

What Difference Does a Robot Make? Managing Ambiguity in Distributed Knowledge Work

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SUBMITTED TO THE DEPARTMENT OF MANAGEMENT SCIENCE IN PARTIAL  
FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN MANAGEMENT STUDIES

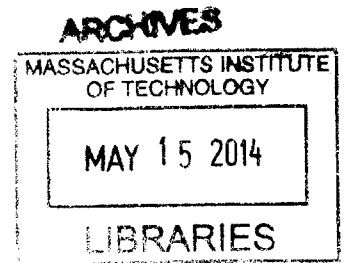
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
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

JUNE 2014

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Submitted to the Department of Management Science  
on May 8, 2014 in Partial Fulfillment of the  
Requirements for the Degree of Master of Science in  
Management Studies

## ABSTRACT

What difference does robotic telepresence make to the management of ambiguity in distributed knowledge work? We examined this question in a post-surgical intensive care where remote medical workers struggled to coordinate their work in the face of ambiguities related to their extremely sick patients. Our in-depth field study allowed us to explore how differently ambiguity was managed when night rounds were performed through robotic telepresence, allowing distributed medical workers to be virtually co-present at the site of work. In contrast to the literature, which suggests that co-located, face-to-face interaction should reduce ambiguity and facilitate coordination, we found that ambiguities were both reduced and intensified with robotic telepresence, resulting in contradictory implications for coordination. We found that these differences in the management of ambiguity and coordination were crucially related to how the distributed work and commitment to that work were materially enacted in practice. After discussing our findings, we explore their significance and contributions to research on the management of ambiguity in distributed knowledge work.

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Ambiguity — lack of clarity about what is relevant given multiple and conflicting interpretations of a situation — arises as workers with different interests (Kaplan 2008; Carlile 2004), experience (Orr 1996), and expertise (Bailey and Barley 2011) engage in different work activities, generate different understandings, and produce varied outcomes. Knowledge workers collaborating on complex, dynamic situations must manage this ambiguity to coordinate their activities. As knowledge work becomes increasingly distributed and mobile (Hinds and Bailey 2003; Hinds and Kiesler 2002; Kellogg, Orlikowski, and Yates 2006; Mazmanian, Orlikowski, and Yates 2013), ambiguity is often amplified as group members interact at a distance and report on conditions and events to other members who are not present at the site of the work (Bailey, Leonardi, and Barley 2012). Managing ambiguity in distributed knowledge work is not only challenging but also consequential for the ongoing coordination of work. And understanding and managing such ambiguity is critical to the effectiveness of distributed knowledge work.

The organization literature suggests that the best way for workers to manage ambiguity is to be co-located and face-to-face. Research has highlighted the ambiguity difficulties that arise as members of different departments (Daft and Weick 1984; Sapsed and Salter 2004), functional teams (Carlile 2004), and occupational communities (Bechky 2003) coordinate to get their work done. Echoing early theoretical work on ambiguity (Daft and Lengel 1986), such studies found that face-to-face interactions and side-by-side examination of work artifacts facilitated common understanding and coordinated effort. This work suggests that co-presence at the site of work is an important mechanism for reducing the ambiguity arising from different tasks, diverging interests, and multiple knowledge systems. Such shared presence also emerged as salient in managing the ambiguity generated by rapid change, in for example, strategy formulation (Kaplan and Orlikowski 2013) and digital project work (Kellogg, Orlikowski, and Yates 2006; Girard and Stark 2002).

Yet co-located, face-to-face interaction is often costly and impractical in contemporary workplaces, where the global nature of organizing means that knowledge workers are often distant from each other in space and time (Hinds and Kiesler 2002; Hinds and Bailey 2003), and tend to participate intermittently in diverse, dynamic projects (Bechky 2006). As distributed work has become more commonplace, so has the use of various technologies — such as telephone, email, and collaborative tools — intended to help distant workers engage with each other and coordinate their collective work. Despite the increasing use of these communication technologies, studies repeatedly find that distributed workers experience more ambiguity and coordination difficulties than co-located workers (Mortensen and Neeley 2012; Cummings, Espinosa, and Pickering 2009; Cramton and Webber 2005; O’Leary and Mortensen 2010; Hinds and Mortensen 2005). This is hardly surprising given the well-established finding that ambiguity is most effectively managed in co-located, face-to-face interactions.

Recently, a number of robotic technologies have been developed to support knowledge work (Barrett et al. 2011; Hinds, Roberts, and Jones 2004), including robotic telepresence, which allows an individual to physically navigate around a distant location while interacting with remote workers through two-way video and audio capabilities. Robotic telepresence has been designed — as the name suggests — to support virtual co-presence through simulating co-located, face-to-face interaction. As a result, we might expect that distributed workers interacting through robotic telepresence would experience less ambiguity and fewer coordination

challenges, as compared to distributed workers relying on communication technologies such as telephone and email.

As we learned in our research, however, things are more complicated in practice. In particular, our empirical study of night rounds conducted by distributed medical workers through robotic telepresence found that ambiguities and coordination difficulties were both reduced and amplified, in comparison to night rounds conducted through the telephone. As we sought to explain this unexpected result, we found that how specifically the night rounds were performed in practice mattered a great deal. That is, night rounds performed through robotic telepresence and through the telephone differed considerably because they included different information, involved different workers in different ways, and generated different kinds of discussions. The significance of these different material enactments of distributed work for the management of ambiguity has not been well understood or articulated in the literature; hence, it is the focus of our attention here. Our research question thus focused on understanding how ambiguity is managed in distributed knowledge work that is performed through robotic telepresence, and with what consequences for coordination.

We addressed this question in a 14-month field study of a post-surgical intensive care unit where ambiguities were an ever-present threat to the highly interdependent, life-saving work being performed. In this unit, patients' conditions were highly unstable and their treatments required frequent adjustment. Without regular attention to emerging ambiguities, symptoms would be missed or dismissed, coordinated work would be impaired, and patients could destabilize and die. Night rounds were a central routine within the unit, aimed at identifying, addressing, and reducing many of the ambiguities that had arisen over the course of the afternoon. The performance of these night rounds was distributed, with physicians located remotely, typically at their homes. Traditionally, physicians had called in by telephone to do night rounds, but in an attempt to facilitate greater interaction, the hospital deployed robotic telepresence technology that allows the distributed medical workers to be virtually co-present at the patient bedside during night rounds.

Adopting a practice lens (Schatzki 2002; Feldman and Orlikowski 2011), we examined how patient ambiguity was managed in the moment-by-moment activities and interactions that constituted night rounds, both through the telephone and robotic telepresence. We find that how effectively ambiguity is managed is contingent on the varying ways in which distributed work is performed through different technologies and different commitments. In this view, the management of ambiguity and coordination of work are crucially dependent on how specific materialities and commitments are enacted in practice. We identified four distinct practice-pairs that accomplished night rounds in the intensive care unit, with each practice-pair managing ambiguity quite differently, and generating different and important consequences for the subsequent coordination of patients' overnight care. Our research allows us to offer a more robust and grounded understanding of how ambiguity in distributed knowledge work is actively managed in material practices enacted by actors with varying commitments to the work at hand.

### **Managing Ambiguity in Knowledge Work**

Existing literature on the management of ambiguity in knowledge work can be understood through three streams of work. The first stream focuses on coordination and points to the importance of co-location and face-to-face interactions in managing ambiguity. For example,

Carlile's (2002) study of automobile design and production found that salespeople, design engineers, and production technicians struggled to coordinate novel requirements because they drew on markedly different experiences, expertise and interests. To manage this ambiguity, these workers would often reference and point to proximate objects such as numbers, blueprints, faxes, parts, tools, and machines that they had simultaneous access to. Likewise, Bechky's (2003) assemblers, technicians and engineers discovered and resolved ambiguities as they met face to face to examine their work products. For instance, when an engineer asked an assembler why scratches and chips had appeared inside a new product, the assembler went to the clean room, retrieved one, and verbally and physically demonstrated how a screw moved inside a chamber, causing the scratches. Both parties then made indexical references (e.g. "Out here you can lift it up") to rapidly propose and test hypotheses (e.g., "can we take the standouts off?"), and suggest changes to the object of work on the spot (e.g., changing an out-of-date part). Bechky cites this simultaneous, shared interaction with the object of work as a crucial mechanism for managing the ambiguity that arose between these occupational groups. Related studies that explore how members of different departments (Sapsed and Salter 2004), functional groups (Carlile 2004) and occupational communities (Faraj and Xiao 2006) struggle to resolve interpretive differences and enable coordinated action similarly find that shared, often simultaneous reference to the object(s) of work in face-to-face settings can be helpful.

The second research stream related to the management of ambiguity emerges from studies of complex, fast changing projects where multiple, diverse participants need to work together to respond effectively and quickly to uncertain and shifting conditions. Whether focused on creative design (Girard and Stark 2002; Neff and Stark 2003; Kellogg et al. 2006) or strategy making (Kaplan and Orlikowski 2013), findings suggest that to keep projects moving forward (important given time pressures) in the face of considerable ambiguity and multiple viewpoints (unavoidable given the multiplicity and diversity of engagement), participants temporarily suspend their disagreements and proceed on the basis of provisional settlements. Without a shared understanding, groups will struggle to coordinate their action (Weick 1979). Yet provisionality is also important. Clients, situations, and ongoing practice will continue to generate ambiguities over time, and responding effectively and flexibly requires that any reduction of ambiguity be held lightly (Girard and Stark 2002). Examining these findings more closely, we see that the production of provisional settlements is facilitated by co-located, face-to-face interactions. For example, in Girard and Stark's (2002) study of a web design firm, designers jealously guarded their seating arrangements so that they could overhear others working in close proximity. Being able to hear changes in tone of voice allowed team members to rapidly detect and settle unproductive impasses. Further, in a study of strategy making, project team members experienced pressure to settle their differences when they met face to face (Kaplan and Orlikowski 2013). Participating in shared, synchronous discussions about strategy was relevant to both the discussion of ambiguous conditions and the production of provisional settlements. Not participating in this way often led to breakdowns. For example, one project lead was notoriously unavailable for key meetings precisely because he did not see a way to settle disparate issues, even temporarily. Co-present interactions facilitated settlements, just as the opportunities for revision, testing and intervention made it easier to treat these settlements as provisional. These findings mirror those in the organizations literature on coordination, in suggesting that interpretive differences are easier to resolve when key interactions occur face to face.

The third stream of work relevant to ambiguity management concerns distributed work and virtual teams. Research studies across a range of settings and types of work has shown that ambiguity is harder to manage when workers are separated from each other and their activities (Barley 1990; Cramton 2001; Leonardi 2011; Hutchins and Lintern 1995). For example, in their study of automotive engineering, Bailey et al. (2012) show how engineers in India and the US struggled to resolve interpretive differences and coordinate their work as they interacted virtually on simulations of automobiles rather than in person with physical vehicles. Without direct access to cars, parts or US colleagues, the Indian engineers made implausible and/or arbitrary assumptions about the ways that different parts of a vehicle would interact in a crash and then encoded these assumptions into the computer models they sent to engineers in Michigan. Not surprisingly, the US-based engineers — who had direct, personal experience with real cars and real crashes — often had to rework these models.

In a study of innovation by 14 virtual teams across seven industries, Gibson and Gibbs (2006) similarly found that many participants placed a premium on co-located, face-to-face interaction, explaining that it was difficult to share concepts and motivate engagement through the telephone. Additionally, the physically remote workers on these virtual teams often felt left out of the loop, expressing frustration for example, that “90% of the decisions are made in the bathroom or near the coffee pot.” Generally, when workers rely on others for direct information about empirical realities, the literature suggests that these others may interpret the situation differently to the remote workers, especially when communication technologies are involved (Hinds and Cramton 2013; Cummings, Espinosa, and Pickering 2009; Hinds and Mortensen 2005; Hinds and Bailey 2003; Kiesler and Cummings 2002; Nardi and Whittaker 2002; Kraut et al. 2002; Olson et al. 2002). The potential intensifications in ambiguity associated with distributed ways of organizing thus present significant coordination challenges to the performance of contemporary knowledge work.

Looking across these three streams of organizational research on coordination, provisional settlements, and distributed work, we see co-presence and proximity figuring prominently in the management of ambiguity in knowledge work. Ambiguity and related coordination difficulties appear to be significantly easier to manage in co-located interactions involving face-to-face meetings or side-by-side examination of objects than when emailing or telephoning from distant locations. This appears to be particularly the case in knowledge work that is fast changing and tightly coupled with dynamic projects and shifting empirical realities (Bechky 2006; Mazmanian, Orlikowski, and Yates 2013). Yet, contemporary work is increasingly being performed at a distance, involving technologies that promise the benefits of co-located, face-to-face interaction (such as robotic telepresence), and we currently lack knowledge of how ambiguity is effectively managed in these circumstances.

Our study provided a unique opportunity to examine this question in the case of distributed medical work being performed in a post-surgical intensive care unit. While night rounds routinely addressed ambiguity in this unit, how effectively this was accomplished varied significantly. In particular, we found that whether ambiguity was reduced or amplified was crucially related to how night rounds were enacted in practice through the different technologies at hand — telephone or robotic telepresence. By explicitly theorizing these distinct material enactments in practice, we are able to account for differences in how ambiguity is managed as distributed work is performed

through various technologies, and explain the different consequences that are generated for the subsequent coordination of work.

### **Research Setting**

Our study took place in the post-surgical intensive care unit (SICU) at Hopeland,<sup>1</sup> a mid-sized, nonprofit teaching hospital. At the time of the study, Hopeland had nearly 450 physicians and more than 4,000 nurses, therapists and other support staff. Its main facility encompassed a 387-bed hospital. Patients only entered Hopeland's SICU to recover from intensive surgery. Each received a sealable room and usually their own highly experienced nurse. They were often unconscious, ventilated, and on a range of life-sustaining machines and drugs. They were all, in the local lingo, "very sick." The purpose of the SICU was to stabilize patients so that they could begin the long road to recovery.

Hopeland's SICU had 24 patient rooms, laid out in two sections, with a nursing station in the middle. Each patient room had a standing desk next to its glass door, with a networked PC, medical monitors that displayed real-time data on vital signs, and two separate paper-based patient records. Both these patient records — the flowsheet and Kardex — were organized in a matrix, with rows recording quantitative indicators of a specific kind (e.g., fluid balance) and columns recording those data at specific times and dates. The SICU night team included three occupational groups: nurses, residents, and attending physicians. These groups drew upon the same system of professional knowledge and had interdependent but distinct forms of expertise and experiences.

*Nurses* in Hopeland's SICU were highly trained and committed to intensive care; almost half of the 71 nurses at Hopeland's SICU had worked there for more than 15 years. Nurses worked in two basic shifts: from 7am to 7pm, and from 7pm to 7am. Our study involved the participation of 27 nurses overall, while no more than 12 of them were working on a shift during any site visit. *Residents* had recently received their medical degrees and were now receiving specialized training. They engaged in two-to-three-month rotations within different departments of the hospital. At any given time, four or five residents rotated through the SICU. During the period of our study, 14 residents rotated through the unit. *Attending physicians (AP)* were senior intensive care specialists with an average of 20 years of ICU experience. Hopeland's SICU included five APs, three of whom had trained as anesthesiologists, one in internal medicine, and one as a general surgeon. All five APs participated in our study. APs rotated their management of the SICU, with one AP managing the SICU for a week, and bearing ultimate responsibility for all the care delivered in the unit during that time.

### **Night Rounds in the SICU**

Our study focused on the performance of night rounds, which produced assessments of patients' statuses and allowed for adjustments to treatment. At about 5pm every day, the AP and four residents departed, leaving one resident "on call" (responsible for the SICU overnight). From approximately 7pm to 9pm, the on-call resident was expected to prepare for night rounds by gathering information on their patients. At about 9pm, the AP contacted the resident to

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<sup>1</sup> To retain confidentiality, the hospital name and additional identifying information have been changed.

conduct night rounds. Traditionally, night rounds were performed through telephone interactions, with the APs at home, or occasionally in other locations (e.g., walking the dog, driving). The SICU administrator typically answered the call, put the AP on hold, then notified the resident — verbally if the resident could hear them or paging them if necessary. The resident then took the call, seated in the nursing station adjacent to a networked PC.

When taking the call, residents sat at the nurses' station (the farthest point away from patients). Nurses occasionally stood or sat five to ten feet away from the resident during telephone night rounds, but they almost never participated. The hard-wired phone meant that the resident could only move a foot or two away from their position, and could only access their notes and a networked-PC during the conversation. The AP only interacted with the resident and, sometimes and with significant effort, accessed online medical records. The resident and AP discussed each patient in ascending order by bed number, and the performance of night rounds concluded after the last patient had been discussed.

In 2008, Hopeland leased six RP-7 robots to assist in the performance of hospital work. The RP-7 is a mobile videoconferencing unit controlled at a distance (see Figure 1). Performing night rounds with the RP-7 involved the AP at a remote location (with a laptop, mouse, custom-designed joystick, and headset with microphone) connecting to the RP-7 securely through proprietary software. The webcam in the laptop captured video of the AP and displayed it on the robot's LCD screen. Two high-quality cameras on the top of the RP-7 captured video at the SICU, which was then displayed on the AP's laptop screen. With the joystick, the AP could move the RP-7 forwards, backwards, and side to side, tilt its "head" (screen and cameras) up and down, and rotate the head nearly 360 degrees. With these controls, APs could navigate the RP-7 around the SICU, initiate, engage, and end conversations with others, and direct their visual attention within the SICU environment.

---INSERT FIGURE 1 ABOUT HERE---

In performing night rounds through robotic telepresence, the AP initiated a remote session with the RP-7 at approximately 9pm. The resident on call approached the robot (parked behind the nursing station) and began verbally interacting with the AP. The AP used the robot to approach each patient's room and conduct night rounds with the resident as well each patient's overnight nurse. As in night rounds enacted through the telephone, the resident and AP began with the lowest-numbered room and proceeded in numerical order. At the end of this sequence, the AP piloted the RP-7 to its charging station where the resident would plug it in for the night.

## **Research Methods**

### **Data Collection**

The first author conducted a field study of the practices constituting intensive care medicine at Hopeland's SICU for over 14 months. During this period, and as part of larger assessment being conducted by the hospital, RP-7 use was randomized for the practice of night rounds. At the beginning of each day, participating APs were given an envelope indicating the robot/phone assignment for that night's rounding.<sup>2</sup>

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<sup>2</sup> By this time, the RP-7 robot had been used intermittently in the SICU for over three years, so APs and nurses were reasonably familiar with it.



During the study, the researcher engaged in situated observation of SICU work activities, and conducted interviews with SICU staff members. Formal interviews were conducted in private office locations in the hospital. These were recorded and transcribed, and typically lasted an hour. Participants were asked to discuss the SICU working environment in general, their interactions with other staff members and the RP-7 robot, and their participation in night rounds. An exploratory approach to data collection was adopted so as to more effectively pursue unexpected, salient findings (Edmondson and McManus 2007).

The researcher visited Hopeland's SICU 62 times, collected detailed observational data on 33 sets of night rounds (16 robotic and 17 phone) covering 439 patients (221 robotic and 218 phone). Residents and APs participated in all 439 patient discussions, while nurses only participated in discussions that involved robotic telepresence. In addition, the researcher conducted 34 formal interviews with 5 APs (three of them twice), 5 residents (three twice), and 14 nurses (four twice). Field notes were taken during each visit. These documented notable events, informal interviews, and basic workflow information.

After four months of initial, exploratory observations, the focus shifted to night rounds. During this time, the researcher generally arrived at the SICU at 7:30pm and stayed until 10:00pm, allowing time to observe activity in the SICU before, during and after night rounds, and to conduct informal interviews. Near-verbatim records of round-related conversations, log information on technology use (e.g., PCs, medical monitors, the telephone, the RP-7), and the relative proximity of actors were entered into a spreadsheet application on a laptop. All spreadsheet data were time-stamped at the beginning and end of each set of rounds and at the beginning and end of the discussion about each patient. At the end of the five-month period that involved intensive observation of night rounds, a subset of the original participants was interviewed again. In addition, we solicited feedback on our preliminary findings with three APs, three residents and a group of six nurses. One year after the study had begun, we interviewed a subsample of nurses and APs a final time.

## **Data Analysis**

Our data analysis was iterative and inductive (Strauss and Corbin 1997), motivated by a broad interest in how ambiguity was managed in distributed knowledge work. Our focus on the moment-by-moment performance of intensive care work in the SICU was informed by a practice lens (Feldman and Orlikowski 2011; Schatzki 2010). While managing ambiguity was a central and ongoing concern within the SICU, our initial data analysis suggested that the management of ambiguity was particularly critical in the performance of night rounds — a clearly circumscribed routine within Hopeland's SICU when key actors were distributed and patients needed to be stabilized for the remainder of the night. We therefore selected night rounds as the unit of observation in our study.

We proceeded with multiple readings of our field notes, exploratory writing, discussions with colleagues, and consideration of a variety of literatures (Eisenhardt 1989), paying particular attention to surprises and puzzles (Abbott and Alexander 2004). We solicited reactions to interim findings in our second (and occasionally third) set of formal interviews. We coded all of this data in Atlas.ti on a line-by-line basis. Though our unit of observation (night rounds) became clear within a month of fieldwork, we remained open to emerging themes throughout the data collection. From a first round of coding, we generated a number of first order themes related to

work in Hopeland's SICU and night rounds in particular. These included basic actions (e.g., didactic questioning), emic categories (e.g., the importance of patients being "stable") and shared understandings (e.g., the purpose of night rounds). This, in conjunction with the time-stamped data referenced above, allowed for a variety of descriptive statistics for key actions performed by the AP, residents and nurses during night rounds.

In a second round of coding and consideration of the literature, we analyzed the activities of night rounds in terms of how the medical workers discussed their patients' conditions, managed the attendant ambiguities, and arrived at a temporary understanding of patients as stable, or on their way to becoming so. This led us to view the production of provisional settlements (Kaplan and Orlikowski 2013) as the unit of analysis with which we might understand how ambiguity was being managed in night rounds. We identified the performance of night rounds as typically following a particular sequence of activities (see Table 1), beginning with the resident reporting on and substantiating his/her descriptions of patient conditions, and the AP responding by either accepting these claims or probing on and revising the descriptions. Then one or both of them would suggest adjusting treatment plans, and the AP would assent to the revised, adjusted understanding of patient conditions and overnight care plans, thus provisionally settling the matter. Aside from basic greeting and closing remarks and some spontaneous chatting, we found that all the night rounds were conducted through this sequence of activities and produced provisional settlements, one per patient.

--- INSERT TABLE 1 ABOUT HERE ---

Despite the similarities in the sequence of activities performed by workers during night rounds, we found significant variation in how these activities managed ambiguity and addressed coordination challenges. It was clear in the analysis that night rounds were performed differently when workers engaged through robotic telepresence as compared to the telephone, and that these differences strongly influenced how work was subsequently coordinated overnight. In addition, we found differences within the performance of night rounds through telephone/robotic telepresence. A third round of coding explored this variation and in this process we found considerable differences in how the residents engaged in night rounds as well as in how they performed their activities before and after night rounds.

In particular, we found that some residents exhibited keen interest in the work of intensive care and sought to build their competence in this area. They consistently arrived early, stayed late, volunteered for more work, and developed experience treating large numbers of sick patients. They hoped to be seen by the APs as having "potential" so that they might receive positive recommendations and attractive job prospects. We see these residents as enacting a *strong commitment* to the work of post-surgical intensive care. Other residents exhibited keen interest in work outside of intensive care (e.g., in anesthesia), and focused their activities within the unit on fulfilling the obligations of their rotation. They had little experience or interest in treating multiple sick patients simultaneously. They tended to arrive on time, did not volunteer for additional work, and took breaks and naps relatively frequently. Overall, they sought to "get through" the SICU rotation without causing harm or attracting negative attention from the APs. We see these residents as enacting a *limited commitment* to the work of post-surgical intensive care. These differences in how residents enacted their commitments to intensive care while rotating through the SICU influenced how ambiguity and coordination of care were managed. We realized that in order to understand what difference robotic telepresence made to the

management of ambiguity, we also needed to understand what difference the distinct commitments to the work of intensive care made to the performance of night rounds.

Our multiple rounds of analyses led us to develop a grounded understanding of how ambiguity was managed in night rounds and how patient care was coordinated overnight. As we discuss below, this understanding leads us to argue that the management of ambiguity and coordination are crucially related to how distributed work and commitment to that work are materially enacted in practice.

### **Managing Ambiguity in Night Rounds**

Given the purpose of Hopeland's SICU — the post-surgical care of patients in critical condition — it is no surprise that the management of ambiguity was a critical and ongoing issue. While the reasons for patient admissions into the unit were well-documented and understood, patients' conditions and views on their status and treatment began to change from the moment they arrived at the SICU. Their temperature, heart rate, and other vitals were constantly shifting, they might spontaneously "crash" (enter cardiac arrest), gain or lose consciousness, excrete too much (or too little) fluid, start struggling against their ventilator, and so on. In addition, nurses, residents and APs attended to different phenomena, drew upon different expertise and experience, sought different data produced with diverse devices, and interacted with different participants, including patients' families. Interpretations and understandings of patients' conditions, their status, and treatment options multiplied and diverged (Mol 2002). Ambiguity increased.

There never is [a black and white answer] with medicine and health. You know what I mean, like, there's always all kind of variables, and it's always through people's perspectives. That's a common thread through any, you know, collaboration — just trying to achieve the best at the time, or whatever is most appropriate at the time. But everybody has different ideas as to what the situation is. — *SICU Nurse*

Differences in how nurses, residents and APs interpreted patients' situations were a direct threat to the smooth delivery of patient care in the SICU. In order to enact the intensive care practices required to treat their patients, nurses, residents and APs each performed varying yet highly interdependent tasks, while relying on ongoing interaction with each other to keep doing their work effectively. For example, nurses' bedside work required physician approval and assessment for key decisions about and changes to treatment plans, while physicians (both residents and APs) could not make major decisions or initiate critical procedures without ongoing verbal input and data entry from nurses on changing patient conditions. The moment-by-moment coordination of care required to sustain life could be jeopardized when these interdependent yet dispersed actors developed multiple, conflicting interpretations of patient realities.

Bluntly, without some clarity — without a shared understanding of how to make and keep patients stable — patients could destabilize and die:

I'm always thinking in the back of my mind, they're in the ICU for a reason, they could potentially get sick. But if they're kind of holding their own, you don't need to do a ton of worrying. These people, when they're unstable, they tend to be pretty unstable and then when it gets worse it gets a lot worse. These are the sickest patients in the hospital, so ... I always want my patients to be "stable." I don't know why, it's a good question. It's kind of hard to [explain]. It's just kind of given that that's the goal, and that is your plan in the back of your mind. — *SICU Nurse*

The most welcomed refrain about patients during night rounds was that they were "stable." Stable patients had been assessed appropriately and dealt with competently; their conditions were more predictable, at least "for now." At the same time, nurses and doctors recognized that total

lack of ambiguity was neither possible nor desirable. Even eliminating as much ambiguity as possible for a given patient was not sought as that would have consumed too much time, attention and resources, and other patients would have suffered. All understood that more ambiguities would soon arise as patients' conditions changed, as treatment plans were implemented by distributed workers, and as new complications or conditions set in. The only practical way to manage ongoing ambiguities in this SICU was to ensure that patients were stable-enough for now. We found that the participants did this by regularly producing provisional settlements that ensured patients were currently stable or on their way to becoming stable, all the while knowing that these settlements would soon be revisited and might well be revised.

The production of provisional settlements began with residents engaging in preparation work before formal night rounds at 9pm. This preparation involved gathering data on (and sometimes adjusting care for) the SICU patients between 7 and 9pm, so as to produce an understanding of patients' conditions that would be the basis for discussions during night rounds. Concretely, residents prepared for night rounds by engaging in such activities as touching, listening to and smelling patients, speaking with nurses, specialists, and patients' families, and examining charts, monitors, and electronic medical records.

Once night rounds were initiated at 9pm, workers drew on a repertoire of core activities to accomplish provisional settlements. In night rounds, provisional settlements were the temporary suspension of disagreement about a given patient's stability, and as in prior work (Kaplan and Orlikowski 2013) they had to be plausible (reflective of participants' shared experiences), coherent (fulfilling participants' criteria for logical integrity) and acceptable (addressing key participants' interests). In the context of post-surgical intensive care, proposed settlements were *plausible* when they were based on direct observation and experience of the patient over time and at the bedside (e.g., knowing that the patient's heart rate was fluctuating because they were struggling against a breathing tube). Plausible settlements only included information that was relevant to the patient's condition (e.g., blood pressure might be ignored if the patient was agitated), and that clarified salient issues (e.g., x-rays of a knee injury might not be taken if a patient's brain was swelling). As Weick et al. (2005, p. 419) note, "To deal with ambiguity, interdependent people search for meaning, settle for plausibility, and move on." To those that had "been there," a plausible settlement was legitimate.

[A plausible account] definitely gives you a better clinical picture as to what's going on with the patient. Again, they're [those at the bedside] going to share the subtleties that they [residents] don't hear, either hard data or subtleties that the resident isn't portraying. Or they put it into perspective, so "The patient is obtunded [depressed]," "Yes, they've been that way for eight hours now, or six hours, or they were that way last night and now they're a little better." You know again, they know the whole course of living with that person. The perspective is key. — *SICU AP*

In the context of post-surgical intensive care, *coherence* required information about the patients' conditions to be framed in theoretically and contextually sophisticated ways. As Abbott (1988) notes, such framing entails the offering of rich and domain-specific descriptions drawn from the knowledge system in use. In night rounds, this required the participants to interpret their observations and experiences of patients in terms of the formal medical schemas, classifications, and logic that they shared. Finally, proposed settlements were made *acceptable* in night rounds when the AP endorsed them, and they remained acceptable after night rounds if the patient's nurse endorsed them. The AP was ultimately responsible for the unit and its patients, and had — by far — the greatest combination of clinical experience with patient care and expertise in the

medical knowledge system within the SICU. This combination of final responsibility and professional legitimacy meant that AP endorsement was required for settlements to be deemed acceptable during night rounds. However, such settlements only stayed acceptable if the nurses subsequently endorsed them in their overnight patient care. When patient conditions changed overnight, some of these settlements reached in night rounds became implausible and would then be resisted or reworked by the nurses in practice.

Within the SICU, APs (and nurses) put a premium on plausible settlements, and as a result put great store in the extent of interactions engaged in at the patient's bedside. Everyone recognized that residents were still learning, and would regularly miss important phenomena, gather inappropriate data, and draw unsophisticated conclusions. To the extent that residents engaged in at least some data gathering at the bedside, the belief was that they would notice important subtleties (often with nurses' guidance) and offer accounts of patients' conditions to the AP in night rounds that would enable the construction of plausible and coherent provisional settlements. An AP articulated the value of direct observation for generating the information needed for plausible accounts when talking about nurses who had considerable, direct and ongoing knowledge of patients through being at the bedside:

They know what to do. They know how to take care of these patients. They may not know *why* but they know. They have good judgment. They know when patients are sick and when they're not sick, and that's the important thing that I need to know because in the middle of the night, I don't need to know specifics, I need to know when somebody is getting better or they're getting worse. If they're getting worse then I have to come in. —*SICU AP*

Once provisional settlements were reached during night rounds, these then informed the coordination of subsequent overnight care that was delivered by the resident and nurses.

Our research question focused on understanding how the distributed SICU workers managed ambiguity during the performance of night rounds through robotic telepresence, and with what consequences for the coordination of their subsequent work. In addressing this question, we first present our analysis of night rounds performed through the telephone, then consider our analysis of night rounds performed through robotic telepresence.

### **Performing Night Rounds through the Telephone**

Night rounds at Hopeland's SICU had been performed through the telephone for over 20 years. These involved the AP calling the unit at 9pm and interacting with the resident on-call. Each patient in the unit would be discussed, and the resident would draw on his/her pre-rounding preparation work to offer status updates and respond to the AP's queries. Such discussions resulted in provisional settlements being reached on all patients. These provisional settlements then informed the subsequent coordination of work as the resident and nurse worked together to provide overnight care to the patients. We identified two different pairs of practices that performed night rounds through the telephone — regulating/calibrating and scanning/guiding — with the differences being shaped by how the residents enacted their commitment to the work of intensive care.

#### ***Regulating/Calibrating***

In preparing for night rounds at 9pm, some residents spent the preceding hour or two moving from patient room to room gathering extensive patient data and making small adjustments to patients' care as appropriate. In each room, these residents typically asked the

nurse how the patient was doing, inspected the medical monitor and flowsheet, examined the patient visually, touched the patient, conversed with the patient (and/or their family) if possible, ordered additional tests and adjusted treatment incrementally (e.g., changing sedation, ventilator settings or bowel regimens). These residents recorded brief handwritten notes for each patient. The process generally took between five and ten minutes per patient, but could take much longer if a patient was new or in a particularly acute condition. When these residents were on call, they were in near constant motion and conversation between 7 and 9pm, visible to many within the unit. In doing so, these residents were clearly and effectively enacting a strong commitment to the work of intensive care.

As the resident discussed and examined each patient with the patient's nurse, consulted lab results and the output of monitors, patient conditions were collaboratively identified. This shared, collocated work at the bedside aligned the resident and the nurse's interpretations of a patient's status and treatment. In addition, the resident and nurse generally agreed upon any incremental adjustments to the patient's care. Such adjustments served to stabilize patients' status while responses to these adjustments often produced diagnostically meaningful information (e.g., blood pressure improvements in response to fluid administration). This practice prior to night rounds — which we label *regulating* — allowed these residents to claim stability for half of their patients to the AP during the subsequent telephone interaction. Credible, substantiated classification of patients as stable and requiring no action was evidence that a resident had attended to their patients competently. As well-documented in the literature (Kellogg 2010; Bosk 2003; Zussman 1994; Conrad 1988), the ideal among residents was to make claims about patient stability without needing to offer any substantiation, and for this to go unquestioned (e.g., by simply asserting "Bed 3's fine"), thus demonstrating that the AP fully trusted the residents' accounts. This was often difficult to achieve given patients' multiple conditions and complications, but these residents offered unsubstantiated claims of patient stability 20% of the time during the enactment of the calibrating practice.

During telephone night rounds, the AP and resident focused most of their time and discussion on the few patients whose conditions had not yet allowed them to be declared stable. In these cases, the AP and resident briefly clarified the patient's symptoms and discussed any available data, but primarily focused on puzzles, raising multiple potential interpretations of complex patient cases, as in the case below where the resident refers to a nurse's question.

**Resident:** He did get the unit of platelets; he still has some blood, the nurse brought up a good question, given that he really doesn't need to be intubated, and the fact that he's now got blood, what's the threshold for keeping...

**AP** (interrupting): He's encephalopathic [has global brain dysfunction], we have to protect his ...

**Resident** (interrupting): airway yeah ...

[Field Notes, 12/26/2011]

These conversations that described and inquired into competing potential explanations for patient symptoms had the distinct flavor of a dialogue — the resident or AP would offer an explanation and they would then jointly discuss whether and how the available information supported this explanation:

If it's something [that] requires a more subjective interpretation, [which] I guess could be the patient looks uncomfortable on these ventilator settings even though I know what the settings are. And I may I ask [the resident], is he uncomfortable because his respiratory rate is high or is it because he's working with each breath, his respiratory rate is fine and he's coughing on the tube or whatever it is? It could be a number of different things. —SICU AP

Such dialogue highlighted ambiguities that arose when multiple actors attended to similar patient realities, but produced different, often conflicting interpretations of these realities, as described in the quote above. Given their conceptual nature, we refer to these as *logical* ambiguities. When interactions during telephone night rounds focused on such logical ambiguities, APs found these conversations to be more efficient and the residents to be more competent:

With surgical residents who are really on top of things, they go to the problem. They will say: Okay, the CT scan was done, and there was no collection, there is no need to do anything.” And we move on, okay? But maybe the other residents will say the stats slowly, and they’ll do this with somebody that I know by heart! —*SICU AP*

In their night round interactions with the AP, these residents sometimes asserted minor adjustments such as changes to ventilator settings or drug/sedation levels. In doing so, they put their reputations on the line. If the resident made adjustments based upon insufficiently plausible or coherent accounts of the patient, the AP often revised their adjustments, calling the resident’s clinical acumen into question. These residents’ extensive bedside preparation put them in a much better position to assert adjustments (they did so for 32% of patients) while avoiding AP revisions. They knew their patients well, understood their conditions in detail, and had already made a number of small-scale adjustments to their care. APs generally accepted these residents’ classifications of patient situations. When these residents offered completely unsubstantiated accounts of stability (e.g. “Nothing to do on bed 7”), APs almost always (92%) responded with silence or minimal affirmation, thus collectively producing a provisional settlement for that patient. In this practice — which we label *calibrating* — APs generally suggested few adjustments for contingencies that might arise (13%). They knew that these residents would continue to spend significant effort overnight, conferring with nurses at the bedside and frequently adjusting care, and they put significant stock in these residents’ ability to competently and consistently resolve ongoing and emerging ambiguities.

Enacting the regulating-calibrating pair of practices effectively managed ambiguity in the short run and eased coordination difficulties overnight. These residents’ regulating approach prior to night rounds ensured that the provisional settlements produced during night rounds were more likely to reflect patient realities and nurses’ interpretations of those realities, as well as address the issues that residents and nurses had jointly identified as most pressing. This meant nurses typically accepted the provisional settlements that had been reached during night rounds. Furthermore, the nurses and residents had regular contact with each other at the bedside overnight, conferring frequently, and they continued to make ongoing adjustments to patient care as necessary. Nurses saw such residents as both helpful and flexible as a result:

If I’m stuck in my [patient] room, I don’t have time to come up and tell you what’s going on with my patient. A good resident will *always* come back and follow up and figure out, “did this work, if not let’s do something else.” They’re there. Their presence is there. They’re working on that patient to figure out what medicine, or what algorithm will work for this particular patient. The follow up, that’s the difference with [these] residents. [They’re] the good ones [and] will always follow up. —*SICU Nurse*

Additionally, the provisional settlements that were produced during the calibrating practice were less complex and better understood, allowing the residents to treat them as genuinely provisional when they returned to work (rather than that sticking rigidly to them). Such an approach to provisional settlements better matched nurses’ orientations to care, thus enabling their coordinated work overnight:

The patient is changing quite frequently; they change at night, part of their whole circadian rhythm and everything. Fevers happen at night, people deoxygenate at night, people sundown [become confused, agitated] at night. There's a lot of things that happen to the body specific to the night shift that kind of like, you know, peak during the night. —*SICU Nurse*

The residents further enacted a strong commitment to intensive care work by more thoroughly and proactively addressing issues collaboratively with nurses as they arose overnight. Nurses put a high premium on these frequent adjustments:

We shouldn't have to stop at 7:00 or 8:00 at night and [then] only deal with earth-shattering stuff [overnight]. You know there are things we can be doing for 24 hours, basic stuff moving people forward, and I find that at night, some of these grind to a halt and that depends on the resident. There are residents who are very proactive and they're making vent changes and weaning people and there are others that just let people coast for 12 hours. That doesn't help the patient. —*SICU Nurse*

The residents' and nurses' joint work overnight managed ambiguity in a similar way to the regulating activities performed before night rounds: making adjustments collaboratively aligned the nurses' and residents' interpretations of patients' situations, thus decreasing ambiguities between them. This significantly eased coordination efforts in their overnight work at the bedside, with important potential implications for patient care.

### ***Scanning/Guiding***

Other residents engaged in relatively little preparation for night rounds. They did just enough preparation to avoid negative AP attention while maintaining a minimally sufficient level of medical care. They were often not physically present in the unit; when these residents were on call, the most common response to the question, "where's the resident?" was a shrug. These residents typically gathered information on patients by consulting the electronic medical records via a PC in the break room and referring to experiences they had had earlier in the day. As they did so, they made handwritten notes on a small piece of paper. These notes typically followed the layout of the Kardex and flowsheet. These residents did occasionally prepare by going to patients' bedsides (43% of observed shifts), but more than half of the time, their preparation practice — which we label *scanning* — omitted bedside observations, making it much harder for them to offer accounts of patient status that were deemed to be plausible by the AP during telephone night rounds. In contrast to the regulating activities engaged in by the residents discussed above, these residents' scanning activities clearly and visibly enacted a limited commitment to the work of intensive care.

Even as their scanning practice reduced the plausibility of their accounts, these residents' lack of interest and experience in intensive care meant that they had difficulty identifying which phenomena were relevant, which information should be collected, and how to classify this information in terms of the medical canon. Offering coherent accounts during night rounds was thus a challenge for these residents, a difficulty exacerbated by their need to report on multiple patients based on limited preparation.

Given their distanced and disinterested preparatory activities, these residents tended to offer accounts during night rounds that rigidly adhered to a Kardex-style protocol, overreporting irrelevant detail and underreporting important distinctions. When they deviated from this and presented puzzles, these tended to be more urgent problems that they needed help with. The performance of night rounds through the hard-wired telephone on the desk made it possible for these residents to speak one-on-one with the AP, while restricting their ability to move around



the unit and observe at the patient bedside. This often meant that their accounts of patients' conditions were neither plausible nor particularly coherent, and thus unacceptable to the AP. As a result, the AP guided these residents in order to generate accounts that might produce provisional settlements:

**AP:** Yeah, [night rounds are] routine, unless – unless you get the sense that the resident is missing something.

**Interviewer:** Okay, and how [do you sense this?]

**AP:** Well, you can – you can sense that simply from what they tell you: “Well, Mrs. Jones is now on, she is on 5 of Neo [-Synephrine, blood pressure boosting drug]” and I said, “Now wait a second, she was only on one of Neo when I left at 6 o'clock, why she is on 5 of Neo?” “Well I don't know.” “Did you check on the hematocrit [red blood cell count]?” “Well, yeah, the hematocrit is down 5 points.” I said, “Well it sounds like maybe they need blood rather than more Neo.” So there's, it obviously takes a bit of experience to be able to tease out when somebody doesn't realize that they're in the weeds. —*SICU AP*

In this response, the AP modeled the form of didactic questioning that she used to elicit additional patient information, compare it to prior conditions, and thus generate a more plausible and coherent account through the exercise of guided logic. As part of revising these residents' accounts, APs also engaged in teaching, which added explanatory power to the emerging understanding by reducing conceptual complexity:

**AP:** I would probably not chase him [on his fluid balance], he's supposedly diabetic. I would try to give him small bolus [injection]. I would give him diuretics, [but] especially with diabetic patients there is increasing evidence that they don't do well on [inaudible drug].

**Resident:** So if he needs fluids, should we do Albumin [protein solution]?

**AP:** No, if he needs something, give him crystalloid [saline solution], but I would not chase it, and he probably won't improve. Overall they have worse outcomes. *[Field Notes, 3/10/2011]*

In contrast to the calibrating practice discussed above, this practice — which we label *guiding* — highlighted ambiguities that arose when different actors attended to different aspects of patients' realities. Not surprising, given that they enacted differing commitments to intensive care, these residents (limited commitment) and APs (strong commitment) focused on different facts on the ground. We refer to the resulting ambiguities as *empirical*. In order to offer a sound baseline for guidance, the APs thus devoted much energy in these night rounds to eliciting and assembling a shared picture of patients' conditions.

Finally, as part of the guiding practice, the AP typically outlined potential clinical contingencies and described possible responses to these contingencies (as in the AP's suggestion above to give the patient crystalloid). Such recommending of possible clinical adjustments further helped to manage ambiguity. The probing character of the guiding practice is more evident when contrasted with the calibrating practice described above. During guiding, the APs revised residents' accounts through the telephone roughly twice as often as they did in calibrating (92% vs. 51% of the time per patient), and they proposed contingent adjustments to treatment plans nearly three times as often (33% vs. 13%).

The enactment of the guiding practice occasionally produced provisional settlements that misrepresented the situation on the ground:

It depends on how they [the resident] understand what is happening to the patient. They may not understand the underlying physiology and they may not report what is happening because they don't consider it significant. If I do not have [the] information, I cannot interfere. So it depends how they view

the patient, how they analyze the situation and then how they present the situation. So, unless I ask in detail about all [bodily] systems, I would not figure out and I would maybe miss [something]. — *SICU AP*

This AP highlights how less coherent understandings of physiology can contribute to incomplete views of patient realities, which may produce misinformed provisional settlements given that the AP does not have direct access to patients. This happened, for example, when a resident did not detect a patient problem, this was not uncovered by the AP during night rounds, and the AP participated in erroneously settling on the patient as stable when this was not consistent with the patient's condition.

While the guiding practice produced acceptable settlements that allowed for coordinated action, these were potentially less plausible and less coherent than they should have been, leaving possibly relevant patient realities unaddressed. The residents' scanning activity greatly limited their access to — and influence on — patients' changing situations (e.g., responses to medication), and did little to address differences between their and nurses' interpretations of patient conditions. The enactment of night rounds through the telephone limited all parties' access to bedside realities. As a result, the guiding practice of performing night rounds generally managed to address only gross empirical ambiguities via provisional settlements, and risked missing issues that had been missed or were omitted by the residents.

Even as the scanning and guiding practices served to decrease ambiguity during night rounds, they often contributed — paradoxically — to heightened ambiguity with nurses as the residents returned to performing overnight care. Given the residents' scanning approach to preparation, the clinical adjustments made during night rounds often did not reflect nurses' understandings of patients. In particular, when nurses found the provisional settlements reached by the resident and the AP during the guiding practice, to be incoherent or implausible, they resisted or modified them in practice:

[Resident says the plan is to stop a given drug]

**Nurse:** So you want to do [discontinue] it?

**Resident:** Yeah.

**Nurse:** Yeah, so we're going to have to wean it, because that drug you can't just drop it down, [pause] you can't just drop it. [pause] We just don't titrate [quickly drop] that drug.

**Resident:** All right.

[Field Notes, 12/15/2011]

These residents' enactment of a limited commitment to intensive care work led them to act in much the same way overnight as they did during preparation. They spent minimal time at the bedside, gathering relatively little information that might lead them to reinterpret their patients' dynamic situations, thus limiting the plausibility and coherence of their understandings as the night progressed. This approach to overnight work also restricted the extent to which they could make adjustments in care that would achieve or maintain patient stability:

You have people [residents] who are knowledgeable and proactive, you have people who are frightened and can't do anything in a crisis. You have people who push off every single decision, no matter how trivial or big to the morning. It's very frustrating. You're in a very dangerous spot. You want a high quality resident who's decisive and knowledgeable, and doesn't wander off, and doesn't fall asleep for 6 hours. — *SICU Nurse*

Nurses often compensated for these residents' relative lack of effective overnight action by making relevant clinical adjustments on their own:

I will — I probably shouldn't even say this out loud — implement an order, then call them [the resident] later: "Listen, this is what we've done, this is what we had to do." You know, because, you know, this is what we had to do to keep this patient [alive]. — *SICU Nurse*

As they spent time at patients' bedsides overnight, nurses continued to gather information and adjust treatment so as to achieve or maintain their patients' stability in the face of complex and dynamic situations. These ongoing adjustments served to increase the ambiguity between nurses and these typically-absent residents even more, further hampering their coordination of overnight patient care.

### **Performing Night Rounds through Robotic Telepresence**

Night rounds at Hopeland's SICU began to be performed through robotic telepresence in 2008 with the leasing of the RP-7 robotic system. To begin robotic night rounds, the AP connected remotely to the RP-7 unit at 9pm, and the on-call resident moved to stand in front of the unit. The AP navigated the RP-7 unit to patients' rooms, discussing each patient with the resident and the patient's nurse. The resident, AP and nurse drew on immediate bedside observation and any pre-rounding preparation to offer updates and respond to each other's queries, resulting in provisional settlements for each patient. These provisional settlements then informed the subsequent coordination of work as the resident and nurse worked together to provide overnight care to these patients. We found that two different pairs of practices performed night rounds through robotic telepresence — *regulating/exploring* and *skimming/bypassing* — where differences were shaped by how the residents enacted their commitment to the work of intensive care.

### ***Regulating/Exploring***

As evident in the performance of night rounds through the telephone, some residents prepared assiduously in the hours before 9pm. They worked with nurses at the bedside, collaboratively noting and making adjustments related to patient phenomena such as temperature spikes, skin pallor, blood gas levels, and mood. During these stabilizing interactions, these residents made short, handwritten notes on each patient, moving visibly around the unit, and stopping at each patient's bedside. As before, this preparatory practice of *regulating* reduced empirical ambiguities about what aspects of patients' dynamic situations were relevant while producing multiple competing explanations for those situations (e.g., a fever could be due to Sepsis or MRSA, both serious but quite different infections). The practice also powerfully enacted these residents' strong commitment to intensive care work.

As they performed night rounds, the resident and the AP (piloting the robot) moved to each patient's room and began to interact with the nurse, the patient, the medical monitors, the patient's flowsheet, and other aspects of bedside reality. In this practice, the AP, nurse, and resident all had real-time access to each other, and they obtained immediate and direct information about the patient from being at the bedside. As these residents offered patient accounts during these bedside interactions, the AP and nurse frequently focused on puzzling clinical patterns with a given patient (38%). APs, nurses and residents engaged with these puzzles by sharing their views about the patient's bedside realities, asking each other questions, offering alternative points of view. They took rapid and frequent turns in conversation, often speaking in incomplete sentences. They collectively revised the resident's original account with

some frequency (159% per patient), asking each other for perspectives and information, jointly consulting the patient's flowsheet, electronic medical records (on a PC), and medical monitors. While engaging in this collective discussion — a practice we label *exploring* — the AP, nurses and the resident frequently discussed potential contingencies and made short and longer term adjustments:

If I gave a piece of information [during robotic telepresence night rounds], it's something that both of them [the resident and the AP] can chew on and then say, "Yeah, let's give that a try tonight" or "No, put that off until tomorrow." Incremental changes that might help, not big stuff. Sometimes we lose a lot of ground overnight. There are things that we could be doing to move the patients along incrementally overnight that shouldn't wait 12 or 14 hours. If you've got them both right there, it's a real quick question; if you've got a tube feed or a vent change, or getting certain treatment started, a bowel regimen, you might get what you need right away. — *SICU Nurse*

The AP and resident made more adjustments to each patient's plan of care (92%) during exploring than in any of the other practices that performed night rounds. Practically, the capacity to engage in bedside interactions during the exploring practice made it far more difficult for residents to appear competent via unsubstantiated accounts of stability. The nurse and the AP each had an order of magnitude more clinical experience than the resident, and the robotic interactions allowed everyone rich, real-time access to each other and patients' environment. These residents could no longer offer accounts of stability and expect them to be accepted. Subtleties were detected, questions were raised, and residents' accounts of patient stability were revised.

Not surprisingly then, these residents offered roughly half the number of substantiated (28%) and unsubstantiated (7%) accounts of stability during exploring (through robotic telepresence) as they had done during calibrating (through the telephone). Indeed, the AP accepted claims of stability only 17% of the time in this exploring practice (in contrast with 47% during calibrating). Instead of offering frequent accounts of stability, these residents proactively raised and facilitated the exploration of puzzles:

I think that generally I found that when the robot was used, I had more opportunity, or the nurses had more opportunity to kind of give some feedback as to what they thought what was going on with the patient, whereas when the robot wasn't in use, that wasn't really an option for them. — *Resident*

[These residents] are bringing up possibilities [on the robot], where[as] on the phone they're being asked less because they have given them [the AP] all the information they need. They're prepared [on the telephone], whereas there's a dialogue going on with the robot, things might be coming at them, they say "Well what happens if we go down this route, like what to do?" — *SICU Nurse*

Given the premium that APs (and nurses) placed on direct bedside observation and interaction with patients' empirical realities, they readily engaged in dialogue that provided an opportunity to account more extensively for patient realities and possibilities. In the midst of producing provisional settlements, however, exploring puzzles temporarily increased ambiguity. As a result, the plausibility and coherence of a proposed settlement was repeatedly challenged (by all parties) as new interpretations were sought:

**Resident:** Essentially his liver enzymes are high, and have fallen to 26 in 2.5 hours.

**AP** (zooms in on chart): and platelet count is 65 and half?

**Resident:** Yes, is he on heparin? (to nurse)

**Nurse:** Yes, he is.

**AP:** I would stop that, guys.

**Resident:** Stop that?

**AP:** It's probably consumption, what about platelet consumption, and Nancy (nurse), how are we with [inaudible]?

**Nurse:** It's 22.

**AP:** What about fluid balance for him?

**Nurse:** 7 liters.

**AP:** So it's probably dilution.

*[Field Notes, 3/27/2012]*

In order to explore these puzzles, the resident, nurse and AP interacted rapidly with each other, taking frequent turns in conversation. They revised residents' accounts by making them more plausible ("is he on heparin?") and coherent ("it's probably dilution"). Nurses interjected (108% per patient), and these interjections generally supplemented residents' accounts. This focus on joint exploration led to the highest frequency of direct assertions regarding clinical care ("I would stop that, guys.") in any of the practices performing night rounds (55% per patient), but residents made fewer of these (13%) than they had in the calibrating practice (32%). The increase in AP adjustments was facilitated by the relative alignment of commitments to intensive care enacted by the residents, nurses and APs. APs' presence at the bedside via robotic telepresence allowed them to more easily challenge the coherence and especially plausibility of a given clinical adjustment:

Had a patient last night on the phone, and the data was "Pulmonary came by, and wants to intubate the patient," so my question was "who is making this recommendation?" So I went back and forth with the resident and I said "Does he look clinically different than he did with us?" "No," and the final thing I said to him was "You're going to decide, because you're there looking at him." If I had the robot, I would be looking at [the patient] and might not let the resident ... I might just say "he's the same, leave him alone." Whereas I've got to put more trust in the residents' decision on the phone. — *SICU AP*

The enactment of regulating and exploring practices produced provisional settlements that provided a great deal of highly plausible and coherent guidance to the resident and nurses in their subsequent overnight care. This was also guidance that both the resident and nurses understood well, and that addressed multiple potential clinical contingencies that might arise. Not surprisingly, — nurses thus generally accepted settlements that were reached in the exploring practice. This anticipatory management of ambiguity eased coordination efforts overnight in many of the same ways accomplished by the calibrating practice. However, given that the robotic interactions in the exploring practice allowed all participants rich, simultaneous and direct access to each other at the bedside, provisional settlements reduced overnight ambiguity — and enabled coordination — to an even greater degree than in the calibrating practice by providing a shared point of reference:

I think [robotic night rounds] provided the opportunity to ask more directed questions, and I found it saved on pages [calls requested by nurses] later on in the evening. If there was a question that they [nurses] weren't really satisfied with the answer that I gave them [during night rounds], I could at least throw it back to the AP with the robot and let the AP kind of give their feedback, and that would be kind of an end-game and they wouldn't keep asking the same question. — *Resident*

After enacting the exploring practice during night rounds, residents and nurses managed ambiguities together overnight, making reference to the provisional settlements produced during their shared discussions with the AP at the patient bedside. Given the extensive adjusting enacted in the course of the exploring practice, overnight ambiguities were both preemptively reduced and accounted for in advance by the provisional settlements reached during these night rounds.

[Night rounds performed through exploring] are more collaborative ... [we] get kind of a night time plan. You'll get kind of like your evening and nighttime, overnight plan at that point. — *SICU Nurse*

The provisional settlements reached during the exploring practice meant that residents and nurses could be even more attentive and responsive to fewer patient changes overnight as they drew upon and revised the provisional settlements that informed their collective and coordinated efforts of patient care.

### *Skimming/Bypassing*

As evident in the performance of night rounds through the telephone, some residents engaged in little preparation for night rounds. They consulted patients' electronic medical records via a remote PC and by referencing experiences they had had earlier in the day, noting these items on a single sheet of paper. They spent even less time preparing directly at the bedside (22%) than they had done for telephone night rounds (43%), making it even harder for these residents to offer accounts that the AP and nurse deemed plausible and coherent in subsequent discussions at the bedside (described below). We label this practice *skimming*, to signal that these residents were even less prepared than they were for telephone interactions. Such activity visibly enacted these residents' limited commitment to intensive care work. Given this limited preparation, these residents struggled to select and interpret information in ways that were consistent with the medical canon, and thus were quite challenged to offer coherent accounts of patients' conditions during night rounds.

In performing night rounds, the resident and the AP (piloting the robot) moved to each patient's room, interacted with the patient's nurse, and examined the patient as well as the medical records and readouts on medical monitors. When these residents offered accounts at the bedside, they often checked patients' flowsheets for relevant information and consulted the patient's medical monitors. During these discussions, nurses interjected their views without prompting, responded to direct questions from the AP and resident, and answered questions that the AP had intended for the resident. As this occurred, the AP and nurse increasingly conversed only with each other, directly interacting with the patient and the clinical records. We label this practice *bypassing*, to indicate how peripheral the residents became in these bedside interactions.

Presenting their assessments of multiple patients was challenging enough for these residents. Doing so in front of practitioners with considerable experience (one of whom happened to be their manager) and in the presence of the living, breathing phenomenon on which they were reporting, was overwhelming:

It sounds initially like it [the RP-7] should be a good thing, but there's good and bad with that. We sort of have a plan, we basically need to brush up on the few things that have to change, small updates, if there's anything that's really especially important to hone in on that, and kind of keep the conversation directed. It's a lot harder to do that when the robot is sort of inviting the contributions of other people. — *Resident*

Somewhat paradoxically, these residents offered *more* accounts of patient stability (42% substantiated, 9% unsubstantiated) than they did on the telephone in the guiding practice (38%, 7%). Telephone interactions with the AP enacted a degree of privacy that allowed residents to ask "stupid" questions, seek help, and offer more lengthy and tentative accounts. Interactions via robotic telepresence, by contrast, enacted a more public exposition — one in which the resident was required to offer accounts in front of nurses and patients, as well as the AP. These residents responded by presenting their cases more firmly during night rounds performed with the RP-7 to avoid looking "stupid" or weak in front of these nurses. Their accounts adhered even more rigidly to a Kardex-style protocol, resulting in overreporting excessive detail and underreporting

important distinctions. This also meant a significant reduction in puzzle declaration (7%) compared to the guiding practice during telephone night rounds (23%). This “keep calm and carry on” approach was clearly evident in bypassing as residents’ default gaze was at their handwritten notes about their patients. As an AP noted:

Some residents [who want to specialize in] anesthesia, they round and they have a list and they read it to me. “The blood pressure is stable, the heart...”. I *presume* it is stable, you know? I don’t need to have it repeated to me, I like to be informed about the *changes*, and they feel that they are obliged to tell me, “we are still on full support, blood pressure is stable, it’s ranging 130/60...” if you say they’re hemodynamically stable, it’s enough, move *on*. But they will read me the numbers, you know. And only on the robot. —*SICU AP*

Synchronous and shared interactions at the bedside allowed nurses and APs to work around these residents’ minimal preparatory activities in order to provisionally settle on patients as stable. Given that these residents’ accounts often lacked plausibility, the nurse and AP primarily worked to make these accounts more plausible. Nurses interjected frequently with new and/or contradictory information, and APs and nurses exchanged and sought information directly on patient situations involving the highest ambiguity, frequently revising residents’ accounts:

**Resident:** Mr. X, he hasn’t gotten two units of blood, vaso is 0.04, 12 and three or five... he hasn’t gotten [a] unit of blood...

**Nurse** (interjecting): Yes, he’s gotten all [the] blood.

**AP:** (turning RP-7 head to nurse) Doug, is he still peeing so much?

**Nurse:** No, it’s definitely tapering down, Chi [specialist] came by, in the last hour he almost got more CBI [bladder irrigation] than urine.

**AP:** And did he contact urology?

**Nurse:** He said no CT (scan), he may embolize [resident moves closer to RP-7].

**AP:** So this is very suspicious, why is he ... ?

**Nurse:** Yeah.

**AP:** You don’t need 10-12 units of blood.

**Nurse:** Right.

**AP:** Do you think we can wean him off dopamine?

**Nurse:** I did, I did what Maria [specialist] did.

**AP:** It should be more vasodilating.

**Nurse:** He likes the blood and whites [immune blood cell count] is important.

**Resident:** Yeah, [inaudible].

[Field Notes, 3/8/2012]

It was clearly evident across our observations, that the residents became somewhat irrelevant to the production of provisional settlements in the bypassing practice. This increased ambiguity between the resident and the AP and nurse, while reducing ambiguity between the nurse and AP. As the nurse and AP’s interactive and iterative revising of accounts made settlements more plausible and coherent (at least on high-priority cases), the AP made frequent (44%) adjustments to patients’ care. As these residents had fewer diagnostic and practical resources needed to make reports more plausible or coherent in these discussions, they made very few such adjustments (4%).

When residents and nurses returned to work after these night rounds, they had a shared list of clinical adjustments to make overnight, but the residents often had limited understanding as to what these adjustments would do and why they might work. While the robotic telepresence

discussions during night rounds had allowed the APs, residents, and nurses rich access to each other and patients at the bedside, the enactment of the bypassing practice had also largely excluded the resident in producing provisional settlements. This was in contrast to the guiding practice performed through the telephone where residents had more opportunity to participate in producing provisional settlements through the probing and teaching activities of the AP:

I definitely felt... a little bit less comfortable with everything after using the robot then after using the phone. There's just too much going on. The conversations were on some level less effective; they got to key issues less frequently than the phone conversations did. — *Resident*

Given their lack of understanding of the provisional settlements produced during the bypassing practice, residents adhered relatively rigidly to them in their subsequent work:

A lot of times if you make a plan or give a theory to a resident, they will accept that as dictum: 'This is the way we do it, this is what we're going to do, we're sticking to this plan.' Whereas the nurses, it's like 'it usually works this way, but if anything changes, you have to shift gears.' So if [nurses] they're listening to the conversation, they'd have a much better perspective as to what the plan is and how important it truly is if things change. In medicine in general, that's a huge thing, when you tell them what you're thinking as far as doing and you tell them why, it makes a huge difference in the care. Or in their buy in, versus 'I'm not doing that', or worse, you get compliance without understanding. — *SICU AP*

Settlements were thus not similarly provisional for everyone involved; nurses and APs held less tightly to the temporary suspensions of disagreement because they expected and could respond to changing patient conditions. In contrast, residents who had been bypassed during night rounds held tightly to the provisional settlements produced in the night rounds, and nurses had to contend with these residents' "settlement rigidity" overnight.

Because nurses had participated directly in substantiating, revising and adjusting the provisional settlement reached on a given patient, they accepted it more readily. This served to reduce ambiguity to a degree, but these residents' general lack of availability overnight served to exacerbate ambiguities as nurses continued to resist and depart from residents' suggestions and directives as these failed to account for changing patient conditions. In addition, that the settlements had been reached via the more public robotic telepresence discussions allowed the nurses to compel residents to adhere to them:

They can't have this like lackadaisical demeanour about them where, "All right, everything seems okay, I'm going to go either grab a bite to eat or I'm going to maybe try to catch a few winks of sleep," where [on the robot] it's like: "No. You have a very - like I said very important and even very powerful role right now and we're going to hold you to it." — *SICU Nurse*

Enacting the bypassing practice thus created unique coordination opportunities and challenges related to ambiguity during the overnight shift. Residents' minimal preparation evident in the skimming practice severely limited access to and influence on patients' changing conditions, and did very little to address differences between their and nurses' interpretations of patients' conditions. While the bypassing practice of performing night rounds meant that provisional settlements resolved more ambiguity than had been achieved during the guiding practice enacted through the telephone, this was typically at the expense of the resident's understanding of the provisional settlements. This exacerbated differences in interpretations among the resident, AP and nurse, and also made it more likely that the resident would treat the provisional settlements as dictum as the night progressed.



## Discussion

Our research question focused on understanding how ambiguity is managed in distributed knowledge work that is performed through robotic telepresence, and with what consequences for coordination. Given the literature's emphasis on the importance of co-located, face-to-face interaction for managing ambiguity in knowledge work, we should expect that in comparison to the telephone, discussions through robotic telepresence should decrease ambiguity and ease coordination. Our study of night rounds at Hopeland's SICU paints a different picture however. In contrast to the expectations emerging from the literature, we found that ambiguities were both reduced and intensified with robotic telepresence, resulting in mixed and contradictory implications for coordination. In particular, we found that the practices performing night rounds within the SICU were thoroughly entangled with the specific materialities and commitments constituting the work of intensive care (see Table 2). Our analysis of these different enactments in practice generated a number of insights and contributions to the literature on ambiguity and distributed work.

First, we found that the different material enactments of night rounds matter a great deal. That is, the performance of night rounds through robotic telepresence and through the telephone included different information, different workers, and different discussions, and these differences significantly influenced the management of ambiguity and the subsequent coordination of work. Conducting night rounds through a hard-wired, centrally located telephone meant that typically only the AP and resident participated in the discussions, with nurses being largely excluded. Furthermore, the AP and resident had no access to the patients or the medical monitors at the bedside. As these workers engaged in calibrating or guiding practices through the telephone, their interactions managed ambiguity differently with distinct implications for overnight caregiving. Specifically, the calibrating practice (enacted by residents with a strong commitment to the work) eased overnight coordination because it produced settlements that the residents understood, the nurses accepted, and that both were willing and able to as they interacted with each other at the bedside overnight. This was not the case in the guiding practice (enacted by residents with a limited commitment to the work) where the residents did not well understand the settlements reached, the settlements typically did not reflect patient realities or nurse understandings and were often resisted by the nurses, who had limited opportunity to interact with the largely-absent residents overnight.

Performing night rounds through robotic telepresence allowed the AP, residents and nurses to engage with each other and patients' bedside realities virtually. In enacting the exploring and bypassing practices these workers produced provisional settlements differently, with distinct implications for the coordination of overnight medical care. Specifically, the exploring practice (enacted by residents with a strong commitment to the work) eased overnight coordination because it produced a large number of settlements that addressed current and possible ambiguities; residents and nurses understood, accepted and held these lightly, as they engaged regularly with each other at the bedside overnight. This was not the case in the bypassing practice (enacted by residents with a limited commitment to the work) where residents did not well understand settlements reached, held to them rigidly, and engaged very little with nurses at the bedside overnight.

Second, we found that how residents enacted their commitment to the work of intensive care mattered considerably, strongly influencing how residents responded to provisional

settlements. In particular, we found that provisional settlements are not equally provisional for everyone. Residents enacting limited commitments to the work at hand held to provisional settlements more tightly than those enacting strong commitments to the work at hand. These differences are in part due to diagnostic sophistication. Residents enacting a limited commitment may not have the capacity or interest to notice and understand subtle changes across multiple, dynamic client situations, whereas residents enacting a strong commitment had both the capacity and interest to notice these changes and understand them with reference to the knowledge system in use. Additionally, those enacting a strong commitment to the work are more likely to spend discretionary time engaged with problems and puzzles, which serves to update understanding — especially for those whose diagnostic sophistication is relatively high. These differences in enactment of commitment to the work help to account for the varying degrees of “settlement rigidity” we found in our study. Such “settlement rigidity” is often problematic as it contributes to further ambiguity in ongoing work, which can hamper coordination. Thus paradoxically, even as the production of provisional settlements reduces ambiguity, it may also increase ambiguity as workers who enact limited commitment to the work cling rigidly to those provisional settlements in ensuing activities.

Third, a comparison of the guiding and bypassing performances of night rounds with those of calibrating and exploring suggests that differences in how provisional settlements are achieved serve to address different dimensions of ambiguity. In the guiding and bypassing practices, the AP and nurse devoted much of their energies to revising the resident’s relatively implausible accounts of patients’ conditions. This served to reduce *empirical ambiguities* about what patient realities were relevant and needed to be taken into account. By contrast, in the calibrating and exploring practices, the workers quickly agreed on the relevant aspects of patients’ conditions, and focused on producing multiple (often competing) explanations for those realities (e.g., all agree that a patient is disoriented, and discuss possible explanations such as dementia, blood sugar levels, and swelling in the brain). These collective considerations of *logical ambiguities* led to further adjustments that often elicited additional data and/or patient responses, which adjudicated between competing hypotheses. The distinction between empirical and logical ambiguities evident in our study highlights how ambiguity is not uniform or singular, but rather multiple and contingent, depending on the various ways in which commitment to the work is materially enacted in practice.

Fourth, our study found that the performance of preparatory work significantly contributed to both the production and management of ambiguity in practice. Prior work on ambiguity management has generally overlooked the activities involved in preparation. As we saw in the case of careful, collaborative, and direct engagement at the site of work, preparation could serve as a key practice for managing ambiguity, involving repeated (albeit minor) interventions in the very phenomenon being observed. Thus in the performance of the calibrating and exploring practices, bedside preparation both served to make subsequent accounts more plausible and coherent, but also more acceptable for the nurse, given that clinical adjustments were in part jointly produced. In contrast, where preparation was performed in a perfunctory fashion, involving relatively little direct connection with the site of work and little or no interventions of any kind, more difficulties in the management of ambiguity were generated. As we found in our analysis of the guiding and bypassing practices, making few adjustments during preparation was an intervention in and of itself, contributing both to additional ambiguity and leading nurses to

make adjustments to care on their own so as to take into account and stabilize dynamic and complex patient situations.

**Limitations.** Our study was exploratory and limited to medical professionals working within a single post-surgical intensive care unit engaged in a particular routine, the performance of night rounds. We focused on the enactment of a specific technology — the RP-7 robotic telepresence system — that was deployed within Hopeland in 2008. These contextual, material, and historical characteristics necessarily shape our insights. However, we believe that the central finding — that the management of ambiguity and coordination in distributed knowledge work is contingent on the specific materialities and commitments enacted in practice — may usefully inform future study. To the extent that knowledge work is becoming more distributed and technologies such as robotic telepresence are increasingly being deployed to facilitate that work, our results offer some insights into their implications. Additionally, we believe that the practices for managing ambiguity we identified here may also play a significant role in the coordination of work in organizations less focused on knowledge work. Further research in this direction is needed to more clearly understand the management of ambiguity in the increasingly distributed contemporary workplace.

### Implications

New technologies such as robotic telepresence allow workers to interact virtually at the site of work, and thus promise many of the benefits of co-located, face-to-face interaction vis à vis managing ambiguity. Our research suggests that it is not co-location or face-to-face interaction per se that facilitates the management of ambiguity in knowledge work. Rather what matters is how work is performed through different technologies and how workers' commitments to the work at hand are enacted in practice. This study has important implications for research in a number of areas.

Our study highlights the value of seeing the materialities of night rounds (whether performed through the telephone or robotic telepresence) as entangled and constitutive of knowledge work rather than treating these as mediating influences on such work. In our study, the enactment of the practice pairs — regulating-calibrating, scanning-guiding, regulating-exploring, and skimming-bypassing — was integrally and thoroughly entangled with the objects, devices, monitors, spaces, documents, and bodies that constituted the work of intensive care in the SICU. We found it to be neither feasible nor informative to study night rounds without an understanding of ongoing practice.

Similarly, our study highlights the importance of understanding how workers' commitment to their work was materialized in practice. That is, we needed to understand how the residents prepared for and conducted night rounds, and how they interacted with patients and nurses before and after those rounds, as these significantly influenced how ambiguity was managed during night rounds and how work was subsequently coordinated. Workers' commitments are not static or fixed but relational in the specific activities they engaged in. They became real and consequential as they were enacted in practice.

Beyond considerations of ambiguity, our study offers insights into provisional settlements and the coordination of collective, distributed work. Specifically, we found that the plausibility, coherence and acceptability of the provisional settlements produced in our study depended upon whether — and to what extent — the participants drew on a legitimized and shared knowledge

system in use. Previous work that analyzes the management of ambiguities has done so in contexts where authority and accountability are uncertain and problems are novel (Carlile 2002; Daft and Lengel 1986; Bechky 2006; Faraj and Xiao 2006). The authority to make provisional settlements is both distributed and unclear in these settings, and therefore more actors with a wider range of interests must find these settlements acceptable. Further, the actors in prior work have come from different fields and occupations, and interacted with different parts of empirical reality (Bechky 2003). They typically do not share a knowledge system and thus interpret their novel experiences in markedly different ways. These differences contribute to a great deal of ambiguity among actors, as there is no single arbitrating authority, and no (or only limited) agreement on a canon to which interpretations can be referred in order to settle disputes (Carlile 2004). Action pressures are typically intense in these settings, however, and provisional settlements are both necessary and difficult to achieve, involving both significant compromise and social influence.

Our study of distributed knowledge work examined actors facing ambiguity in the context of a shared, legitimate knowledge system in use (the medical canon), and generally low uncertainty about decision-making authority and accountability (Abbott 1988; Freidson 1988). The production of provisional settlements in such conditions was thus easier than in conditions characterized by uncertainty over authority and strong disciplinary boundaries. While the provisional settlements discussed in the prior literature were seen to be infrequent and hard-won, we found the production of provisional settlements to be both ongoing and frequent. In particular, because the management of ambiguity in post-surgical patient care was a moment-to-moment, complex, and dynamic process, it required multiple, recurrent provisional settlements to achieve and maintain patient stability, while moving their care forward.

Previous work on provisional settlements does not indicate the relative importance of the plausibility, coherence or acceptability of a given settlement for coordinated action. We found that in knowledge work that is tightly coupled to the empirical world such as intensive-care medicine, plausibility is at a premium. Patients' realities are dynamic and complex, their conditions are poorly understood at times, and medical knowledge is imperfect. Being able to make and quickly correct for small errors on the ground (or at the bedside) is therefore important, especially in critical patient care (Abbott 1988). As ambiguities arise, experienced workers turn to direct observation of and interaction with the object of work to explore and resolve ambiguities. If not examined closely, this finding could be seen as supporting the previous view in organization studies that co-presence at the site of work is uniformly helpful in the management of ambiguity. However, the prioritizing of plausibility might not be relevant in other attempts to produce provisional settlements. In complex, collective work that is more focused on abstracted models and quantification — as for example, in financial trading (Beunza and Stark 2004) or expert systems design (Forsythe and Hess 2002) — the coherence of a provisional settlement may be seen as more critical. This kind of work tends to operate within and on representations of reality, rather than on empirical reality through representations (Bailey, Leonardi, and Barley 2012), where matters of logical integrity tend to matter more than empirical fidelity. When change is significant and/or experience, expertise and interests vary widely (e.g., filmmaking crews (Bechky 2006)), it may be more important for settlements to be acceptable. Indeed, Kaplan and Orlikowski (2013) suggest that this criterion was central to provisional settlements in strategy making amidst massive market upheaval.

## **Conclusion**

Our research posed the question, what difference does a robot make to the management of ambiguity in distributed knowledge work. Our study leads us to suggest that ambiguity in distributed knowledge work is actively managed in material practices enacted by actors with distinct commitments to the work at hand, and that these practices have performative implications for how subsequent collective work is coordinated. We find that enacting strong commitment to the work at hand entailed assiduous preparation, collaborative and preemptive management of ambiguities, attention to logical ambiguities in producing provisional settlements, and light attachment to those settlements. This eased subsequent coordination considerably. Enacting limited commitment to the work involved less preparation, attention to empirical ambiguities in producing provisional settlements, and rigid attachment to those settlements, which hampered subsequent coordination. Given our findings, we suggest that ambiguity always arises and is managed in practice, and it is only through close examination of how practices are materially enacted and with what commitment to the work at hand can we understand how ambiguity is managed more or less effectively in distributed knowledge work.

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**Table 1: Activities in Provisional Settling during Night Rounds**

<b>Activities</b>	<b>Representative Data</b>
<i>Accounting</i>	
<b>Unsubstantiated stability claiming</b>	<b>Resident:</b> “Bed 3’s fine.”
<b>Declaring puzzles</b>	<b>Resident:</b> “We started him [patient] on Solumetrol, he's been fine, he's been having ABGs (blood gasses) drawn, his last ABG was kind of weird, the pH was 7.44, his O2 is 68, and the Bicarb was 21, but when you look at him, he's sat ... [saturating his blood with oxygen, contrary to ABG results]”
<b>Substantiated stability claiming</b>	<b>Resident:</b> “Mr. X, bed 2, so, um, a surgeon followed up on his cat scan, saw no free air, looks like he aspirated a bit of contrast, he's been transfused to a hematocrit of 29, which was the goal per hematology, so he's stable to be honest with you, he's satting [maintaining good oxygen levels], pulse is 90.”
<i>Revising</i>	
<b>Questioning</b>	<b>Resident:</b> His pressure starting dropping a bit into the 90s now.
<b>Teaching</b>	<b>AP</b> (interrupting): did they give him 5 percent Albumin? (nurse nods)
<b>Interjecting</b>	<b>Resident:</b> Yes.
(data illustrate all)	<b>AP:</b> So how much [inaudible drug]? <b>Resident:</b> they gave him 50, gave him 50 grams total, he got how many percent ?
<i>Settling</i>	
<b>Minimal acknowledgement</b>	<b>Resident:</b> [claim] (e.g. “Nothing has changed on him, he’s great”). <b>AP:</b> [Silence]/”Mhm.”/”Okay.”/”Great.”/(etc.)
<i>Adjusting</i>	
<b>Asserting</b>	<b>Resident:</b> His chloride is... the last one this morning was 107. <b>AP:</b> Finox [drug] might be reasonable. Give him a .14. IV dose.
<b>Suggesting</b>	<b>AP:</b> If you send him back to have it [procedure] done, I would bump the Propofol to 100 and possibly paralyze the guy. <b>Resident:</b> Sure. <b>AP:</b> ...to make sure he's not contributing [to a blood-pressure increase].

Table 2:

		<b>Preparing for Night Rounds</b>	<b>Conducting Night Rounds</b>	<b>Coordinating Subsequent Care</b>
<b>Night Rounds performed through the Telephone</b>	<b>Residents enact a strong commitment to the work</b>	Ambiguity decreases as: <ul style="list-style-type: none"> <li>• residents always observe patients at the bedside and interact with nurses</li> <li>• residents always make adjustments to regulate patients</li> </ul>	Ambiguity decreases as: <ul style="list-style-type: none"> <li>• provisional settlements are achieved on all patients</li> <li>• the AP and residents calibrate their assessments on the more complex cases that require addressing logical ambiguities</li> </ul>	Coordination is facilitated as: <ul style="list-style-type: none"> <li>• provisional settlements reached in night rounds are seen to be plausible, coherent, and acceptable by nurses</li> <li>• residents are on hand overnight to jointly adjust care with the nurses as needed</li> </ul>
	<b>Residents enact a limited commitment to the work</b>	Ambiguity increases as: <ul style="list-style-type: none"> <li>• residents scan medical records from break room and only occasionally visit patients at the bedside and interact with nurses</li> <li>• residents only occasionally make adjustments to regulate patients</li> </ul>	Ambiguity decreases as: <ul style="list-style-type: none"> <li>• provisional settlements are achieved on all patients</li> <li>• the AP guides residents through didactic questioning to address empirical ambiguities on the less complex cases</li> </ul>	Coordination is challenged as: <ul style="list-style-type: none"> <li>• provisional settlements reached in night rounds are seen to be implausible by the nurses given the omission of bedside realities</li> <li>• residents are largely absent overnight requiring nurses to make unilateral decisions</li> </ul>
<b>Night Rounds performed through Robotic Telepresence</b>	<b>Residents enact a strong commitment to the work</b>	Ambiguity decreases as: <ul style="list-style-type: none"> <li>• residents always observe patients at the bedside and interact with nurses</li> <li>• residents always make adjustments to regulate patients</li> </ul>	Ambiguity increases initially but then decreases as: <ul style="list-style-type: none"> <li>• AP, nurses and residents address logical ambiguities in the more complex and puzzling cases</li> <li>• residents and nurses have good understanding of the provisional settlements reached and the plans for multiple contingencies</li> </ul>	Coordination is greatly facilitated as: <ul style="list-style-type: none"> <li>• provisional settlements reached in night rounds are seen to be plausible, coherent, and acceptable by the nurses</li> <li>• residents are on hand overnight to jointly work with the nurses to adjust care based on the provisional settlements and plans produced during night rounds</li> </ul>
	<b>Residents enact a limited commitment to the work</b>	Ambiguity increases as: <ul style="list-style-type: none"> <li>• residents skim medical records from break room and rarely visit patients at the bedside and interact with nurses</li> <li>• residents rarely make adjustments to regulate patients</li> </ul>	Ambiguity decreases but also increases as: <ul style="list-style-type: none"> <li>• AP and nurses address empirical and logical ambiguities, and bypass the residents</li> <li>• nurses have good understanding of provisional settlements reached and the plans for multiple contingencies; residents have little understanding of provisional settlements reached and the plans for multiple contingencies</li> </ul>	Coordination is badly challenged as: <ul style="list-style-type: none"> <li>• residents stick rigidly to provisional settlements that they do not understand while nurses feel need to adjust in response to changing circumstances</li> <li>• residents are largely absent overnight and nurses take unilateral action based on the provisional settlements and plans produced during night rounds</li> </ul>