs to learn about the patient's injury mechanism, how the patient fared during transport, medical history, and related conditions. Whether a patient was injured in a motor vehicle rollover or suffered from smoke inhalation has immediate implications for how the bay is to be prepared and whether to call in additional specialists. Once the treatment is underway, significant new information is generated from the examination, monitoring devices, and lab results. The team builds on the data to discuss alternative treatment plans and reevaluate the diagnosis several times within a brief period. Ensuring that knowledge is shared prevents errors of omission, faulty cognitions, and individual actions based on partial information.

A great deal of the knowledge sharing is verbal and face-to-face. The medics delivering a patient to the TRU are required to call out loud the key facts of the case in front of the team. Another process that occurred frequently is an attending-led "conference," mostly occurring near the bay where the patient is being treated, during which the team members share the technical information in their possession and pool their knowledge about how the treatment is proceeding. Finally, during shift change, a lot of information accumulated over the previous shift must be shared. An anesthesiologist stressed the need for a full debriefing: "It's important, that turnover of information from the person who is leaving, getting that forward knowledge that they have."

All team members pay close attention to the overall information flow and extract those items that may

affect their own functioning because any new piece of information could have a major impact on the evolving treatment plan. Furthermore, depending on the patient load, the attending or fellow who was working on the patient may be called away at a moment's notice, and another team member should be able to step in without needing to be brought up to speed. But sometimes during stressful situations, team members may forget to share knowledge or report some important piece of information. Because of the importance of knowledge sharing for evolving treatment plans, team leaders take such lapses very seriously.

Everyone from the top down needs to have some idea of the things that are going on, and if things don't flow all the way up, what happens is the next day or whenever, it suddenly comes up that, oh, the patient had this done yesterday, and you're like, I didn't know about that! (Interview with surgery fellow)

Ensuring that knowledge-sharing processes are well maintained is one of the most difficult aspects of expertise coordination. Technological solutions provide redundancy but cannot replace the human element. The system works well only when people invest the time to share what they know. As one attending anesthesiologist noted, "There are various gradations of redundancy in the communications, but despite all of that, many times neither the trauma attending nor the nurse actually communicates anything."

### Dialogic Coordination Practices

The expertise coordination processes discussed so far ensure expertise integration and flexible teamwork under conditions of multiple concurrent interdependencies driven by patient condition variability and overall patient load. However, coordination requires more than smooth integration of individual actions to ensure patient outcomes. As the treatment process unfolds, new interdependencies are generated and new paths and possibilities are created, not all of which are positive from a patient-outcome perspective. Like some organizational work processes, such as R&D work, trauma medicine is an inherently stochastic process that cannot be fully elucidated and controlled. Diagnoses can sometimes be little more than educated guesses and errors are frequent (e.g., Gawande 2002). In the high-pressure setting of TC, the combination of severely injured trauma victims needing immediate intervention and highly motivated but inexperienced doctors in training can be especially risky.

In this section, we extend previous definitions of coordination to reflect some unique practices that occasionally take place and are crucial to ensuring coordination success and patient safety. In our fast-paced setting, we find it necessary to highlight

the continuous interactions, joint sensemaking, common responsibility, and cross-boundary interventions that are so important for saving patients. The term *dialogic*—as opposed to *monologic*—recognizes differences and emphasizes the existence of epistemic boundaries, different understandings of events, and the existence of boundary objects (e.g., the diagnosis or the treatment plan). A dialogic approach to coordination is the recognition that action, communication, and cognition are essentially relational and highly situated. We use the concept of trajectory (Bourdieu 1990, Strauss 1993) to recognize that treatment progressions are not always linear or positive. The idea of a treatment trajectory emphasizes the dual nature of the treatment process. On the one hand, it is a recognizable course of action that typically moves the patient from a state of trauma admission to a state of successful treatment. On the other hand, the treatment trajectory is partially stochastic, unpredictable, and affected by patient condition as well as team actions, interactions, and contingencies. Treatment steps (and missteps) can limit later options, generate new dependencies, and launch a patient on a different trajectory. For example, a patient whose health is degrading requires different coordination interactions than a patient who is responding well to treatment. Thus, from a coordination perspective, it is important to distinguish between habitual trajectories and problematic ones.

A *habitual trajectory* is a sequence of actions and interactions that moves the patient steadily toward successful treatment as per expectation. A *problematic trajectory*, defined as a deviation onto a path hazardous to the patient, is often driven by a novel event, an unexpected realization, or disconcerting information that challenges participants' mental models. Because in fast-response settings, time is short and stakes are high, alternative responses are suddenly required without the benefit of complete analysis or planning. Novel events in trauma settings include a patient deteriorating badly contrary to treatment protocol and medical expectation, or a novice surgeon attempting to perform a surgical intervention that other actors feel may needlessly endanger the patient.

A dialogic coordination practice differs from more general expertise coordination processes in that it is highly situated in the specifics of the unfolding event, is urgent and high-staked, and occurs at the boundary between communities of practice. Because cognition is distributed, responsibility is shared, and epistemic differences are present, interactions can be contentious and conflict laden. Much is at stake along with patient well-being: reputations, group interests, epistemological claims, and occasionally blame apportioning.

We identify four kinds of coordination practices: epistemic contestation, joint sensemaking, cross-boundary intervention, and protocol breaking. Table 2 provides detailed evidence and a description of triggers for dialogic coordination practices.

**Epistemic Contestation.** The interactions between COPs during treatment can sometimes be touchy because opinions may differ as to the patient's condition and what must be done at the moment. Boundary work requires the ability to see perspectives developed by people immersed in a different community of knowing (Boland and Tenkasi 1995, Star and Griesemer 1989). Often, particular disciplinary foci lead to differences in opinion regarding what steps to take next in treating the patient. For example, a surgeon is likely to want to perform surgery quickly. To do so, he or she needs the anesthesiologist to anesthetize the patient. But the anesthesiologist is sometimes concerned about the overall state of the patient's health and the danger posed by putting an unstable, severely injured patient under anesthesia. This can lead to differences of opinion.

Typical case is I'm the attending trauma surgeon and there's an attending anesthesiologist, I think the patient should be intubated and the anesthesiologist doesn't. So who outranks? Sometimes it goes by the level of seniority. Who has been there longer? Or it goes by who's more aggressive about standing firm, or the interpersonal relationship between the two. (Interview with attending surgeon)

There is general consensus in trauma centers as to which medical interventions belong to which disciplinary communities. Separation of roles and responsibilities is medically, legally, and historically long standing. As an attending anesthesiologist exclaimed: "The responsibility of the airway is the anesthesiology team; responsibility of the belly issue is the surgical team." However, some medical cases fall on the boundary and generate an epistemic tussle among specialties. The existence of this tension is not usually emphasized and is kept under control by the attending physicians. Several times, individuals shared with us the story of a dispute between a surgeon and an anesthesiologist regarding the proper treatment of a patient in a New York hospital that degenerated into a fistfight. The story carries two messages: The epistemological contestation is serious; however, things would never be allowed to go that far at TC.

**Joint Sensemaking.** In some cases, patients do not respond well to the given treatment plan and their condition deteriorates. An attending surgeon said: "No matter how much you say about what should happen, patients do not follow textbooks, they don't follow all the rules." The fact that patients sometimes do not react according to diagnosis and treatment

**Table 2 Evidence of Dialogic Coordination Practices**

| Epistemic contestation   | Joint sensemaking  | Cross-boundary intervention  | Protocol breaking   |
|--|--|--|---|
| Trigger: Different beliefs among different specialties as to which treatment step is required  | Trigger: Patient is not responding to treatment in line with diagnosis   | Trigger: Safety of patient is compromised by actions of a team member  | Trigger: Following the protocol negatively slows down treatment   |
| "There are times when the surgeon wants to perform an operation, and the anesthesiologist doesn't want to compromise the patient's health, 'You can't put this patient out, he's too sick for the drugs.' Then the attending surgeon has to figure out what they are going to do at all, and sometimes they are at odds." (nurse anesthesiologist) | "In highly uncertain states of affairs, you see a lot more communication occurring at a higher level in the team structure, so you'll see the attending level group discussing what they think the problem is, and each group of experts at the attending level will be chipping in with what they think, (...) we may ask someone else to 'just quickly take a look at this patient,' have they 'any thoughts about this?' " (anesthesiologist) | [Talking about nurses] "So if they pick something up and they tell me they're concerned or if they disagree with the resident, chances are I'll go along with the nursing decision rather than my second year resident. Because, you know, I'm throwing 20 years versus two years or a few months of trauma experience." (attending surgeon)                     | "For example, you see that, at least the experienced person sees, that the issue is not ABC but is FGH. You can, in the hands of the experienced person, skip the ABC, go to FGH, and then cover the ABC just as a double-check after you dealt with what you think is the critical problem that the patient has." (attending anesthesiologist) |
| "If the resident is pushing for something that really seems outrageous to the nurse, then they'll say, 'Well this is what you've asked us to do and this is what we're supposed to do and these are the consequences.'" (technician)   | [Describing a difficult case] "They say 'Yeah, but here, look at it!' OK, you do it [surgical intervention] and then just what should happen according to every textbook known to man, doesn't happen and you're like, 'Argh!' Patients don't follow textbooks." (attending surgeon)   | "We actually have to like say, 'Do you want this test done? Do you want that test done?' We nurses are pretty assertive in terms of getting things going. I'm not putting the doctors down but they're thinking of something else. So lots of times we do ask them, prod them to do this test." (nurse)  | [Talking about pressured situations] "Obviously different patients require different things and so, sometimes we bypass or make a cookbook out of it, you know. We pick out whatever is appropriate to that patient and then go on from there. But, yes, there is a set of guidelines to follow." (nurse)                                       |
| "I have seen it all, I have seen attendings [physicians] yelling at each other, screaming at each other, and I have seen intelligent discussions and negotiations." (nurse anesthesiologist)   | "The way we cope with [mysteriously deteriorating patients] is to consult with our colleagues; to vocalize more freely about what we think about the possibilities; to consult at the highest level of the organization with those who might have more experience, or might have seen cases or something like it before." (attending anesthesiologist)   | "In circumstances where we see someone doing something which isn't right, for example, not being appropriately gowned and gloved to do a surgical procedure, or if we see someone contaminate their sterile field, their gloves, or their gown, we tell them—we don't let them proceed with the process and contaminate the wound." (attending anesthesiologist) | "Another example is putting a central line and auto transfusion of blood because they hadn't gotten the cross-match blood for the patient. There was this huge amount of blood coming out of the patient's chest, we could just re-circulate it back into the patient's circulation." (anesthesiologist)  |

is well recognized in emergency medicine (Gawande 2002). The reasons may be multiple but primarily have to do with incomplete diagnoses or emergent complications. When it becomes clear that the patient has shifted to a problematic trajectory, disciplinary boundaries that seem so rigid in "normal" cases suddenly melt away. A process of joint sensemaking begins with the team and spirals up the hierarchy as more experienced doctors are pulled in to help solve the puzzle. An anesthesiologist described it as a process where everyone chips in: "[We pull in experts] and discuss a very brief scenario, we let other people know what we are thinking, and get their opinion as to what they think is reasonable in this state of affairs."

During joint sensemaking, significant negotiation of meaning takes place, regardless of COP boundaries. Other specialists are sought to confirm the reading of the patient condition (did we miss anything?) and ultimately to warrant the correctness of the steps

taken (we did the right thing). Having expert others join the conference increases the chance of having someone recognize a rare condition. It also facilitates difficult interventions where high levels of skills are required at the boundary of specialties. The practice is emergent and specific to the patient at hand. During such events, when time-critical cross-disciplinary decision making has to occur, the specialization-based boundaries are temporarily discarded and replaced by an emergent dialogue intended to generate a new collective understanding of the patient.

**Cross-Boundary Intervention.** A cross-boundary intervention occurs when the safety of a patient is compromised, or is about to be compromised, by the actions of a team member. For example, we observed that when a surgeon inadvertently contaminated his gloves, a nurse drew his attention to that fact and prodded him to replace them. These practices are emergent because specific actions cannot be specified

or predefined. Because the expertise level of many staff members is so high, it is possible for people in the nonfocal disciplines to know when things are not going right and to take action. The actions can take the form of reminders, such as when a nurse reminds a resident to do a task or when an anesthesiologist tells the surgeon that he has breached the sterile field. The actions can also be indirect: Nurses feel that their role includes warning the attending surgeon when his residents are engaging in actions that in their opinion endanger the patient. These are not formal mechanisms but emergent coordination practices that ensure either that operations are error free or, that if an error does occur, the relevant personnel takes immediate action. For example, several attending surgeons actively rely on nurses to provide warning about possibly dangerous behavior by surgery residents.

Our trauma nurses here are probably better than anybody's. Because they've just been doing it for so long. So if they pick something up and they tell me they're concerned.... If they disagree with the resident, chances are I'll go along with the nursing decision rather than my second-year resident. Because, you know, I'm throwing 20 years [of experience] versus two years or a few months of trauma experience. (Interview with attending surgeon)

With experience, specialists recognize the value of the complementary perspective provided by others on the team. An attending surgeon grudgingly recognized the value of others stepping in on his turf: "In a sense, they [the anesthesiologists] are probably policing me; saying, 'Hey, I don't think this guy is stable. You need to just get his blood pressure up.' And the nursing does the same thing." Nonetheless, the interactions can be contentious because no individual likes to be told that he or she is putting a patient's life in danger. One attending surgeon actually disagreed with the majority opinion and felt that residents were too frequently the victims of sarcasm and abuse by nurses: "The relationship between nurses and physicians can be stressful. Sometimes they don't accept the kind of decision where the intern says that I am the doctor." Nonetheless, the value of cross-boundary checking and intervention is universally recognized as crucial for patient safety.

**Protocol Breaking.** Breaching a trauma treatment protocol is a risky step that is sometimes undertaken in an emergency situation when following the protocol would take too much time and, thus, delay a crucial intervention. Medically, it is a judgment call that goes against the evidence-based best practices that have been incorporated in the protocol. A missed or delayed treatment step may result in further harm to the patient. The doctor who violates the protocol in error faces an inquiry and is no longer protected

under the commonly accepted norms of medicine. A serious medical error can have major repercussions on a medical career. In addition, if the patient's family learns about the error, there is the possibility of legal liability.

Still, often there are compelling medical reasons to violate protocol. For example, an anesthesiologist said that protocol calls for gunshot victims to come in with a C-spine (neck) collar to ensure that the neck is not injured. But the collar makes it difficult to manage the airways. Therefore,

If there was an urgent need to intubate the patient and I was having difficulty, I would just take the collar off, I wouldn't bother with maintaining that sort of strict requirement of keeping the collar on, because I know that the instance of neck injuries is probably less than 1%. Whereas the harm associated with managing the airway incorrectly is much greater than the risk to the neck of having neurological deficits. (Interview with anesthesiologist)

From a coordination perspective, protocol violation upsets work plans, roles, and expectations. The team has to accept the break in protocol and reorganize its actions and interactions to support it on the fly. For all these reasons, protocol is seldom broken without the approval or involvement of senior team members, such as an attending or a fellow.

## Discussion

Using a combination of observation, archival, and interview techniques, we have identified coordination practices that permit a trauma center to operate reliably and effectively in the face of inordinate input and task uncertainty. Principally, we have argued that the combination of expertise specialization, overlapping interdependencies, and a rapid tempo requires organizational members to enact new coordinative responses. We have identified two interrelated dimensions that are critical for effective coordination in a fast-response setting. First, expertise coordination practices such as COP structuring and knowledge externalization make it possible to manage various intra and interpatient dependencies. These practices effectively reduce the need for formal structural coordination or arrangements while guaranteeing that the right expertise is brought to bear during patient treatment. Second, dialogic coordination practices operate as timely and situated responses to unexpected developments and failing patient trajectories. Because ensuring patient safety is an overarching goal, these latter practices are potentially contentious and operate in the space between COPs. By describing specific coordination practices, this study increases the understanding of how complex and highly interdependent work can effectively be coordinated.

Recent research has attempted to extend coordination models beyond the traditional focus on modalities and structures and their contingent relationship with the environment. For example, recent investigation of coordination in design and manufacturing activities has resulted in the development of more complex taxonomies of coordination mechanisms (Adler 1995). Other researchers have focused on the detailed specification of dependencies in processes and the generation of libraries of coordination methods (Malone and Crowston 1994, Malone et al. 1999). Our findings point to the limitations of approaches emphasizing the development of prespecified coordination methods. In environments characterized by distributed expertise, high uncertainty, and variable interdependence, coordination needs may not be easily specifiable. Our findings provide support for relational conceptualizations of coordination as an emergent phenomenon highly dependent on the quality of the relationships across functions and individuals (Gittell 2002) and on the presence of transactive memory processes (Faraj and Sproull 2000, Liang et al. 1995).

Our findings also point to a broader divide in coordination research. Much of the power of traditional coordination models resides in their information-processing basis and their focus on the design issues surrounding work unit differentiation and integration. This design-centric view with its emphasis on rules, structures, and modalities of coordination is less useful for studying knowledge work. However, as we have seen in our trauma setting, these response mechanisms are ineffective when the organization is faced with novel equivocal situations coupled with the potential for disaster. To be effective, such organizations need to accept a certain amount of cross-boundary contention in return for the immediate and flexible response provided by dialogic coordination practices. These practices are highly situated, emergent, and contextualized and thus cannot be prespecified the way traditional coordination mechanisms can be. Thus, recent efforts based on an information-processing view to develop typologies of coordination mechanisms (e.g., Malone et al. 1999) may be too formal to allow organizations to mount an effective response to events characterized by urgency, novelty, surprise, and different interpretations.

Our practice-oriented view of coordination challenges the implicit focus on rules and structure that has guided most of coordination research. Recently, some researchers have emphasized the enabling view of bureaucratic structures (Adler and Borys 1996), whereas others have conceived of structures as flexible scaffolds for dynamic improvisation (Bigley and Roberts 2001, Brown and Eisenhardt 1997, Moorman and Miner 1998). However, our findings regarding dialogic coordination practices and their contested

nature point to the limitations of a structuralist view of coordination. In the same way that an organizational routine may unfold differently each time because it cannot be fully specified (Feldman and Pentland 2003), coordination will vary each time. Independent of embraced rules and programs, there will always be an element of bricolage reflecting the necessity of patching together working solutions with the knowledge and resources at hand (Weick 1993). Actors and the generative schemes that propel their actions under pressure make up an important component of coordination's modus operandi (Bourdieu 1990, Emirbayer and Mische 1998). Thus, coordination practices cannot be specified by the organization in the same way that administrative and expertise coordination processes can be articulated. Organizations that are hospitable to dialogic coordination practices recognize the stochastic nature of trajectories, expect appropriate reactions to novelty, and accept the contentious nature of cross-boundary intervention. In short, a practice view provides a richer and more balanced view of coordination as it is actually practiced. This practice-based rethinking of coordination builds and complements parallel research on the related topics of work practices (Orlikowski 2002), organizational routines (Feldman and Pentland 2003), learning (Lave 1988), and innovation (Brown and Duguid 2001).

Our findings about the ways in which COPs play important coordination roles enrich the growing literature on COPs' role in organizing knowledge work (Brown and Duguid 2001, Orr 1996, Wenger 1998). Not only are the specialty-based COPs used for regulating within-specialty learning and participation, but they are also used to manage key knowledge interdependencies, generate schedules and plans, and negotiate boundary objects (such as the diagnosis). This reduces the overall coordination load on the organization by allowing those with local knowledge to take on this role and, thus, free scarce managerial attention and resources. The results also support the contentions of several researchers that interacting communities of practice are effective prisms through which to view complex interdisciplinary technical work (e.g., Boland and Tenkasi 1995).

Recently, Brown and Duguid (2001, p. 208) suggested that coordination of organizational knowledge is likely to be more challenging than coordination of routine work, principally because the "elements to be coordinated are not just individuals but communities and the practices they foster." As we found in our investigation of coordination at the boundary, significant epistemic differences exist and must be recognized. As the dialogic practices enacted in response to problematic trajectories show, the epistemic differences reflect different perspectives or priorities and cannot be bridged through better knowledge

exchange. This is why they are often contentious and require joint sensemaking and complicated decision making. This finding confirms important recent findings about the importance of common ground (Bechky 2003) and the need for negotiation and transformation across boundaries (Carlile 2002) for effective knowledge transfer.

The situated and emergent nature of coordination does not imply that practices are completely unique and novel. On the one hand, they vary according to the logic of the situation and the actors present. On the other hand, as seen in our categorization of dialogic coordination, they follow a recognizable logic and are only partially improvised. This tension between familiarity and uniqueness of response is at the core of a practice view of work (Orlikowski 2002). Although we have identified four core dialogic practices surrounding trauma care, these are not constant and may evolve in response to a change in the actors or the environment. They differ from informal coordination because they involve the intersection of multiple epistemologies. They also involve an element of bricolage. In turn, they demand reinterpretation and realignment of cognition and action (Mische and White 1998). They are distinctly intersubjective and require accommodation, trust, and respect.

At the most basic level, dialogic coordination practices are reactions aimed at rectifying failing performance trajectories. Their dialogic nature is based on the need to cross epistemic boundaries, disregard hierarchies, and publicly challenge a teammate's "expert" judgment. That is why these practices are fraught with danger to the actors, the patient, and the team processes. They are also essential from a performance perspective because, without them, coordination is likely to become stylized and formal or to fall apart completely. Much recent work on high-reliability organizing stresses aspects of safety culture and mindfulness that are consonant with the promotion of dialogic coordination (Grabowski and Roberts 1999, Weick et al. 1999). Creating the space for such practices is difficult. Stakes are high: Errors can easily damage professional reputations or injure patients. Sustaining dialogic practices requires organizational leadership and structures that create a safe haven where mistakes can be admitted with little loss of face (Edmondson 1999). This requires efforts at bringing together different communities of practice and making sure various members respect and accept the value of the alternative epistemology to the situation and the patient (Boland and Tenkasi 1995).

This study has limitations that must be recognized and addressed in future work. First, the theoretical framework of coordination in fast-response organizations is based on the insight gained from a single site and, thus, may be limited. Our primary goal was to understand in great detail how a leading trauma

center develops and uses coordination practices; therefore, there was an inevitable trade-off between sample breadth and depth of immersion. Future research is needed to corroborate the extent to which our model is generalizable to other fast-response environments in medical as well as nonmedical settings. Second, our study did not address the link between the various coordination practices and organizational performance. Because our focus was on the detailed understanding of coordination practices in one setting, we cannot establish causality between the coordination practices we observed and TC's performance profile. Third, because of the situated nature of the coordination practices that allow TC to operate flexibly and reliably, future research is needed to specify which coordination practices operate in other settings and, thus, to identify theoretical boundary conditions.

## Conclusion

Organizational knowledge researchers have suggested that practice is central to understanding work and have called for a deeper understanding of complex organizational work processes (Brown and Duguid 2001, Carlile 2002, Feldman and Pentland 2003, Orlikowski 2002). The research reported here focuses on knowledge-work coordination and, thus, represents an effort to answer this call. Our findings from our in-depth investigation of a fast-response organization indicate that coordination practices are highly emergent and cannot necessarily be prespecified. Expertise coordination practices are needed to manage evolving skill and knowledge interdependencies during treatment of a single patient and between treatment of different patients. Dialogic coordination practices are necessary because much of the coordination occurs at the boundary of epistemological communities and involves cross-boundary interventions, leading to contention and contestation. Future studies of knowledge coordination may benefit from a deeper investigation of both expertise coordination practices and dialogic coordination at the boundary.

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