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Technological Objects and the Restructuring of Workplace Boundaries

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ABSTRACT

Recent research has highlighted the role and use of workplace artefacts by occupational communities in enacting jurisdictions within organizations. This article builds on these insights to understand how the use of a new technological object by community members has implications for the restructuring of workplace boundaries. Our study of hospital pharmacy automation examines how a newly introduced dispensing robot mediated the work of dispensing technicians and distribution assistants. We found that use of the robot, which was expected to improve patient safety and pharmacy productivity, also served to restructure spatial, temporal, task and role aspects of workplace boundaries, having important implications for the visibility and invisibility of different forms of work. We identified three boundary relations that emerged among different occupational groups and which served to enable and constrain their cross-boundary work: *boundary strain* between technicians and assistants; *boundary cooperation* between technicians and pharmacists; and *boundary neglect* between pharmacists and assistants. Our study goes beyond the predominant focus on boundary objects as bridging and coordinating work, and seeks to provide a richer conceptualization of the role of technological objects in shaping boundary relations within organizations.

Keywords:

Technological objects; technicians; robots; work (in)visibility; boundary relations; boundary strain; boundary cooperation; boundary neglect

Organizational scholars have recently highlighted the inadequacy of viewing organizations as circumscribed by fixed and unambiguous boundaries. Instead, they argue that boundaries should be recognized as dynamic (Hernes 2004) and emergent, established through processes of boundary setting (Abbott 1995). With the advent of the Internet and the proliferation of digital technologies in the workplace, post-bureaucratic organizations have been characterized as dynamic, flexible, and "boundaryless" (Hirschhorn and Gilmore 1992), though other scholars (e.g., Heracleous 2004) have emphasized the 'subtle' proliferation of boundaries in modern organizations. Despite these noteworthy studies, there is little understanding as to how new digital technologies are restructuring workplace boundaries within organizations.

Prior research on technological objects has focused on cross-boundary coordination of work between different occupational groups (Star and Greismer 1989; Carlile 2004). In these studies, boundary objects are used to deal with the differences in meanings, norms, and interests by allowing for common ground and forms of translation that facilitate shared understandings and transformation processes (Kellogg, Orlikowski, and Yates 2006). While the notion of boundary objects has provided important insights, the emphasis has largely been on their role in bridging and coordinating work across boundaries. Less research has examined the role of technological objects in boundary relations characterized by schisms or tensions, rather than by coordination and cooperation. Furthermore, the focus has been on the boundaries between relatively skilled workers, leaving unexplored the role of technological objects in the boundary work of relatively unskilled, "invisible" workers who are often forgotten as those merely performing what is seen to be "boring work" (Star and Strauss 1999; Star 2002).

Our field study of hospital pharmacy automation within two hospitals seeks to address these gaps in the literature by drawing on a practice-based approach to explore the question of

how new digital technologies are restructuring workplace boundaries. We are particularly interested in understanding these dynamics in the context of both skilled and unskilled work, and the implications of such restructuring for the boundary relations between different occupational groups. Thus we investigated the implications of the introduction and use of a dispensing robot for the enactment of workplace boundaries across three occupational groups co-located within hospital pharmacies: the pharmacists; the dispensing technicians; and the distribution assistants.

Our study highlights the way in which occupational members' use of technology restructured the spatial, temporal, role, and task elements that constitute their work boundaries. Furthermore, we found that use of the new technological object led to increased dependencies and tighter coupling between skilled technicians and unskilled assistants. In the process, technician work was privileged while the unskilled distribution work became both more visible (through increased monitoring) and more regimented (through the engagement of technological inscriptions). As discussed below, these shifts led to the emergence of three boundary relations across the occupational groups: boundary strain, boundary cooperation, and boundary neglect.

The next section reviews the literature on technological objects and boundaries, followed by a discussion of our methodology. Our study of new technology in two hospital pharmacy departments is then described and the main findings presented. We then discuss our findings on boundary restructuring in the light of recent insights on the ecology of visible and invisible work to examine the implications of shifting boundary relations for both skilled and unskilled workers.

Technological Objects and Boundaries

We examine the organizational literature on technological objects and boundaries in terms of two broad streams. First, we briefly discuss the well-developed literature on technology and the social organization of work, highlighting how boundaries are largely implicit in these

studies. We argue that theorizing explicitly about workplace boundaries can be valuable for our theorizing about technology in organizations. Second, we discuss recent research on boundaries including both the organizational studies literature on boundary objects and the sociological literature on symbolic and social boundaries. While boundary objects are useful in understanding knowledge sharing and coordination across occupational groups, this literature tends to treat the boundary as given and relatively fixed. The sociological studies of workplace boundaries tend to view boundaries as dynamic and enacted (Vallas 2001), and this is the approach that we follow in our study.

Technology and the Social Organization of Work

Barley's (1986) study of the introduction of CT scanners as new medical imaging devices in two radiology departments highlighted technology as an occasion for restructuring the social order of radiology departments, altering the established division of radiological work. Role reversals between radiologists and technologists were evident as were shifts in temporal orderings between these occupational groups. Barley argued that technologies should be viewed as social objects whose meanings are defined by the contexts of their use. Similarly, studies on technological change in health care organizations (Aydin and Rice 1992; Davidson and Chismar 1999) have examined the introduction of information systems as occasions for a variety of changes in tasks and roles, involving new patterns of interaction among different groups.

Barley (1990) further developed a role-based approach to understanding how the social dynamics occasioned by new technologies "reverberate up levels of analysis." In this view, technology's material properties are seen to have an impact on the non-relational elements of work roles, that is, on skills, tasks and activities. These changes in turn influence the relations among occupational groups, eventually affecting the structure of organizational social networks.

While the analytical focus is on roles, Barley's findings implicitly recognize the importance of workplace boundaries as these are influenced by the introduction of new technological objects.

In another study, Barley (1996) highlights the rise and emergence of technician work as a new ideal-typical occupation. With the proliferation of technology development and use in the post-bureaucratic firm, he argues that work is changing, specifically requiring more technical expertise. Barley postulates that with the rise of technicians in the workplace, hierarchy and bureaucracy may be less effective modes of organizing, as the authority of expertise may no longer coincide with authority of position. Subsequent work has further explored the changing nature of the contemporary workplace (e.g. Kalleberg 2001; Kellogg et al. 2006). For example, Novek (2002) has recognized the occupational consequences associated with the introduction of new drug distribution technology within a healthcare organization. Pharmacists perceived the introduction of new technology as an opportunity to facilitate re-professionalization. That is, digital technologies would allow the redefinition of the pharmacists' core tasks to performing clinical work as therapeutic advisers and guardians of drug safety, while delegating more routine dispensing tasks to technicians.

Another central theme concerning technology and the social organization of work is that as the number of skilled technicians grows, the number of unskilled jobs will decrease (Barley 1996). While this trend may be operating at the macro-level, we have less knowledge at the micro-level of the specific implications for unskilled occupational groups of boundary restructuring associated with new technologies. While automation may reduce the need for unskilled workers, they remain a relevant occupational group for the coordination and execution of work in organizations. We are thus interested in understanding the implications of new technologies for the work boundaries and boundary relations of both skilled and unskilled workers.

Technology and Boundaries in the Workplace

The literature on boundary objects has recognized the role of technological objects in coordinating knowledge transfer and communication across occupational communities (Star and Greismer 1989; Bechky 2003). Boundary objects are defined as "objects that are plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites" (Star 1989, p 393). Boundary objects, such as physical prototypes (Bechky 2003) and shared IT applications (Pawlowski and Robey 2005), seek to address difficulties in coordination and knowledge transfer across boundaries.

For example, problems of syntax can arise as a result of incompatible routines (Carlile 2004). Second, coordination challenges can arise as a result of occupational groups' differences in meanings and assumptions (Bechky 2003). Third, coordination and knowledge sharing can be difficult for political reasons (Carlile 2004). Occupational members invest in specific know-how and there is consequently a lot at stake for members when they engage in cross-boundary coordination. Given this range of problematic boundary conditions, effective boundary objects can help address them by establishing a shared syntax for representing differences and dependencies at the boundary. They may allow individuals to learn about each others' differences and dependencies, and may help to create a "common ground" (Bechky 2003) that facilitates the transforming of specialized knowledge into novel jointly produced knowledge that transcends each community's local interests.

While this literature provides useful insights on boundary objects bridging differences (Star 2002), its analysis does not extend to shared objects that do not function as bridges. For example, in our case, a new technological object was introduced which was not designated as a boundary object nor did it become a boundary object-in-use (Levina and Vaast 2005).

Nonetheless, the technological object had important implications for boundary dynamics between occupational communities. Furthermore, while the boundary object literature tends to assume that the boundaries between groups are given, and focuses on coordination across the boundaries, we are interested in how boundaries are enacted as interactions among occupational groups shift and how this enactment is bound up with the use of the new technological objects.

This view of boundaries as dynamic and enacted is emerging as an important recent theme in the sociological literature. For example, Abbott (1995) has argued for conceptualizing "things of boundaries" — a reversal of the ontological priority of organizations and boundaries. In other words, his relational theory of boundaries suggests that we should "start with boundaries and investigate how people create (social) entities by linking these boundaries into units" (1995,p.857). It is not that occupational groups first exist and then enter into relation with other entities; rather, privileged groups engage in boundary work (Lamont 1992) and boundary-defining acts of exclusion, thus constructing and maintaining distinctions between themselves and others.

Although this work has significantly enhanced our understanding of a dynamic view of boundaries, the focus of analyses has tended to be on inter-occupational competition and conflict at the level of the professional field or at the inter-organizational level (Abbott 1995; Hernes 2004). There is thus little work on the interactional processes by which inter-occupational contests occur within workplaces (for an exception, see Bechky 2003), and limited research on the role of symbolic boundaries in generating and sustaining workplace inequality (Vallas 2001).

Bechky (2003b) argues that the task boundary is specified through occupational interactions at the point at which the work takes place. Investigating such inter-occupational encounters has been a focus in ethnographic studies of the hospital workplace, where due to frequent cross-professional interaction and boundary work, informal practices have been shown

to alter and blur task boundaries (Chambliss 1997). In her study of an equipment manufacturing company, Bechky (2003) examined inter-occupational dynamics through an analysis of occupational members' use of organizational artefacts including technological objects. Amongst other findings, she demonstrates how authority over these objects by different occupational communities can reinforce or redistribute task boundaries. While Bechky's work is valuable in focusing on the use of established technological objects by different occupational groups, she does not examine how boundaries are restructured with the introduction of new technologies.

Vallas (2001) examines the restructuring associated with new technology in his study of symbolic boundaries in the workplace (see also Sherman 2005). He draws on Bourdieu's notion of symbolic boundaries, but leaves space for human agency in understanding how symbolic boundaries — for example, class distinctions or cultural signs — contribute to the articulation of social boundaries as salient divisions among social groups (see also Lamont and Molnar 2002). Vallas emphasizes the negotiated and contested character of symbolic boundaries in the workplace, and is interested in how each occupational group negotiates the symbolic representations that obtain within work organizations. His study is particularly insightful in shedding light on the enactment of inequality following the introduction of new technologies. We build on Vallas (2001) below, but also seek to go beyond his insights by more centrally theorizing the role of technological objects in boundary restructuring and boundary relations.

Research Site and Methods

Our inductive field study focused on developing theoretical insights from an in-depth examination of the reorganisation of pharmacy work during the introduction of new technology for stocking and dispensing drugs. Data were collected from two hospital pharmacies in the UK

that together were part of an acute care health organisation called Rainbow Trust.[1] We first discuss the details of the research site before describing our research methods.

Site

Rainbow Trust, located in a large cosmopolitan city in England, is composed of four hospitals, two of which are large tertiary care centres within the city. Each of these hospitals included a pharmacy unit[2] that served as the focus of our study. . We refer to these two units as "Brown" and "Yellow" pharmacies. Overnight pharmacy "on call" coverage was shared between the pharmacies of these two hospitals, so the staff pharmacists had some familiarity with both units. Between 300 and 350 prescriptions were dispensed daily by each pharmacy, and each had around 12 full-time equivalent workers, 7-8 working in dispensing and 4-5 in distribution.

Both pharmacies were responsible for *distributing* stock to hospital wards and clinics, and for *dispensing* medicines to specific patients based on doctors' prescription. The distribution staff consisted of unskilled pharmacy assistants[3] who were responsible for maintaining both pharmacy and ward stock levels. Medication tablets, fluids and other stock items were purchased regularly from the pharmacy "stores," delivered daily and put away into the pharmacy stock. From the pharmacy stock, items were delivered weekly to wards and clinics. Ward staff used the ward stock to fill the ongoing influx of prescriptions for ward patients. On occasions when the ward supply of a particular medication was depleted, ward nurses brought down green requisition sheets to the pharmacy's distribution staff. The requested items were then delivered to the respective wards by hospital porters. Any items needed by the ward that were not on the stock list would be ordered through the pharmacy dispensary and designated to a specific patient.

[1] Names of all institutions and individuals have been disguised.

[2] The units we studied were called "dispensaries" in the hospitals, as they are a subsection of the total pharmacy department, which includes such activities as aseptic preparations, ward rounds, stores and purchasing, research and education. We are only focused on the dispensing activities in this study.

The dispensary staff, comprising technicians[4] and pharmacists,[5] was responsible for issuing medications designated for specified patients as prescribed by doctors. The dispensing process involved four activities: *screening*, *labelling*, *dispensing* and *checking*. Only pharmacists were allowed to perform the screening task, while the final *check* could be done by either pharmacists or accredited technicians, though the latter were not allowed to check their own dispensing. The *labelling* (typing patient labels onto the medications) and *dispensing* (picking items from shelves) could be performed by either pharmacists or technicians, though this was most commonly done by technicians.

We studied these two pharmacy units because both planned to install a dispensing robot to assist in the work of the pharmacy. Within the Rainbow Trust, the business case for the robot focused on its assumed benefits of reduced dispensing errors and improved productivity. These benefits were seen to fit well with the UK government's modernization plan for health and improved patient safety. The Brown pharmacy installed the first two modules of their robot in Spring 2004, with funding restrictions requiring subsequent addition to be added in a phased approach. A storage intake belt was added in January 2005, and a third module in June 2005. Furthermore, a distribution interface system and medicine ejection chute was installed in Feb 2006. Yellow pharmacy purchased only one, large module[6] from a competitor company and installed this in October 2005. The robots, complete with dispensing chutes and interface system, resembled small walk-in closets lined with tightly fit shelves and a mechanical picking arm

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[3] Assistants were not expected to have any prior training before taking on their jobs.

[4] Technician training requires a minimum of two years in a practical college, though further qualifications are possible. Training focuses on attaining accuracy in managing and dispensing medicines. Technicians are members of a national body for licensed healthcare professionals in the UK — the Healthcare Professions Council or HPC. It is noteworthy that technicians' training was not specifically related to machines or systems training but to the techniques of accurately identifying medications.

[5] Pharmacists are required to complete at least four years of university education, and a subsequent practical training year before being licensed to practice independently.

which could place and remove items from shelves (see Figure 1 for photographs of the robot installed in the Brown pharmacy). Medicines, which are stored in their manufacturers' packaging, are moved in and out of the robot area via intricate systems of conveyor belts. Though the two robots relied on slightly different handling technologies, both had a storage capacity of around 10,000 items and both used barcodes to store and retrieve items from the robot shelves. Retrieved items were then transported via output chutes to the front of the pharmacy where the dispensing activity occurred. A schematic illustration of the Brown pharmacy is shown in Figure 2, showing the area layout before and after the robot was installed.

Insert Figures 1 and 2 about here

While many of the pharmacy practice issues at Yellow were similar to those at Brown, the implementation was quicker and went more smoothly. Yellow benefited from the advice and experience gained from Brown's implementation and by only implementing a single (albeit larger) robot module they were able to be up and running relatively quickly. At the same time as the robot was being installed, Yellow was also given permission from the hospital to complete long awaited general renovations to the department.

Methods

Our research study focused on the everyday organization and performance of hospital pharmacy work within the two locations. We collected the data through field visits, observations, informal discussions, formal interviews and documentary analysis at both pharmacy sites. The interview and meeting data were collected between July 2004 and June 2006, while the non-

[6] The large module had a storage capacity of 10 000 items, while the 3 modules at Browns had a combined capacity of 12 000 items.

participant observation took place between October 2005 and June 2006, which coincided with the robot implementation at Yellow Pharmacy. Our goal was to gain an understanding of what happened on the ground, why it happened, and how pharmacy workers perceived and responded to these changes.

In total, 30 formal interviews were conducted with pharmacists, technicians, assistants and relevant administrative workers and key vendor contacts. Formal interviews ranged from 20 minutes to 2 hours, depending on availability of the interviewed staff person, the majority lasting one hour. Interviews were conducted in private offices or meeting rooms and were tape-recorded. Key informants were interviewed several times over the period of study. During interviews, informants were asked to describe their everyday work routines, and to comment on their perceptions and experiences of the robot and the subsequent changes they had observed in pharmacy work routines. The discussion focused on how and why work (and its social organization) was different since the robot's introduction. Assistants were noticeably less comfortable with interviews, especially when on tape. However they were very responsive and articulate during informal discussions in situ during the field visits. Field visits were made to both locations over a period of 18 days staggered between October 2005 and June 2006.

We also attended five project planning meetings held by senior workers to discuss implementation issues at Yellow pharmacy. Documents generated by the pharmacy staff were collected, including quantitative comparative studies of "before and after" dispensing errors and dispensary efficiency. Physical bulletin boards regarding staff news were regularly scanned. Technicians, in particular, used this space a lot to communicate news from their licensing body.

Data was analyzed inductively so as to generate insights into changes that were occurring in the Yellow and Brown workplaces. Our unit of analysis was practice, defined by Schatzki and

colleagues (Schatzki et al. 2001) as recurrent, materially mediated and situated social activities engaged in by workers. Data analysis proceeded in an iterative fashion. The collected data were carefully read and then coded into key themes. While the initial focus of the research was not specifically on work boundaries, the ongoing boundary issues became a prominent theme early in the study. We also drew on our reading of the literature on boundaries in organizations and technology and the social organization of work, integrating key insights from prior work with themes grounded in our field data to develop an understanding of new technological objects and the (re)structuring of boundaries in the workplace. In our iterative analysis we sought rich descriptions of events, meanings and actions, and we employed a number of techniques for representing qualitative data (Eisenhardt 1989; Langley 1999).

Boundary Restructuring in the Pharmacy Workplace

Our focus in this paper is on shifts in boundary relations among occupational groups following the implementation of a new technological object in their workplace. Specifically, we were interested in how the use of a new dispensing robot restructured boundaries in the two hospital pharmacies we studied. As summarized in Table 1 and detailed below, we found that the boundaries among the different workers in the pharmacy — pharmacists, technicians, and assistants —were restructured along at least four dimensions: spatial, temporal, task, and role.

Insert Table 1 about here

Spatial Restructuring of Work Boundaries

Pharmacy work has a clear division between the front stage — dispensing — and the back stage — distribution (Goffman 1959). Technicians and pharmacists, who do the dispensing work, occupy the front stage, while assistants, who handle distribution, occupy the backstage.

The introduction of the robot has reinforced the front stage-back stage boundary that separates pharmacists and technicians from distribution assistants.

Technician work involves labelling, dispensing, and (increasingly) checking activities. With the introduction of the robot, technicians spend more time sitting in the front end of the pharmacy waiting to be served by the robot, instead of constantly walking to the back and physically fetching the products from the open shelves (as they used to do). Technicians now enjoy a pleasant, neatly organized, well-lit, hi-tech, and modern-looking physical environment that symbolizes a shift away from the traditional view of dispensaries as dingy spaces in the basement of hospitals. More importantly perhaps, and in playing to the political tune of patient safety, the robot and its associated spatial reorganization of workflow meant increased bench space in the front end of the pharmacy, which was expected to reduce dispensary errors.

> *An increase in workspace means that we practice more safely, [and] we have definitely increased our bench space for working, because we've gotten rid of our shelves that were there before.* [Pharmacy Manager]

Since the pharmacists work alongside the technicians in the dispensing area, their work environment is now similarly improved, becoming more spacious and tidy. The presence of the robot has also enabled them to decrease their presence in the pharmacy unit, freeing them up for other more clinically related tasks, such as examining patient medication charts on the wards or engaging in patient counselling.

The work of the distribution assistants involves stocking both the shelves and the robot. The input of items into the robot, which is positioned towards the back of the pharmacy unit, reinforces the back-end nature of their work. The location of the robot in this space, and the requirement to input items to it by placing them physically on the feeder belt had the effect of tying the assistant worker spatially to this geographical area. In contrast to the front end, the

assistants' workspace has become more cluttered since the introduction of the robot, with loaded trolleys often taking all day to be unloaded and with back shelves becoming more untidy.

> *The shelves at [the distribution] end are very cluttered, very crowded.* [Pharmacy Manager]

Some of the assistants perceived these spatial boundaries as symbolizing and reinforcing existing social boundaries (Lamont and Molnar 2002), where they are "second class citizens" and located even further back in the pharmacy unit. The majority of the assistants are considered to be unskilled workers, older, and job- rather than career-focused. Some of the assistants are also temporary workers. In contrast, the technician job is increasingly seen as career-oriented and is staffed with younger permanent staff who have increasing levels of vocational training.

Temporal Restructuring of Work Boundaries

A key rationale for implementing the robot infrastructure was to improve the productivity of the dispensing activity, which has been increasingly driven and legitimized by government targets. Using the robot, with its delivery of items directly to the front end via output chutes, technicians and pharmacists have less walking to do between the dispensing benches and the shelves at the back. These workers perceived an improvement in their efficiency as it now took less time to fill prescriptions. The pharmacy was also perceived to be less frenetic.

> *[Now with the robot] we don't have to go and traipse round the shelves. Most everything that you need is already there in the tray.* [Technician]

> *There is less walking and sometimes it seems less busy, less bustling around.* [Technician]

The faster pace of dispensing and the change in the tempo of work was seen as technicians were able to handle increased workloads.

> *The new renal unit has made a lot more work and we are okay. Otherwise, without the robot, I think we would be drowning with all the extra work.* [Technician]

By working with the robot to retrieve items, technicians were able to get a head-start on subsequent activities, and in so doing blended labelling and dispensing activities, as a technician at Brown commented:

> *You may be faster than the robot in dispensing and you can look ahead to the printed labels, before the robot has delivered anything. That way you can get started and you can gain sometimes if the robot is cooperative.* [Technician]

The technician also explained that she can begin applying the labels of previous orders that had already been delivered while sitting at the terminal waiting for the current items, even though this is actually part of the next step, dispensing, and is normally done at the dispensing bench.

Initially, pharmacists working within the pharmacy were spending more of their time on the tasks that technicians were not certified to perform, such as screening and checking technicians' dispensing. These tasks were minimally influenced by the introduction of the robot. Bottlenecks, however, tended to occur at the checking point, particularly when the few pharmacists in attendance were called away to a nursing station, or were required to call a doctor regarding an ambiguous prescription.

Distribution assistants, while initially curious about the new technology, gradually became disillusioned with its operations. What had been a relatively quick and straightforward job of stocking shelves had now become a slow and monotonous process, extending over the day and involving dual stocking of the robot as well as the open shelves. What had been a relatively self-paced job had now become more regimented by the robot's inputting procedure and the need to negotiate with the front-end dispensing activities.

> *[The robot] takes too long to load. They [nods towards front of dispensary] are the most important ones, and then us [in distribution], I suppose. And then it is loading. So it is about prioritizing.* [Assistant]

Prior to setting limits to the volume and size of stock going into the robot, frustration was evident amongst both assistants and technicians. Scanning large numbers of single boxes into

the robot was less efficient than merely stocking a bundle of cellophane-wrapped boxes onto a shelf, especially if they were to be simply retrieved as a bundle shortly thereafter. Once the items had been broken down into single boxes, only to be retrieved in large volumes, the retrieval process would occupy the robot for many minutes. This started to frustrate technicians as it tied up their much smaller, more urgent orders, which were being monitored to satisfy government waiting times for dispensing.

> *We have a very big eye clinic here and yesterday, for example, one of the girls in distribution was topping up the eye clinic and needed 40 of an eye ointment. So she ordered 40 at once. … The dispensary in the meantime have ordered lots of one-off boxes for patients and they had to wait… I don't want the robot wasting 5 minutes picking those 40.* [Technician]

Apart from the introduction of new rules and standard operating procedures for stocking the robot, the system administrators in the pharmacy entered a number of priority rules into the robot's program. These privileged dispensing and limited the number of products of a particular type/brand that assistants could retrieve from the robot at any time. This change in technology operations inscribed new timings and priorities into the robot, and did not go unnoticed by the distribution assistants:

> *When [the robot] gets busy, we have to wait… I can see how it benefits the dispensary. [pause] But you know how it is just easier to pick up a bunch of boxes from the shelves [points to shelf right beside her], rather than go and wait for the robot to do it. But I can see how it is better if you are just picking one box at a time… It prioritizes their work, I think. So it can take ages sometimes to get the [distribution] order out.* [Assistant]

The pharmacy manager responsible for the pharmacy sought further temporal restructurings to reduce inefficient wait periods at the front end. This led to a rescheduling of the work of the distribution assistants. Assistants' work times at Yellow were reset to an earlier start time, thus allowing more time to input stock into the robot before the regular start of the other workers. Additionally, the manager of Brown requested that orders from pharmacy stores arrive

on stocking trolleys earlier in the day so that these could be handled out of the regular work hours of the dispensing activity.

> *We did discuss with [the distribution manager] times of the day [they] were doing things, so that it had the least impact on the dispensary, [like] what times of the day they put through their lists and things like that so it had least impact on the other sections. [Pharmacy Manager]*

Task Restructuring of Work Boundaries

The technicians perceived the robot to improve some of their mundane tasks, which had included "a lot of wandering round the shelves looking for drugs." They now found it rather satisfying to have drugs served directly to them by the robot, neatly delivered in a basket, and with corresponding labels that needed to be attached. This change was also noted by pharmacists, although they now focused their time on more skilled tasks of screening and checking.

While the pharmacists at both sites were initially involved in programming, organising and implementing the robot, as time went on, the daily and routine operations of the robot were left to the technicians. The original system had been designed by the main systems administrator (who was also a pharmacist) in close discussion with the senior pharmacists. The robot thus inscribed the assumptions, preferences, and priorities as understood by pharmacists. In this sense then, the pharmacists were still able to control the workflow of the pharmacy, albeit from a distance and through the mediating work of the robot and the technicians who tended to it.

The robot thus expanded technicians' tasks, which now included activities around keeping it running (e.g., fixing routine breakdowns), and doing ongoing maintenance (e.g., installing upgrades etc.). These new tasks required significant technical expertise and training.

> *Our work is more technical now…we have to do more tasks that involve checking the systems and doing housekeeping on the robot… [For example] we have to clear [the errors] every morning*. [Technician]

Technicians thus needed to work closely with the technology vendors in order to act effectively as the first line of support in correcting any problems that assistants or others had in operating the robot on a day-to-day basis. For more difficult problems, technicians communicated virtually with the vendors as they worked remotely to fix the problems with the robot. Where these efforts failed, vendor representatives would come to the pharmacy to work on the robot directly. The day-to-day operating and maintenance tasks on the robot were made the responsibility of the chief technicians, who demonstrated significant ownership of the robot as their 'baby."

> *[The chief technician] has actually done most of [the vendor liaison] because she's had a relationship with them from day one, so I've actually left her to speak to them about problems. Only when she hasn't been here, have I had to call them.* [Pharmacist]

The technology vendors' advice that the robot be managed and maintained by one person further reinforced the dependence of others on the chief technician. Whether it was assistants stocking the robot or the pharmacy manager worrying about the functioning of the pharmacy as a whole or even the other technicians, the increased reliance on one technician became a concern:

> *[The chief technician] knows everything about the robot so, I mean it's difficult to replace her… If she were to leave we'd be stuck. The pharmacists are dependent on the technicians doing the things that [technicians] can do… Five years ago, we would have all been there muddling in together.* [Pharmacy Manager]

The chief technician's reputation for contextual knowledge and skills of operating and implementing the robot infrastructure extended beyond the hospital:

> *[The chief technician has] had a lot of visits from other hospitals who actually want to see the technology and see how it works.* [Pharmacist]

An unintended consequence of the introduction of the robot for technicians' (and Pharmacy Managers') tasks was the increased supervision and surveillance of assistants that developed in this increasingly tightly coupled work environment. Somewhat ironically, the

trigger for this change in practice was the need to identify and mitigate new errors that were being introduced by the robot whose very function it was to decrease dispensing errors. In an effort to resolve these new errors, technicians carried out surveillance of assistants who were inputting robot stock, a shift in tasks that led to significantly closer supervision of the assistants' work than previously.

> *[The assistants] had problems filling [the robot] accurately. So the technicians and ourselves would stand and watch them. You would think it would be easy, but actually it wasn't. When you were doing it repetitively and there were things that we hadn't realised were inbuilt to the system… that made it harder. We couldn't understand why they were having problems filling [the robot], but when you started looking at it, it wasn't surprising, wasn't surprising.* [Pharmacy Manager]

Prior to the introduction of the robot, the assistants' tasks were clearly defined and were performed relatively autonomously. First thing in the morning, the distribution assistants would go to the wards and decide what medications the wards needed for the week. They would return to the pharmacy with their requisitions and put them through the stock control system. They would then "walk the shelves and have completed their ward orders in boxes all done by one o'clock." The pharmacy manager highlighted the relative autonomy that assistants had enjoyed:

> *[Before] the assistants job wasn't so dependent on being checked… Their work has been more of a one-man band… [Now] they've got to work together more.* [Pharmacy Manager]

> *The assistants are needing to communicate with each other more. Before they could just do their own thing, independent of each other. But now they can't just all put their stock through at once [or they will be queuing and waiting]. So they need to work together more… Before, absolutely no communication was needed; people just got on with their jobs.* [Technician]

The introduction of the robot as a shared technological object led to tighter coupling and increased dependence of tasks amongst assistants and technicians, as well as the increased surveillance noted above. The assistants' task of stocking, once a relatively quick and painless endeavour, was now more complicated, tedious and painstaking. The slower inputting process,

which was interrupted by dispensing use, machine breakdowns and jams, was far removed from the more straightforward stocking of open shelves in their own time. While some of the problems and frustrations of this process were gradually being alleviated over time, the pharmacy manager reflected that this relief was late in coming, especially as compared to the benefits received by technicians.

> *The distribution staff… had a lot of pain before they got their gain… The dispensary had the pain and the gain almost simultaneously… So it was a much more neutral process [for pharmacists and technicians,] whereas the distribution workers had a backslope… [they] were double keying… and we just hadn't appreciated all that.* [Pharmacy Manager]

The introduction of the robot symbolized a new dimension to the boundary between the front and back ends of the pharmacy, and consequently between pharmacists and technicians, on the one hand, and assistants, on the other. While the distribution assistants had always been responsible for stocking the shelves from which they, as well as the dispensary staff, filled their orders and prescriptions, the robot now symbolized and accentuated the "serving" relationship of the back end to the front end. As there were significant costs and few benefits for assistants in stocking the robot, assistants perceived the task of stocking the robot to be primarily for the benefit of dispensing, and with little value for their own work. The robot came to symbolize pain for the distribution assistants, and gain for the dispensing technicians.

> *[It took a long time] to get that distribution chute functioning. We were happy to let it ride because it didn't affect me and it didn't affect what they were doing at the front of the dispensary. It did affect the distribution staff and I don't think we actually quite realized that [it] had.* [Pharmacy Manager]

The tight work coupling that followed the introduction of the robot made assistants more dependent on technicians for carrying out their work. We observed these forms of dependence, which played out in practice in different ways. For example, the following excerpt from our field notes highlights the reliance on passwords to access the order system to place orders for the

emergency department. The assistant who normally places this order was away sick, and someone else needed to do the job. The technician who typically supervised this work, and who only wanted one assistant to have the password, was also absent. The pharmacy manager was left to sort out the late order delivery, as the emergency department had called to query the delay.

> *The assistant explains to the pharmacy manage] that she does not have the password to place the order, as it is different from the other wards she normally works on. She mutters to the fieldworker, "And annoying because I feel like a second class citizen … It is not necessary you know." The pharmacy manager comes back shortly thereafter, giving the assistant a password, and getting her to place the order. "I feel honoured now." she says with a smile. [The supervising technician had not acquiesced to her earlier frequent requests for this password.]*
>
> *Another assistant says to her colleague, with a mock bowing motion, "Now we will all be coming to you. [pause] It really isn't necessary to have some having a password and not another. It only causes division. That is what it is for – to separate … It's not like we're not capable.* [Field notes]

Assistants also perceived a loss of autonomy and discretion in their work, as they now had to wait for technicians to fix even the simplest of jams on the robots during the inputting process. This dependence symbolized the front-back end boundary in new ways. It served to surface and make visible the deeply-rooted distinctions between assistants and technicians, highlighting the unskilled nature of distribution work, a point that we will return to later. The following excerpt from our field notes highlights these different perceptions:

> *The assistant who is entering items into the robot comments "Oh the bloody thing. It has gotten stuck." She walks off toward the dispensary in the front end. Soon a technician slowly walks to the back. She opens the robot door and walks in, goes to the picking head, and seems to just move a box slightly, coming out a few seconds later. She offers a clarification to the assistant about resetting the robot after the alarm has gone… She explains, "The box was out of position and the robot couldn't find it." With that, she returns to the front end.*
>
> *The assistant says, "Sod 'em. They don't want to show me. That took five seconds [to fix], and I have to run up there [to the dispensary end to fetch someone] each time."*
>
> *Another assistant comments, "You of all people should know [how to fix these basic problems]. You're here all by yourself early in the morning. What will you do if it breaks down? Or gets stuck?"*

> *The first assistant replies, "Why bother. Why should I care if they don't want to show me. I'll just sit down and have a cup of tea. I don't mind. [laughs] They will tell me quick when they see me having a cup of tea in the morning ... I have tried to mention it a few times. But if you haven't been to college or uni[versity], they don't want to show you. It is like we are not good enough." The assistant goes on to explain that she has had to call on a technician five times so far today to deal with the alarm bell.* [Field notes, around noon]

The frustrated assistant feels dependent and belittled by not being able to fix simple technical glitches that arise during robot use. Each time an error message is flashed on her inputting screen, the robot picking arm ceases to function, the error needs to fixed and the robot reset. She is unable to complete her inputting task, and she is equally unable to retrieve an order from the robot. Being physically located by the robot at the back and watching the picking arm freeze as it attempts to input the stock, she is immediately aware of the problem, while the technicians who are working at the front end cannot see what has happened. She has to go forward to tell them about the problem, and request their assistance. She attributes her situation to her lower status in the pharmacy and her lesser educational qualifications.

Role Restructuring and Workplace Boundaries

Technicians enjoyed an expanded role in their work. Their traditional roles focused on dispensing and checking medicines during the filling of patient prescriptions. With their newly acquired robot maintenance tasks and vendor interactions described above, technicians gradually established caretaking and brokering roles in their increasingly technical work. Their jobs were reclassified to recognize this shift in responsibilities:

> *[In redoing job classifications] there are definitely bits of the robot that had to be taken into account when assessing [the technician's] job.* [Pharmacy Manager]

As Barley (1996) had observed in his sites, technicians in the pharmacy took on the responsibility for taking care of the machines that they oversee. In their broker role, technicians bridge two communities. In this case, they bridge the robot vendor and the other pharmacy

workers (assistants and pharmacists) whose work depends on the robots. Contrary to Barley's brokers, who were responsible for educating users about the system, the brokers in this case did little in this regard. Rather, they acted as expert troubleshooters to remedy problems and to safeguard the equipment. In a sense, they have a wider caretaker function in addition to the more technical one, representing vendors' interests to the user community.

Technicians also developed contextual knowledge and skills through the everyday practice of their work upon which others became very dependent. It is in this sense that technicians became a critical node in the functioning of the pharmacy despite their lower skill levels as compared to pharmacists. With the introduction of the robot in Brown, more prescriptions were now double checked by both technicians and pharmacists. Previously, it was not uncommon for pharmacists to do single checking — to dispense the medication and then check their own work — as opposed to having these tasks done separately by different individuals as part of a double checking process.

> *We [the Brown pharmacy] have inherited the [single checking system]. We have always been single checking since I came here. But we've reduced our number of pharmacists so our technicians on the whole do the piece of work and then it gets checked [by someone else]. So [now] a lot of our work by nature of the fact that it is dispensed by a technician and checked by a pharmacist, is double checked.* [Brown Pharmacy Manager]

In this latter practice, the level of buffering between technicians and pharmacists was noticeably increased. In his study of technicians, Barley (1996) introduced the concept of buffering in referring to how their expanded role served to reduce the contact other occupations had with the "empirical phenomena" over which they are reputed to have mastery (in this case, drug dispensing). Not only do they stand between the pharmacist and the empirical phenomena that grounds the pharmacists' work, they share the pharmacy practice of dispensing and checking. By taking on more of the dispensing tasks, technicians provide pharmacists with an

opportunity to shift the focal point of their empirical phenomena away from the dispensing activity towards more clinical and counselling activities. This altering of the skill mix in the dispensary associated with the new technological object thus influenced the level of buffering between technicians and pharmacists at their role boundaries.

> *We've altered our skill mix in the dispensary. We decreased the number of pharmacists out there and we have filled our [previously vacant] technical staff. … We got [the robot] to free up [pharmacy] staff to take them out to the wards. It was to free up staff to facilitate discharge and you know counsel patients and all the rest of it.* [Pharmacist]

Boundary Relations and Work (In)Visibility

Our analysis of how use of the robot led to shifts in the temporal, spatial, task and role elements of workplace boundaries also highlighted issues associated with the visibility and invisibility of work. These issues have important consequences for the redefinition of relations among the occupational groups.

Drawing on Goffman's (1959) term of a "non-person," Star and Strauss (1999) distinguish between the visibility of an employee and that of their work. Under some conditions, the product of a person's work can be visible even though the person may be largely invisible. They suggest, for example in the case of domestic work of cleaners and servants, that employers with significant power and status differences over employees may define what is legitimate work, with the employee largely invisible in the process. Under other conditions, workers may be visible yet their work is invisible or "relegated to the background of expectation." In such cases, technology can play a role in disembedding what has previously been deeply embedded. For example, nurses may be able to contribute to the development and use of medical records to construct an arena of voice to make their work more visible (Bowker et al 1996).

In our case, the assistants are seen as a group of “non-persons” whose work is largely invisible. Though their work is necessary in distributing medicines to the wards and in supporting dispensing work through the initial stocking of medicines, it is not perceived to be as legitimate as the “real work” of the pharmacy — dispensing. They have little voice, often symbolized by face-time with patients (a well-established proxy of value in hospital work). Despite their low status and low visibility, assistants nonetheless enjoyed significant autonomy before the introduction of the robot, completing their work at their own pace and schedule.

In contrast, technicians have been increasingly visible in dispensary work in recent years, both before the robot introduction and subsequently. They have been successful in constructing an arena of voice to make their work visible. The status of their work has become increasingly important as they take on responsibility for the technology, becoming its caretakers and brokers. These developments have increased the technical content of their role, leading to a higher job classification and increased standing for their occupation within medical work.

As explained earlier, technicians have also played a role in buffering the work of the pharmacists, thus freeing them up to pursue what they see as more highly valued work — patient counselling. The technology has also afforded an occasion for pharmacists to expand their role as project managers of exciting high-tech work. For many, this is a welcome stimulus to what is often seen as boring dispensing work. As experts in this area, they have worked alongside technicians to inscribe rules into the robot technology as a way of facilitating their capacity to manage dispensary work at a distance.

Work visibility has led to concomitant changes in the operation of the pharmacy. For example, the legitimacy and increased visibility of dispensing work relative to the more invisible distribution work has been reflected in the rescheduling of distribution activities in deference to

dispensing activities, so as to meet government-imposed targets for how much time patients can wait for their prescriptions to be filled. These changes in work visibility have also reinforced the low status and power relations which are bound up in and symbolized by the direct serving of technicians and pharmacists in the front end by the assistants situated in the back end .

These shifts in the (in)visibility of work and workers resulting from the restructuring of boundaries had important implications for boundary relations within the pharmacy. We identified three distinctive boundary relations that emerged among the different occupational groups as a result of their use of the robot in the pharmacy (see Figure 3). Specifically, we identified *boundary strain* between technicians and assistants, *boundary cooperation* between pharmacists and technicians, and *boundary neglect* between pharmacists and assistants.

Insert Figure 3 about here

Boundary Strain

As Figure 3 highlights, the expanded role of the technician as caretaker and broker of the robot technology shifted the location of their work boundary with assistants. The resulting expansion of the technicians' jurisdiction simultaneously reduced the assistants' jurisdiction. The consequence was tension between these two groups, a tension we label "boundary strain."

The assistants experienced this loss of jurisdiction as a concomitant loss of autonomy. They were no longer able to work in parallel in producing their orders, but could only draw on the robot in sequence. Their relationship to each other and to the technicians became more coupled, as their work also became more tied to the technology. Their interaction with the robot also caused fragmentation and delays in their work, requiring new levels of multi-tasking. Their interaction with the robot was largely characterized by frustration; they were seldom able to relate to the technology with confidence or control. In contrast, technicians were knowledgeable

and able to interact with the technology in those terms. They had the requisite skills and access controls to directly intervene in the robot's operations, both at its initial programming (along with the pharmacists) and its subsequent ongoing maintenance.

The robot mediated these altered dependencies and closer couplings between technicians and assistants. For example, as users of the technology, the assistants became dependent on the technicians' ability to fix the robot "when it got stuck." Thus the assistants were frequently unable to get their work done without the intervention of the technicians. They had become dependent on both the robot and the technicians to accomplish their work. These changes in assistants' work practice following the introduction of the robot brought a new level of visibility to their work, but this was both unwanted and disadvantageous as it resulted from inadvertent "inputting errors." In addition to the errors, the robot also served to make visible and heighten perceptions that the assistants were "inept": their work areas cluttered with trolleys displaying inefficiency in the inputting of items; their inability to fix the simplest of jams in the robot; and the various unexplainable errors from what many others saw as an "infallible technology." Furthermore, the subsequent surveillance by technicians to identify these inefficiencies and errors reinforced the assistants' negative visibility and status as "non-persons" with limited skills and thus requiring heightened levels of supervision and control in their day-to-day work.

In contrast to Vallas' (2001) sociological analysis of boundary work between process engineers and skilled production workers, the interlinking and shifting of workplace jurisdictions between technicians and unskilled assistants in our case was not a planned strategy of class differentiation on the part of technicians seeking to claim jurisdiction from the assistants. Rather, it evolved as an emergent consequence of the operation of the robot, the assignment of responsibilities for interacting with it, and the resultant visibility of the assistants' work. These

shifts of roles and changes in jurisdictions produced considerable strain at the boundary between technicians and assistants. This was expressed as passive resistance by assistants who quietly voiced their feelings of frustration and anxiety to one to another (and the fieldworker). The technology as a shared object along this boundary symbolically sharpened the boundaries between themselves and technicians, a process exacerbated by the perception that educational skills were becoming ever more important in the technological workplace.

Boundary Cooperation

Figure 3 shows that technicians also gained jurisdiction from the pharmacists in taking on more of the dispensing work. This added jurisdiction provided a buffer for the pharmacists, allowing them to concentrate their time and energies on other activities. In contrast to the relations with assistants, this expanded jurisdiction on the part of the technicians was not experienced as a zero sum game where the technicians' gain was the pharmacists' loss. On the contrary, expanded technician jurisdiction was cooperatively negotiated between technicians and pharmacists, with the pharmacists embracing the shift as it held positive implications for their aspirations to spend more time on the wards and with patients, allowing them to engage in more counselling. This was a more valued aspect of their work than the dispensing activity that many pharmacists saw as somewhat boring and clerical. As a consequence, the new boundary relations that emerged between pharmacists and technicians were both supportive and mutually beneficial. We label this type of boundary relation "boundary cooperation."

Prior to the introduction of the robot, technicians' technical expertise had primarily related to their ability to work with medicines, that is, to recognize types of drugs or to mix compounds. With the robot in place, technicians increased their skills and knowledge in managing the robot technology. While pharmacists were also knowledgeable regarding robot

maintenance and support, they remained relatively invisible in dealing with these tasks, becoming involved only if system reprogramming was required. At Brown for example, where the technician-to-pharmacist ratio increased (as a result of one pharmacist leaving and not being replaced), pharmacists became less visible within the pharmacy, both through their reduced numbers and because they had been freed up to engage in patient-related medical work elsewhere. Pharmacists were not threatened by the encroachment of the technicians into what was once their central jurisdiction, even though this included new levels of dependence on technicians in using robot technology to run the pharmacy. Of more importance to pharmacists was their perception that these changes were compatible with their ongoing professionalization efforts. Indeed, this increased the visibility of their work in patient counselling and clinical guidance, and further allowed them time for patient advocacy.

Pharmacists also engaged in other activities that affected their work visibility and reflected the boundary cooperation they enacted with the technicians. For example, the Rainbow Trust they all worked for promoted research on dispensing errors and patient safety. By participating in this research activity, pharmacists reinforced the visibility and importance of dispensing work by focusing on the measurement of error rates and productivity around the dispensing process. This further strengthened pharmacists' jurisdiction beyond the pharmacy to other parts of the hospital and the Trust more generally. As shown in Figure 3, this shifted the location of the boundary of work for pharmacists, extending their jurisdiction beyond the confines of their local unit.

Boundary Neglect

As Figure 3 depicts, a third boundary relation associated with the introduction of the robot was that between pharmacists and assistants. Prior to the introduction of the robot,

assistants as “non-persons” were largely invisible. Nevertheless, assistants enjoyed a fair amount of autonomy and some discretion in their day-to-day work practices. This changed, however, when use of the robot made their work became more visible and required negotiation through the technology as a shared resource. Their previously taken-for-granted articulation work (Star and Strauss 1999) in the pharmacy, stocking medicines, was now made visible as a result of robot breakdowns and delays, resulting in surveillance and supervision of their work.

Interestingly, pharmacists and particularly the pharmacy managers expressed surprise when assistants made their voices of frustration heard through anonymous survey responses and research feedback. This surprise highlighted how the distribution assistants had been largely forgotten in the planning and consideration of robot operations. As one pharmacy manager remarked, she “could not believe that they [the assistants] were there suffering in silence.” She expressed concern and some guilt that this could be misconstrued as management “not caring.” The technical infrastructure of the robot as a shared object had had a single narrative that did not problematize the diversity of the work in the pharmacy, overlooking the work of assistants who were largely unnoticed and thus not formally recognized in the preoccupation with the dispensing activity on pharmacy’s front stage.

The pharmacy managers’ subsequent reflections of what we have labelled “boundary neglect” led to their late recognition that their boundary relations with the assistants required attention. They realized how their actions had inadvertently created delays in assistants’ work and consequent feelings of frustration and even alienation. The managers were concerned that their oversight had created what Star (2002) refers to as “layers of silence” and quiet pain amongst the assistants. The pharmacists also came to realize that their inscriptions of the robot’s

operations had limited the assistants' autonomy by reinforcing and privileging the robot as predominantly a *dispensing* technology.

> *In our enthusiasm we perhaps forgot about some of the other staff, and just assumed that the assistants would accept it, adapt to it, and know why we were doing things… we forgot about them.*

While we have discussed the three boundary relations of strain, cooperation, and neglect separately for analytical purposes, they should be understood to be interdependent and as recursively influence each other. For example, boundary neglect between pharmacists and assistants influences and amplifies boundary strain between technicians and assistants. Unintentioned as it may have been, the pharmacists' focus and privileging of the robot as a dispensing technology not only enacted an expanded role and jurisdiction for the technicians but also legitimated their subsequent encroachment into the assistants' area of jurisdiction, thus producing boundary strain. The growing realization of this inequity contributed to a passive anger among the assistants. Initially, they were "suffering in silence" but as they became increasingly vocal (particularly when given an anonymous forum to express their frustration), both pharmacists and technicians sought to remedy the boundary strain between the occupational groups.

Conclusion

Earlier research has shown how artefacts can serve as shared objects to mediate the relationships between occupational groups, with implications for how occupational jurisdictions are enacted within organizations (Bechky 2003). Other research (Vallas 2001) has also accounted for boundary change in the context of new technologies, examining symbolic boundaries in the study of workplace inequality. This paper builds on this previous stream of research to contribute to boundary research in organizations in a number of distinctive ways.

First, while boundaries have emerged in recent years as an important area of research in organizational theory, there has been relatively little work studying boundary change involving new technology in the workplace. Our study therefore draws on boundary theory (Vallas 2001; Tilly 2004; Lamont and Molnar 2002) and the notion of boundaries as dynamic and relational (Abbott 1995) to analyze how the introduction and use of a new technology restructured workplace boundaries along spatial, temporal, task, and role dimensions. Furthermore, we built on this analysis to identify and conceptualize three distinctive boundary relations that emerged among the different occupational groups in the pharmacy as a result of their use of the robot — boundary strain, boundary cooperation, and boundary neglect.

Second, our findings also highlight the importance of looking at work visibility in understanding the inter-occupational dynamics among occupational groups within the workplace. The implications of the robot for the (in)visibility of technicians and assistants and their work were significant. Technicians' work was made more visible with new technical tasks and an expanded set of roles and responsibilities. In contrast, the increased visibility of assistants' work was not a positive development. While they retained their status of "non-persons," the new visibility of their work led to increased surveillance and reduced autonomy. These shifts in work (in)visibility associated with the use of the new technology further influence the boundary relations we identified: strain, cooperation and neglect.

Third, our work differs from other research that tends to focus on the dyadic contestation and negotiation between occupational groups (e.g., engineers and production workers) in the workplace (Vallas 2001). Our study suggests the importance of looking not only vertically and laterally at occupational boundaries, but also of examining the multiple boundaries in the ecology of interactions across different occupational groups in the workplace. Furthermore, our

findings suggest both advantages and disadvantages may be associated with boundary restructurings following the use of new technology. While Vallas (2001) only focuses on worker inequality, we also found some positive consequences for workers. For example, technicians were able to expand their jurisdictions in multiple ways while also developing technical knowledge and special access to the technology. Pharmacists as the privileged group perceived the introduction of the technology as allowing them to potentially expand their role by freeing them up from dispensing and enabled to focus on ward based clinical skills.

In sum, our study adopted a boundary approach to begin to understand how the use of new technological objects restructured workplace boundaries. We further identified the ways in which such shifts increased both the visibility and invisibility of work among the different occupational groups, generating specific boundary relations that had both positive and negative consequences for the workers. Our findings are limited to the extent that we only examined one technological object — a specific robot to dispense medications in pharmacies — in a particular organizational context — hospital pharmacies in the UK. While we believe these findings are interesting and generative, considerable future research is needed to elaborate them, and to examine them in other contexts and with other technologies.

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Table 1: Implications of robot for the restructuring of workplace boundaries in pharmacy

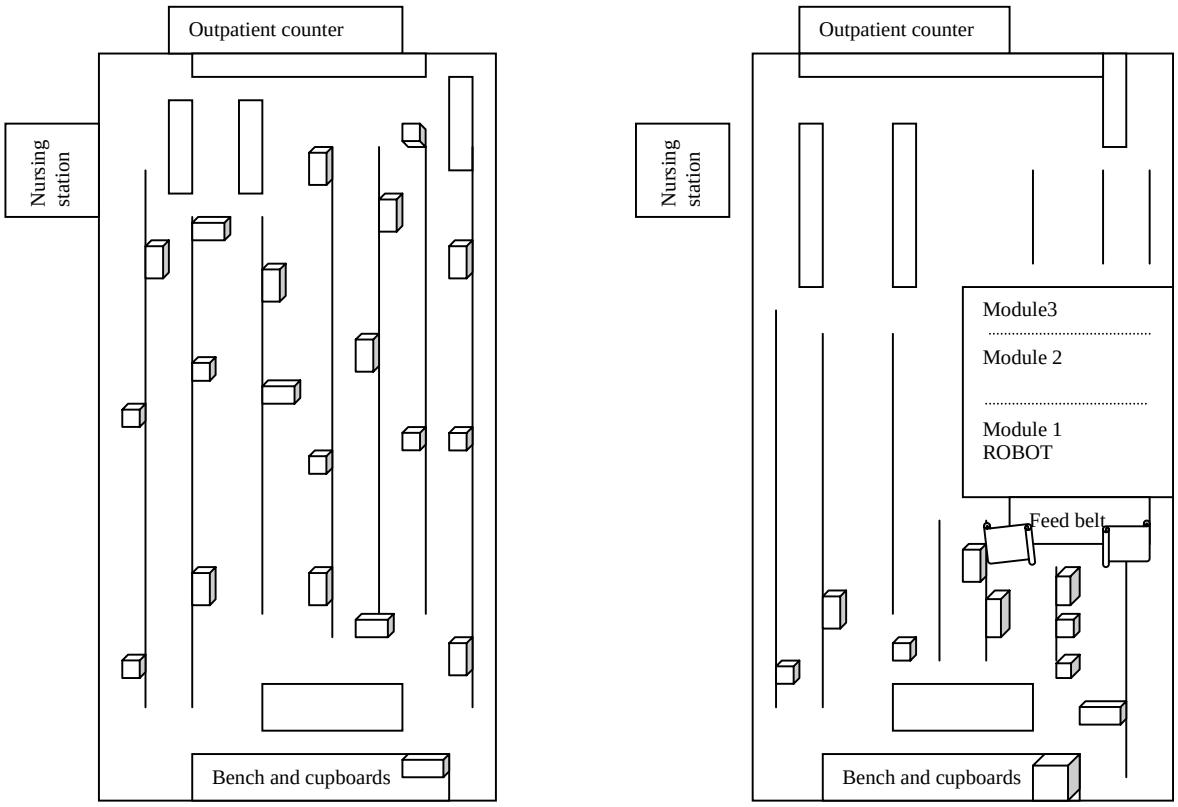
	Spatial Restructuring	Temporal Restructuring	Task Restructuring	Role Restructuring
Pharmacist	More space, which also becomes neater, and tidier Frees pharmacist up to engage in more clinical activities elsewhere in the hospital	Improved efficiency of overall process but has little effect on efficiency of screening and checking processes	Pharmacist concentrate their effort on fewer tasks, which only they are qualified to perform Able to supervise from a distance	Becomes less visibly present in the dispensary Focus energies on developing more cognitive, medical roles
Technician	More space, which also becomes neater, and tidier Workers become more tied to the front end of the room	Improved time efficiency Timing - Inscribes work priority and increases coordination Tempo – Faster pace and interrupted rhythms	New housekeeping and maintenance tasks Dependent on technology and vendors to accomplish work Increased surveillance and supervision	Engenders new roles as caretaker, broker, and buffer
Assistant	Working area becomes cluttered with delivery trolleys while shelves remain untidy. Workers become more tied to the back of the room, stocking the robot	Decreased time efficiency and time delays Timing- Rescheduling of work Unloading stock extends over the day as a result of slow inputting to robot	Less autonomy and discretion, and increased dependence Fragmentation of work accompanies increased multitasking Coordination needed amongst assistants	Engenders new role as equipment user Faces breakdowns and needs caretaker interventions

Figure 1: Photographs of dispensing robot installed at Brown Pharmacy

External view

Internal view

Figure 2: Layout of Brown pharmacy before and after installation of dispensing robot



Legend

Box containing medications

Trolleys from stores with medicines to be stocked into robot

Bench workspace

Shelves

Figure 3: Workplace restructuring and boundary relations between occupational groups