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Technology as an Occasion for Structuring: Evidence from Observations of CT Scanners and the Social Order of Radiology Departments

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New medical imaging devices, such as the CT scanner, have begun to challenge traditional role relations among radiologists and radiological technologists. Under some conditions, these technologies may actually alter the organizational and occupational structure of radiological work. However, current theories of technology and organizational form are insensitive to the potential number of structural variations implicit in role-based change. This paper expands recent sociological thought on the link between institution and action to outline a theory of how technology might occasion different organizational structures by altering institutionalized roles and patterns of interaction. In so doing, technology is treated as a social rather than a physical object, and structure is conceptualized as a process rather than an entity. The implications of the theory are illustrated by showing how identical CT scanners occasioned similar structuring processes in two radiology departments and yet led to divergent forms of organization. The data suggest that to understand how technologies alter organizational structures researchers may need to integrate the study of social action and the study of social form.•

From the standpoint of social science, organizational theorists could hardly pose a more plausible thesis than that technology shapes organizational structure. Anthropologists, sociologists, historians, and economists have repeatedly shown that technologies transform societies by altering customary modes and relations of production. Since most production in industrial society occurs within formal organizations, when modern technologies alter relations of production they should also, by implication, shift organizational forms (Blau et al., 1976). However, as most investigators admit, after two and a half decades of research our evidence for technology's influence on organizational structure is, at best, confusing and contradictory (Hickson, Pugh, and Pheysey, 1969; Mohr, 1971; Blau et al., 1976; Gerwin, 1981; Fry, 1982).

To salvage the thesis that technology shapes the organization of work, theorists have therefore proposed numerous strategies for untangling the empirical confusion. For example, the Aston group admonished researchers to control for the effects of size (Hickson, Pugh, and Pheysey, 1969). Child (1972) suggested that managers' decisions be taken as intervening variables. Comstock and Scott (1977) argued against the "creative use of indicators," the presumption of "modal technologies," and the tendency to confuse levels of analysis. After observing that different researchers have attributed similar characteristics to both technology and structure, Stanfield (1976) even urged researchers to pay closer attention to categorization. Yet, despite the long history of clarification, results remain inconclusive (Gerwin, 1981; Fry, 1982).

Rather than continue to scrutinize research for additional methodological and conceptual flaws, a more fruitful ploy may be simply to embrace the contradictory evidence as a replicated finding. One could then seek alternate theoretical frameworks that would explain technology's link to structure while treating inconsistent outcomes as a matter of course. This paper draws

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on recent sociological thought on the relation between institution and action to sketch such a perspective.

TECHNOLOGY AND THE STRUCTURING OF STRUCTURE

Most students of technology and organization have used the term structure to denote abstract, formal relations that constrain day-to-day action in social settings. When structure has been treated as an autonomous, formal constraint, three other presumptions have typically followed: that technology is a material cause, that relations between technology and structure are orderly, and that these relations hold regardless of context. Moreover, since relations are usually held to transcend contexts, researchers have tended to study technology's influence on structure at organizational levels of analysis. That such a notion of structure and its corollaries undergird organizational research on technology is substantiated not only by the prevalence of cross-sectional research designs but by the determinism that haunts the literature in such phrases as the "technological imperative" (e.g., Khandwalla, 1974; Fry, 1982).

In contrast to this dominant notion of structure, organizational theorists such as Silverman (1971), Weick (1979), Van Maanen (1977, 1979), and Manning (1977) have advocated an alternate formulation that views structure as patterned action, interaction, behavior, and cognition. Unlike in the first usage, in which structure stands outside of and prior to human endeavor, in the second, structure is understood as an emergent property of ongoing action. The contrast reflects the essential difference between those sociological traditions that portray structure as a template for action and those that treat structure as a contour of human behavior (see Burrell and Morgan, 1979; Salaman and Thompson, 1980). Although this alternate conception of structure legitimates the probability of multiple outcomes, it has yet to seriously penetrate the study of technology.

Taken alone, however, neither conception may adequately represent the way technology influences the structure of a workplace. As Goffman (1983) was fond of observing, in everyday life actors are simultaneously the marks as well as the shills of social order. While it is difficult to see how social structure can arise except out of the actions of people, people's actions are also surely shaped by forces beyond their control and outside their immediate present. A full account of structural change therefore appears to require a synthetic view of structure as both a product of and a constraint on human endeavor.

Negotiated-order theory and structuration theory represent two recent attempts to forge such a synthesis. As articulated by Strauss (1978, 1982), negotiated-order theory derives from symbolic interactionism and takes as its point of departure the events of everyday life. In contrast, structuration theory attempts to broach functionalist and phenomenological notions of social order at the level of social theory (Giddens, 1976, 1979). But while the two approaches differ substantially in scope and detail, both share the premise that adequate theories must treat structure as both process and form.

Noting that action is "constituted by" and "constitutive of" social organization, Giddens suggested that structure be understood as a duality: ". . . by the duality of structure I mean that

the structural properties of social systems are both the medium and the outcome of practices that constitute those systems" (Giddens, 1979: 69). Similarly, Strauss (1978) argued that even though social order is a product of negotiations that take place as interacting individuals attempt to define situations, all negotiations are nevertheless constrained by prior interaction that has become institutionalized. Both perspectives liken social order to language. Structures consist of sets of rules that specify parameters of acceptable conduct, but structures are also modified by the actions they inform, just as languages are altered over time by everyday speech.

Both theories therefore attempt to bridge the gap between a deterministic, objective, and static notion of structure, on one hand, and its voluntaristic, subjective, and dynamic alternative, on the other, by positing two realms of social order (analogous to grammar and speech) and by shifting attention to the processes that bind the two together. Structure can be viewed simultaneously as a flow of ongoing action and as a set of institutionalized traditions or forms that reflect and constrain that action. More important than either realm, however, is the interplay that takes place between the two over time. Through this interplay, called the process of structuring, institutional practices shape human actions which, in turn, reaffirm or modify the institutional structure. Thus, the study of structuring involves investigating how the institutional realm and the realm of action configure each other.

Negotiated-order and structuration theories concur that structuring is driven by actors' interpretations of events, by differential access to resources, and by moral frameworks that legitimate a setting's social order. To these engines of stability and change should be added the intended and unintended consequences of decisions and the press of forces, such as technological innovation and economic change, that are initially exogenous to the setting but that impinge and occasion response (Ranson, Hinings, and Greenwood, 1980; Archer, 1982). The structuring of a social setting may be understood to unfold as actors draw on institutional patterns of signification, domination, and legitimation to construct roles and to interpret persons, objects, and events in their environment (Giddens, 1979: 82).

To the degree that actors' behaviors and interpretations give life to these abstractions, the institutional structure is recreated. But since acts of communication, power, and moral sanction necessarily entail the vagaries of interaction, some slippage will occur between the institutional template and the exigencies of daily life. The likelihood of slippage increases when a social system encounters exogenous shocks, such as the acquisition of new members or the arrival of a new technology. Slippages are inconsequential for the institutional structure when they are momentary and random or when they can by subsumed under a framework of prior action, interaction, and interpretation (Meyer, 1982). However, when slippages persist, they become replicated patterns whose contours depart, perhaps ever so slightly, from former practice. Eventually, changed patterns of action reconfigure the setting's institutional structure by entering the stock of everyday knowledge about "the way things are" (Berger and Luckmann, 1967: 56–61).

Approaching the question of technology's relationship to structure from the foregoing vantage point frees researchers from three practices that may have sustained the inconsistencies that have plagued research on technology. First, since structuring implies a process, its temporal nature enjoins researchers to adopt longitudinal as well as cross-sectional perspectives on technical change. Second, since the social context of actions and interpretations is important, it becomes unsound practice to lump together organizations with radically different institutional histories and ecological milieux. Finally, since technologies exist as objects in the realm of action, one cannot hope to understand a technology's implications for structuring without investigating how the technology is incorporated into the everyday life of an organization's members.

Taken together, these epistemological and methodological axioms challenge the presumption that technologies cause organizational structure. Rather, from the point of view of a theory of structuring, technologies are better viewed as occasions that trigger social dynamics which, in turn, modify or maintain an organization's contours. Since these dynamics are likely to be multifaceted, to vary with time, and to reflect the situational context, it is quite likely that identical technologies used in similar contexts can occasion different structures in an orderly fashion. To grasp order in disorder requires a research strategy sensitive to the contextual dynamics by which structuring unfolds.

MAPPING THE EVOLUTION OF STRUCTURE

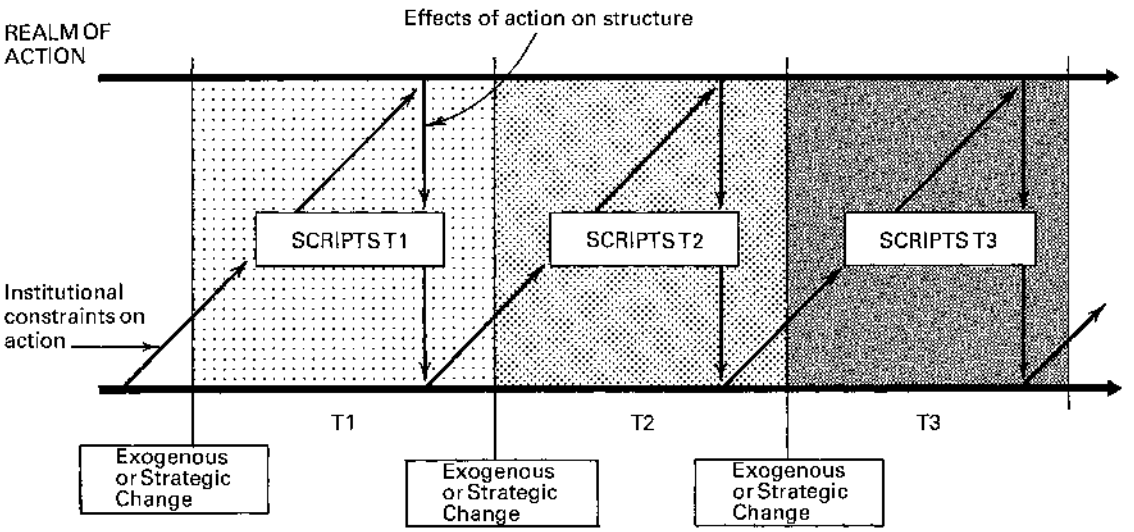
Several organizational theorists have recently noted the value of a theory of structuring for the study of organizational phenomena (Ranson, Hinings, and Greenwood, 1980; Willmott, 1981; Sitkin and Boehm, 1984). But, with the exception of Manning's (1982) careful analysis of how police officers enact the occupational structure of policing and Riley's (1983) study of two subsidiaries of a large corporation, few have actually investigated the structuring of organizational worlds. Manning explicated the logic of a mundane encounter between police and citizen to demonstrate how institutional structures shape and are shaped by the minutia of interaction. In contrast to Manning's emphasis on unfolding behavior, Riley coded interview data, using Giddens' categories of signification, domination, and legitimation, to show that one can account for organizational differences in terms of the dynamics that undergird an organization's traditions. Thus, Riley's work suggests that organizational differences can in fact be understood in terms of structuring processes, while Manning's analysis indicates how structures are produced and reproduced by situated action.

Although both Manning and Riley explicated Giddens' premise that structure's duality is evident in all instances of action, neither specified how articulations between institution and action evolve. But as Ranson and his colleagues emphasized, to account for change as well as stability requires a temporal model of the structuring process. Evolutionary visions are particularly important for studying technical change, since technologies occasion adaptations whose implications may congeal but slowly as actors redefine their situation (Ranson, Hinings, and Greenwood, 1980: 13). The present research therefore extends and

specifies previous work by modelling the dynamics of structuring sequentially rather than concurrently.

The sequential model of structuring that guides the analysis is shown in Figure 1. The two realms of social organization, action and institution, are depicted as parallel, horizontal arrows signifying contiguous flows through time. The institutional realm represents the setting's social logic: an abstract framework of relations derived from prior action and interaction on which actors draw to enact their daily lives. In contrast, the realm of action refers to actual arrangements of people, objects, and events in the minute-by-minute flow of the setting's history. Since the institutional realm encodes idealized patterns derived from past practice, it may be considered equivalent to what Ranson, Hinings, and Greenwood (1980) call "realized structure."[1] The realm of action parallels Goffman's (1983) "interaction order."

Figure 1. Sequential model of the structuring process.



Note: The progressively denser backgrounds signify structuring's cumulative effects.

As shown in Figure 1, the present analysis parses structuring's ceaseless flow into temporal phases (T1, T2, T3, etc.) to better specify the interaction between structure's realms and to highlight changes that accumulate gradually. To avoid arbitrary partitionings, changes in circumstance recognized as significant by an organization's members and brought about by exogenous events or shifts in organizational strategy signal the start of each phase. The diagonal and vertical arrows linking the two realms indicate the duality of the structuring process: the diagonal arrows signify institutional constraints on action while the vertical arrows represent action's shaping of the institution. The sequential nature of the process is captured by the relation of the diagonal and vertical arrows to the phases' temporal boundaries. Institutional patterns provide programs of action and interpretation at the beginning of each phase, while actions modify institutions within phases. Social practices therefore constitute institutions synchronically while institutions con-

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While I concur with Ranson, Hinings, and Greenwood (1980) that it is often useful to distinguish analytically between "prescribed structure" (the organization's formal dictates) and "realized structure" (patterns of actual practice), I submit that only those aspects of prescribed structure that become embedded in realized structure influence the round of life in social settings.

strain action diachronically. The progressively denser backgrounds in Figure 1 signify structuring's cumulative effects.

The sequential model of structuring points to a broad empirical strategy for investigating social dynamics occasioned by technology. Since most technologies enter established contexts whose institutions will influence subsequent events, researchers must document traditional patterns of behavior, interaction, and interpretation before the technology arrives. Such assessment is critical not only because institutional patterns influence the action that surrounds the technology's adoption, but because such patterns set contextually specific baselines for judging structural stability and change. Once the technology arrives, attention shifts from the institutional context to the social practices that envelop the technology's use, in order to document behaviors and cognitions, which are the raw material from which interaction orders emerge. To map emergent patterns of action and interpretation accurately requires at least partial reliance on participant observation to record who interacts with whom in what ways at what times and to elicit actors' immediate interpretations of events. Retrospective accounts and archival data are insufficient for these purposes, since individuals seldom remember, and organizations rarely record, how behaviors and interpretations stabilize over the course of the structuring process. As an interaction order solidifies, one's analytic focus shifts back to the institutional realm, where the contours of practices that form the interaction order are specified and compared to prior patterns to assess the extent to which the technology has occasioned replication or modification of the previous structure.

While the presumption of sequentiality enjoins researchers to oscillate from one realm to the other, it provides no analytic or empirical fulcrum for pivoting between the two realms. However, such a mechanism can be found in the notion that scripts link the institutional realm to the realm of action (see Goffman, 1959, 1967). Scripts are outlines of recurrent patterns of interaction that define, in observable and behavioral terms, the essence of actors' roles (Schank and Abelson, 1977). As manifested in the flow of behavior, scripts appear as standard plots of types of encounters whose repetition constitutes the setting's interaction order. Scripts can be specified by sampling interactional episodes that occur in the social context under investigation. From details of actual behavior and speech, the analyst abstracts each episode's logic in terms of turns, roles, and categories of acts that outline the episode's unfolding. More specifically, actors' identities are replaced by the positions they play, their behaviors and speech are reduced to generic form and content, and the action's unfolding is charted as a sequence of turns composed of typical acts. Once each episode has been reduced to its essential plot, the frequency of plots can be counted. Recurring plots signify forms of interaction common to the setting and constitute scripts germane to the interaction order. This method of identifying scripts parallels the technique by which structural anthropologists uncover the syntax of myth and narrative (see Propp, 1958; Lévi-Strauss, 1963). By analogy, scripts can therefore be viewed as behavioral grammars that inform a setting's everyday action.

Just as scripts can be conceived of as behavioral grammars that shape instances of action and interaction, what we tradi-

tionally call formal organization can be viewed as the grammar of a set of scripts. From this vantage point, global principles of organization such as centralization, formalization, and specialization represent core attributes of scripts that characterize a setting's activity. The link between action and formal structure can be visualized as a chain of successive encodings that abstract, first, from instances of action and interaction to properties of scripts and, then, from scripts to properties of formal organization. The role that scripts play in the structuring process is also shown in Figure 1. Although action modifies institutional patterns along vertical arrows and institutional patterns constrain action along diagonal arrows, scripts mediate both flows.

Thus to occasion the structuring of organizations, technologies must first disturb or confirm ingrained patterns of action to reformulate or ratify scripts, which, in turn, delimit the organization's institutional structure. However, since technology is but one among many elements of social context that influence patterns of action, even identical technologies may occasion processes that lead to different scripts and, hence, to different organizational structures in different settings. Such a situation occurred in the radiology departments of two community hospitals where I was a participant observer during the year that each began to operate its first whole-body, computed tomography (CT) scanner.

SITES AND METHODS

Urban and Suburban were two of four community hospitals in Massachusetts whose radiology departments received CT scanners in 1982. Both departments employed six radiologists and approximately fifty other individuals, both performed a standard range of radiological procedures, and both purchased identical machines, Technicare 2060's. Although Urban had operated a first-generation EMI head scanner since 1977, the body scanner represented Suburban's first experience with CT. However, since the Technicare scanner and Urban's EMI scanner were technically quite different, and since an ability to read head scans is no qualification for interpreting body scans, Urban's experience with head scanning proved relatively unimportant to the evolution of its body-scanning operation.

The research initially focused on documenting traditional radiological practice to establish a comparative base for determining the extent to which the scanners would affirm or modify institutional patterns in the two departments. Historical data on the technical and social organization of the specialty were gathered from published sources and from interviews with senior radiologists at two large medical centers. However, since actual practice in a specific hospital may depart from the occupation's norms and institutions, it was also critical to study traditional operations at each research site. Consequently, I began observation at both Urban and Suburban in June 1982, four months before the scanners began to operate.

Since radiography and fluoroscopy form the traditional technical core of radiology, from June to September observation centered on the actions and interactions of radiologists and technologists performing x-ray and fluoroscopic procedures in Urban's and Suburban's x-ray areas. As throughout the study, I

gathered data by attending individual examinations in their entirety. The occurrence and timing of events were recorded chronologically during the course of each exam in small spiral notebooks to create behavioral records for every procedure observed. Conversations between participants were either taped or written in a shorthand devised for the purpose of documenting setting-specific argots. In addition to behavioral records, I also sought and recorded participants' interpretations of events at the time they occurred or shortly thereafter.

Once the scanners went on-line in late September, observation shifted from the x-ray areas to the two newly created CT areas. However, the method of observing and recording detailed behavioral information remained constant. Over the course of the study approximately 400 complete radiological examinations, including 96 CT scans, were observed. With the exception of a six-week hiatus during the Christmas holidays, data were collected at the two sites on alternate working days for a period of a year. The text of field notes and tape recordings collected during observation of the two CT scanners provided raw data for the analysis.

Analysis began by identifying breakpoints to define phases of structuring at each site. Mapping phases before scripts avoided temporal distinctions based on knowledge of the scripts themselves. To have used distributions of scripts to locate breakpoints would have risked theoretically propitious, but historically spurious, partitionings by maximizing the homogeneity and heterogeneity of scripts within and between phases. As indicated in the discussion of the sequential model of structuring, phases should start with significant exogenous events or shifts in organizational strategy, as judged by insiders. Aside from the arrival of the scanners themselves, alterations in the scanner's staffing pattern were uniformly viewed by members of both departments as crucial disjunctures. Consequently, such shifts were taken to mark the temporal boundaries of structuring's phases at each site. Field notes revealed that, by this criterion, Suburban experienced two and Urban four phases of structuring.

The second step in the analysis entailed recursive scrutiny of the interactions that took place between radiologists and technologists, to isolate scripts characteristic of each area's interaction order. All recorded interactions between radiologists and CT technologists were culled from the field notes and were arranged by site in chronological order. Each episode was then reduced to an initial plot, using the approach described in the previous section. Generic plot statements were refined by comparing episodes, and each plot's frequency was tabulated across the phases of structuring at each site. By examining the relative frequency of the plots in each hospital over time, I identified scripts characteristic of interaction in each CT area during each phase of its structuring. The scripts' content and form provided a basis for comparing role relations in the two CT areas with their analogues in the x-ray areas, while the scripts' temporal distributions traced the scanners' evolving interaction orders.

The third and final stage of analysis linked the scripted parameters of the two interaction orders to properties of each CT

area's formal structure. Centralization was deemed particularly relevant, for both substantive and empirical reasons. As is explained more fully below, prescribed distributions of discretion and authority lie at the core of radiology's traditional division of labor. Moreover, data were available for constructing measures of centralization that were independent of the scripts and the interactions from which they were derived. Consequently, by focusing on centralization it was possible to examine the link between the two interaction orders and one of radiology's fundamental institutions by using data independent of the scripts.

Measures of centralization were constructed by coding instances of routine decision making found in the field notes. Regardless of hospital, all CT scans were punctuated by nine operational decisions: (1) when to start a new patient, (2) where to start scanning, (3) how far to scan, (4) what techniques to use, (5) whether to reposition the patient, (6) whether to inject contrast, (7) what windows and centers to use, (8) whether the radiologist should view the scans, and (9) when to end the exam. Since each decision was made as a scan unfolded and since each resulted in overt action, as part of my observational regimen I routinely recorded the identity of the decision maker. My field notes documented 91 scans in sufficient detail to determine whether the radiologist who was nominally in charge or a technologist had made each decision. Thus, the percentage of decisions made by a radiologist during the course of a scan constituted the index of centralization. Plots of the indices over time were interpreted as a department's centralization profile.

If institution and action in the CT areas were in fact linked via the structuring process, then the shape of each department's centralization profile should parallel trends revealed by a chronological analysis of scripts. This hypothesis was tested by regressing each department's centralization scores on the day of operation on which the scans took place, as well as the square of that value, to test for linear and curvilinear trends suggested by the analysis of the scripts. Day of operation was measured as an interval variable from the start of each department's scanning operations. The centralization scores were also used to validate the adequacy of the phases defined for each department's structuring. If phases were identified correctly, then a scatterplot of each department's centralization indices should evidence similar periodicity. To examine the adequacy of the phasing, each department's centralization scores were regressed on a series of dummy vectors that defined a two-stage and a four-stage model for Suburban and Urban, respectively. Each scan was assigned to a stage by the date on which it was performed. If phasing was accurate, one would expect a model constructed from the combined phases to predict Suburban's and Urban's data no better than the two-phase and the four-phase model, respectively.

The data analysis thus traced the analytic logic suggested by the sequential model of the structuring process. In keeping with this analytic flow, the following discussion of Urban's and Suburban's experience begins with a brief description of patterns of traditional radiological work in the two hospitals' x-ray areas: the background against which structuring occurred.

RADIOLOGY'S INSTITUTIONAL CONTEXT AND TRADITIONS

Radiology's ascent from a scientific association, formed soon after the discovery of x-rays in 1895, to its current status as a medical specialty traces the rise of a "professional monopoly" (Larson, 1977) and the institutionalization of a system of "professional dominance" (Friedson, 1970). As Larkin (1978) and Brown (1973) have documented, by the 1950s radiologists had secured an exclusive license to interpret medical images by excluding physicists and engineers from medical radiography, by barring other physicians from interpreting films, and by controlling the education and registry of radiology technologists. The profession's dominance therefore was built on and maintained by a distribution of expertise that separates radiology's productive and interpretive work.

In Suburban's and Urban's x-ray areas, radiological technologists, individuals with associate's degrees, managed patients during examinations and produced films for the radiologists. In turn, the radiologists extracted diagnostic information from films and provided referring physicians with readings. Although the "techs" were trained to run equipment and to recognize anatomy, they were not taught to interpret. Thus, even after years of experience, most x-ray techs recognized few pathologies revealed by a set of x-rays (Barley, 1984). In contrast, the radiologists were taught to operate x-ray equipment as well as interpret, and although they rarely developed the technologist's finesse, they routinely took control of the equipment, particularly during fluoroscopy. This pattern of expertise created a hierarchy of authority in which radiologists knew what technologists knew, but not the reverse.

The radiologists' dominance was routinely enacted as x-ray techs and radiologists at Urban and Suburban went about their daily work. Perhaps because radiography and fluoroscopy are well understood and because the occupational traditions surrounding this work are well encoded, traditional practice was similar in the two departments. Most interactions between members of the two groups involved a radiologist giving a technologist orders, which the technologist then carried out. During fluoroscopy, for example, interactions between radiologists and technologists consisted almost entirely of imperative sentences spoken by the radiologist and directed toward the technologist. Radiologists rarely provided technologists with justification for their commands and preferences (Barley, 1984). Radiologists also rarely sought an x-ray tech's opinion, even on matters regarding the use of a technology. Technologists, however, routinely awaited directions from radiologists, even when they knew the appropriate action was obvious. Similarly, radiologists never sought from x-ray techs, and only occasionally volunteered, information on a patient's pathology. And while technologists were free to ask radiologists about pathological signs, few actually did. These interactional patterns instantiated the radiologists' institutional dominance and the x-ray techs' corresponding dependence. Not only were x-ray techs prohibited from making numerous routine decisions, but in most interactions information flowed from the radiologist to the technologist. Thus, even in mundane matters, authority was centralized.

Although the radiologist's interpretive monopoly and the x-ray technologist's subordination arose from institutionalized and socially enacted power, it is important to recognize that radiology's traditional structure is linked to its technical history. Until the late 1960s, most technical change in radiology came as incremental improvements to existing machines (Dewing, 1962). Augmentation of the profession's diagnostic knowledge was similarly gradual. Thus, as recently as twenty years ago, the work of a radiology department consisted entirely of procedures performed with technologies that had existed for decades. In this era of incremental technical change it was relatively easy for radiologists to remain proficient in the use of machines as well as in the interpretation of films.

Over the past fifteen years, however, computer-driven technologies such as ultrasound, the CT scanner, and nuclear magnetic resonance have revolutionized medicine's ability to peer inside the human body. Each innovation not only operates by principles dramatically different from traditional machines, but each has created a completely new system of diagnostic signs that radiologists have had to master. If, as at Urban and Suburban, few radiologists follow the professional literature on a new technology until faced with the necessity of using the machine themselves, then when departments acquire new technologies most members will know little about the machine or its images.[2] At both research sites, Technicare's standard four-day orientation program was the only formal training that radiologists or technologists received before the scanners went on-line. The training focused exclusively on the scanner's routine operation and had nothing to do with interpreting anatomical or pathological signs. There was also little discussion of how the scanner worked or how one might troubleshoot problems.

Since radiology's professional dominance arises from traditional distributions of expertise, the implications of a situation in which a department's members are relatively ignorant of the technology and its system of signs are that prior structures are likely to be more difficult to maintain and opportunities for structuring are likely to be occasioned. Such was the case when the scanners arrived at Suburban and Urban.

THE STRUCTURING OF SUBURBAN'S CT OPERATION

Phase 1: Negotiation of Discretion

Since none of Suburban's personnel had experience with CT scanning or could interpret a scanner's images, the department faced the untenable prospect of scanning patients without the necessary expertise. To alleviate the problem, Suburban hired a sixth radiologist who had recently completed a fellowship in computed tomography and charged him with coordinating the start of CT operations. In addition, the department recruited two technologists previously employed by one of the region's first body-scanning installations and transferred two of its x-ray techs to the CT area. The two experienced technologists, the two inexperienced technologists, and the new radiologist brought the scanner on-line.

These personnel decisions and the scanner's arrival signaled the start of the first phase of structuring at Suburban. Since the

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Interviews with senior radiologists at medical centers indicated that the practice of waiting to learn a new technology until the time of adoption is widespread. However, one might expect radiologists to seek interpretive training as soon as they know they will acquire a new imaging technology. At Urban and Suburban, at least, the radiologists did not embark on such a course of action. Instead, both departments hired young radiologists trained in CT to serve as shadow consultants for the others, who learned by doing.

CT area had no standard procedures, none of the personnel had operated a Technicare machine, and the radiologist and the technologists had never worked together, interactions during the first weeks of the scanner's operation centered on clarifying roles, particularly with regard to who had what competencies and would assume what duties. Field notes from this period document several forms of interaction that differed substantially from those characteristic of the scanner's later operation.

Unsought validation. As the CT techs worked to complete early scans, they frequently acted without inquiring whether the experienced radiologist thought their action desirable. Usually the radiologist either failed to note what the technologists had done or chose not to comment on the act. However, on some occasions, the radiologist did question a technologist's decision. Generally, the radiologist framed his interrogation in terms of a request for information or a rationale. In response, the techs recounted facts to justify their action. The radiologist then usually commented on the action's suitability and, more often than not, agreed with the decision, offering compliments on a choice well made. The script of such interactions, which may be called "unsought validation," evidenced the following structure: (1) a technologist took action, (2) a radiologist questioned the action, (3) the technologist provided a justification, and (4) the radiologist confirmed the action as appropriate.

An actual example of unsought validation will clarify the script's role-making relevance and demonstrate how scripts summarize instances of interaction. Several days after Suburban began to operate its scanner, the experienced radiologist was called to the control room to view a patient's scans on the scanner's video monitor. Unknown to him, the technologists had decided among themselves to construct the images using a 512-pixel matrix rather than the 256-pixel matrix that had been used up to that time.[3] Consequently, the images were sharper than usual. As the scans appeared on the monitor, the following exchange occurred between the radiologist and an inexperienced technologist:

Rad: *(Incredulously)* These are 256's?

Tech: *(Matter of factly)* No, these are 512's.

Rad: *(Surprised)* They're 512's?

Tech: Yes. We reconstructed them at 512.

Rad: Oh! That's good! I was wondering on the way over here if you could reconstruct at 512 and do quicklooks too. Well, that's great! It's real important.[4]

As can be readily seen, the interaction unfolded in the sequence specified by the script's plot. Except for the fact that the subject matter pertained to CT scanning, the specifics of conversation were irrelevant to the script's unfolding. The example also suggests how unsought validations created unsolicited opportunities for technologists and radiologists to negotiate knowledge. By confirming the advisability of a technologist's action, the radiologist publicly recognized the tech's competence to make a type of decision about the course of a scan. At the same time, the radiologist's questioning and subsequent acceptance revealed his own understanding of CT work, since he raised questions about acts that might bypass a novice. Although the script subtly maintained the radiologist's

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A pixel, loosely speaking, is a small, square unit of a video image that can take on a unique data value. CT images are constructed by assigning values to each pixel in a matrix of pixels and by then correlating these values to shades of grey ranging from white to black. Since a 512 pixel matrix has four times as many pixels as a 256-pixel matrix, more precise images can be constructed.

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"Quicklooks" are images constructed with half the pixels of a 256 matrix. They are displayed after each scan is taken and are used to locate one's current position in the patient's body and to initially identify pathological structures.

dominant role by instancing the radiologist's right to question a technologist, as a whole it affirmed both parties' expertise at neither's expense.

Anticipatory questioning. In contrast to unsought validation, the anticipatory-question script, a script common to the early days of Suburban's CT operation, unfolded when technologists conferred with the radiologist before taking action. Like all scripts, anticipatory questions followed a plot that subsumed numerous interactional episodes: (1) a technologist asked the radiologist a direct question, (2) the radiologist provided the technologist with a direct answer, (3) the technologist made a statement about his or her next course of action, and (4) the radiologist confirmed the technologist's stated plan as appropriate. Although the initial question often resembled a genuine request for information, the situational context and the tech's subsequent statement framed the question as rhetorical. Since anticipatory questions presumed their answers, they were typically posed by the experienced technologists, who were better positioned to demonstrate knowledge of scanning protocols. For example, during an early scan, an experienced technologist inquired about an injection she perceived to be imminent:

Tech: Are you going to inject the patient, doctor?

Rad: Yeah.

Tech: I'll go draw up the dye. A hundred cc's?

Rad: Yeah.

Although the encounter appears as a simple request for information, in fact, much more was communicated. To ask the question, the technologist had to surmise, either from the images or the patient's requisition, that an injection was probable, since the radiologist had not stated his intention to inject. By waiting until the radiologist had almost completed his viewing, she demonstrated that she knew how to time an injection. Her question therefore carried the message: "From the looks of things an injection is likely, and if it's going to happen it should happen soon." Moreover, by stating that she would draw up 100 cc's of dye, the technologist acknowledged her role at this point in a procedure and demonstrated that she was willing to execute her duty without being told. Thus did the anticipatory question venture, and the radiologist's affirmation confirm, the experienced technologist's expertise. By initiating encounters with anticipatory questions the techs also maintained the veneer of deference that typified interaction in the x-ray area. In the present case, use of the term, "doctor," underscored the technologist's deference. Since anticipatory questions validated the tech's expertise while preserving the radiologist's status, it is not surprising that the form of interaction was common during the scanner's early operation.

Preference stating. Regardless of their experience with the technology, the CT techs expected radiologists' knowledge of disease, anatomy, and diagnostic signs to surpass their own. Moreover, they stood willing to accept radiologists' technical preferences, so long as they seemed reasonable. Since radiologists customarily state opinions on technical matters in the x-ray area, it was hardly surprising that Suburban's experienced radiologist freely informed the CT techs of his

preferences in conducting scans. However, interchanges scripted as preference stating went beyond the mere giving of directions common in the x-ray department: (1) the experienced radiologist not only made his preferences known, (2) he also provided a rationale for his preferences.

The radiologist usually justified a preference by explaining how his suggestion would either make the scanner's operation less burdensome or provide more conclusive diagnostic evidence. The latter type of explanation often led the radiologist to discuss the signs of pathology in a scan. These interchanges ofter involved lengthy conversations about disease and interpretation that were uncharacteristic of the x-ray area.[5] Moreover, by outlining the grounds for his preference, the radiologist established his credibility and competence while treating technologists as if they deserved reasoned explanations. Since the radiologist offered justifications, the technologists rapidly came to expect them.

Interactions scripted as unsought validations, anticipatory questions, and preference stating shaped the early definition of role relations in Suburban's CT area. Although the fledgling interaction order reaffirmed the radiologist's traditionally greater authority and expertise, it also ratified the technologists' claim to occupational knowledge. As the techs demonstrated responsibility and competence, the radiologist began to grant them greater discretion. By the end of the third week a tentative climate of joint problem solving arose to create an atmosphere that more closely resembled the ideal of complementary professions working in concert. The radiologist became less involved in routine decisions and the experienced techs began to administer injections, a highly symbolic event, since no other technologists at Suburban were allowed to inject. However, the technologists' gains in discretion were trivial when compared to the windfall of autonomy that accrued during the next phase of structuring.

Phase 2: Usurping Autonomy

Although the CT-inexperienced radiologists sporadically attended scans during the first three weeks of the operation, the newly hired radiologist was always present and clearly in charge. In fact, field notes reveal that aside from social conversation, the inexperienced radiologists rarely interacted with the technologists. Instead they addressed their questions regarding the scanner to their experienced colleague. During the fourth week, however, the radiologists decided to rotate CT duty on a weekly basis. The experienced radiologist subsequently resumed primary assignments in other areas of the radiology department and rotated through CT on the same schedule as his colleagues. The decision to share CT duty marked the beginning of the second phase of structuring at Suburban. At first, the technologists tried to enact scripts that had evolved during the first phase of the scanner's operation. But former interaction patterns were quickly transformed as role relations between radiologists and technologists shifted.

Clandestine teaching. Accustomed to exercising authority in other areas of the department, the inexperienced radiologists were also inclined to initiate encounters with CT techs by stating preferences or by raising questions reminiscent of

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In only 14 percent of the 74 procedures I observed performed in Suburban's x-ray area did radiologists inform technologists about the pathological signs in a set of films. In contrast, such discussions occurred in 40 percent of CT scans I observed at Suburban (Barley, 1984)

those that had cued unsought validations. However, since these earlier interactions presumed knowledge of the scanning context, and since such knowledge was precisely what the inexperienced radiologists lacked, their preferences and questions could not sustain the former interaction patterns. Instead, their questions and preferences often led to exchanges in which technologists responded to a radiologist's inquiry or suggestion by attempting to teach without appearing to do so.

Instances of clandestine teaching typically began when a radiologist posed questions or made statements that would not have been made by someone familiar with the technical context of CT work. For the technologists to have openly corrected a radiologist's faulty question or preference would have been to risk affront and boldly invert the institutionalized status system. Therefore, the technologists typically responded to the radiologist with a question or statement that tangentially supplied information necessary for the radiologist to reformulate his presentation of self as a knowledgeable partner to the interchange. Picking up the cue, the radiologist then adjusted his claim or action to be more in line with standard protocol. Interactions scripted as clandestine teaching unfolded when (1) a radiologist asked an irrelevant question or made a faulty suggestion, (2) the technologist offered corrective information, and (3) the radiologist adjusted his claim.

Clandestine teaching threatened the institutionalized roles of radiologists and technologists. Under radiology's traditional system, radiologists taught technologists, but the reverse was uncommon and nearly taboo. Only the radiologist's front of self-assurance and the technologist's deference, both of which were encoded in the semantics and pragmatics of the exchange, kept clandestine teaching from becoming open instances of role reversal. Yet, open role reversals did occur with some frequency after the fourth week of the scanner's operation.

Role reversals. In the most important type of role reversal a radiologist asked a technologist directly whether a scan evidenced pathology. Discussions of pathology between radiologists and technologists in the x-ray area occurred only when radiologists volunteered interpretations. Thus, diagnostic knowledge always flowed from radiologist to technologist, in keeping with the radiology's institutional division of labor. But the traditional distribution of diagnostic expertise was difficult to sustain in the CT area, since the inexperienced radiologists initially knew less about the images than did the experienced technologists. Although the radiologists tried to avoid conferring with CT techs on interpretive matters, daily exigencies occasionally necessitated consultations, especially when radiologists were pressed to give referring physicians immediate readings. These occasions inverted the script of typical interpretive discussions in that (1) the radiologist now questioned the technologist about pathology and (2) the technologist provided the radiologist with an interpretation. In the following exchange, the radiologist explicitly inquired whether spinal scan revealed pathology:

Rad: *(Sitting down at the console)* You just photographing them?

Tech: Yes, I'm rematrixing.

Rad: *(Pointing)* Is that a fracture?

Tech: No, that's probably a foramen [one part of a vertebra].

Rad: Did you see a disk here? [Was the disk ruptured or bulging?]

Tech: I just saw a little bit. It's so small you can't see it.

Although instances of clandestine teaching revealed the radiologist's ignorance, the script maintained the patina of their traditional professional dominance. If need be, the actors could claim that nothing unusual was going on, since techs were supposed to know how to operate the scanner and recognize certain anatomical signs. However, role reversals blatantly violated institutional mores by mandating that technologists assume the interpretive role. Since radiologists and technologists both perceived this inversion of the institutional order, role reversals generated anxiety. After the incident recounted above, the radiologist rushed awkwardly out of the room and the technologist nervously confided to the author, "I don't like it when doctors ask me what a film means. It's not my job to tell them how to do their job."

Blaming the technologist. Of all the interaction patterns that arose in the second period of structuring, none was more indicative of how the interaction order had changed than the tendency for radiologists to mistake machine problems for a technologist's incompetence. On such occasions, the radiologist (1) stated or questioned a perceived problem, (2) insinuated or directly claimed that the problem was the technologist's fault, and (3) rejected the technologist's claim that the nature of the problem lay with the technology. The following typifies the script:

Rad: *(Brusquely)* This is pretty bad. The films on the last patient are pretty dark. Can you do anything about it?

Tech: I don't know.

Rad: What do you mean you don't know?

Tech: The problem is either in the processor or the camera there. I don't know how to set them. Dr. X knows how to set the camera. Maybe we should get him to come over and set the camera and I'll rematrix them.

Rad: *(Pointing to diagonal lines through the basal portion of the brain in a head scan)* Is this all artifact here?

Tech: Yes. There's nothing you can do about it.

Rad: Why not? You mean there's nothing *you* can do about it?

Tech: I believe it's all bone artifact. [Bone artifact in the basal brain was a chronic problem with all Technicare 2060's.]

As role reversals, clandestine teaching, and incidents of blaming the technologist gradually defined a new interaction order, the radiologists' moral authority tarnished and the technologists began to regard the inexperienced radiologists with disdain. To account for the new interaction patterns, the technologists formulated the view that the radiologists knew less than they rightfully should and that their ignorance created unnecessary work and kept the CT operation from running smoothly. The radiologists were also uncomfortable with the situation. Unaccustomed to having their knowledge perceived as inadequate, anxious that they might make a serious mistake,

and baffled by the computer technology, they began to express hostility toward the technologists.

As anxiety, hostility, and disdain increased, both technologists and radiologists acted to reduce their occurrence. The technologists began to take responsibility for routine decisions where in the past they would have consulted a radiologist before acting. At first the techs took such steps hesitantly. But when autonomous action elicited no repercussions, as was usually the case, the technologists assumed similar responsibility in subsequent exams. At the same time, the radiologists began to withdraw from the scanner's minute-by-minute operation to save face. When assigned to CT duty, most radiologists remained in the radiologists' office and several even went so far as to close the door to the office and shut the window between their desk and the secretary's desk. Another radiologist stayed in the x-ray department whenever he was assigned to CT and visited the CT area only to pick up films. Thus, as an upshot of the interaction patterns that arose during the second phase of structuring, Suburban's CT technologists gained a large measure of autonomy over their day-to-day work.

THE STRUCTURING OF URBAN'S CT OPERATION

Phase 1: Negotiating Dependence

Although Urban also faced the prospect of operating a body scanner without experienced personnel, it mobilized to meet the problem by relying solely on knowledgeable radiologists. Two months before the scanner arrived, Urban hired a young radiologist who had specialized in CT scanning during his residency. The second radiologist charged with organizing the scanner's operation was a long-time member of the department who had dominated Urban's head scanner and who had followed the body-scanning literature even though he lacked practical experience with the technology. To complete the scanner's staff Urban assembled a group of eight technologists: four drawn from the head scanner and four from other areas of the department. As at Suburban, these personnel decisions combined with the scanner's arrival to signal the first phase of structuring, but the interaction order that evolved substantially differed from Suburban's.

Direction giving. Since all of Urban's technologists were novices at body scanning, their initial problem was not to demonstrate technical competence but to discover what it entailed. Moreover, since the four days of training offered by the scanner's vendor were little more than an orientation, responsibility for training fell mainly to the radiologists. But, because they had never developed training programs, since they were themselves unfamiliar with the Technicare scanner, and because the work of scanning patients posed countless exigencies that undermined structured pedagogy, the radiologists resorted to giving directions as a primary means of teaching the technologists. The script underlying such interaction was simple and direct: (1) a radiologist told a technologist what to do and (2) the technologist carried out the radiologist's orders, often without asking for clarification or reason. In most cases, the radiologist's utterance was imperative and pertained to minute details of the scanning process.

Direction giving's order-act unit rapidly became the fundamental building block of interaction between radiologists and technologists during the scanner's early period. Direction giving was frequently the only form of verbal communication that passed between radiologist and technologist over the course of a scan. The following example, which begins as a radiologist discovers that a tech has not entered the patient into the scanner's computer, illustrates how incidents of direction giving could be chained together to support lengthy interactions:

Rad: *(Perturbed)* You don't have her in yet?

Tech: Not yet.

Rad: *(Noting the prompts on the terminal, the radiologist tells the technologist what to enter.)* Default . . . Default . . . Default . . . Oral IV contrast.

Tech: *(Hits the return key three times and begins to enter the label as the radiologist spells.)*

Rad: O . . R . . A . . L . . I . . V . . C . . O . . N . . T . . R . . A . . S . . T. Now, what technique are we going to use?

Tech: Let's see. This is an abdomen so we use "A." Manual select and then, A? *(referring to two buttons on the scanner's console).*

Rad: Yeah. Ok. Set 40. *(The tech pushes the button.)* Push "pause scan." *(The tech pushes the button.)* And then, "start scan." *(The tech pushes the button.)* Now, you're not going to do quicklooks, just 512's.

Direction giving differed from preference stating in that the experienced radiologists offered no justification for their suggestions. The script's success as a training strategy therefore hinged on the technologist's ability to form habits and abstract rules of action. That the excerpt above occurred over a month after the scanner came on-line, and that a more routine aspect of CT scanning could scarcely be found, casts doubt on the script's effectiveness. Direction giving failed as a training strategy because it was predicated on one-way communication in which the radiologist assumed the role of conceiver-of-action and the technologist the role of executor-of-action. Consequently, the interaction pattern not only failed to train, it reaffirmed the radiologists' professional dominance by extending their authority to such mundane matters as when to push what button. Even in the x-ray area a radiologist's directions were rarely so detailed.

Countermands. That technologists were unable to infer rules from radiologists' directions was partially explained by a second common interaction pattern whose script also consisted of an order-act sequence but whose context differed from direction giving. Simple direction giving presumed that radiologists would communicate preferences before technologists acted. But the radiologists did not always formulate orders prospectively. On numerous occasions radiologists recognized only in retrospect that an alternate course of action would have been more desirable. When such realizations struck, they typically redirected the exam, regardless of whether they thereby contradicted earlier directions. Order-act sequences that invalidated previous directions composed the script of a countermand.

Occasions for countermands were multiple. Radiologists countermanded directions for diagnostic reasons when they noticed unexpected signs of pathology while viewing a patient's images. More frequently, countermands arose from the

radiologists' personal proclivities and rivalries. Unlike their counterparts at Suburban, Urban's experienced radiologists were intrigued by the scanner's technical capabilities and enjoyed testing its limits by posing on-the-spot hypotheses about what the scanner could do. Moreover, the two experts often disagreed as to how the scanner should be operated. Consequently, the radiologists requested numerous alterations as a result of side debates and routinely countermanded each other's orders. Since the radiologists rarely justified changes and since the technologists were not usually privy to the radiologists' side debates, from the technologists' perspective countermands appeared capricious. As unpredictable order-act sequences that could occur anywhere in the context of a scan, countermands underscored the radiologists' authority, undercut opportunities for the technologists to infer rules of informed action, and reinforced the technologists' subservience, since countermands provided no basis for action other than blind obedience to a radiologist's orders.

Usurping the controls. Urban's experienced radiologists did not limit their interventions to commands and countermands. As early as the first scan, the radiologists also literally took the scanner's controls away from technologists at the console. This practice became so well established that for the first two months of observation no day passed without an instance of a radiologist usurping the scanner. In sharp contrast, Suburban's radiologists rarely took control of the scanner until asked to review images, and even then they limited their manipulations to altering the video display. Unlike previous interaction patterns, usurping the controls was purely behavioral and required no verbal exchange. Its script consisted of a radiologist (1) approaching the console and (2) interrupting the technologist's work by pushing buttons or typing commands at the keyboard.

Urban's technologists treated usurpation as an emotionally charged event that signified disregard for their role and disdain for their abilities. At first the technologists challenged the radiologists' right to usurp control of the scanner, but as it became clear that the technologists could not quell the behavior, they gradually accepted the encounters as routine. However vociferously they might complain to each other, when a radiologist made a play for the console, the technologists acquiesced passively.

Direction seeking. Aside from direction giving, encounters between Urban's radiologists and technologists in the first phase of structuring were most frequently scripted as incidents of direction seeking. Direction giving and direction seeking were interactional complements. A radiologist's orders initiated the first type of encounter and a technologist's request for guidance cued the second, but both forms of interaction specified the task the technologist should perform next. Direction seeking's script was as simple as direction giving's: (1) a technologist inquired about an appropriate course of action, (2) the radiologist answered, and (3) the technologist acted. Like direction giving, direction seeking initially grew out of the technologists' need to learn, but direction seeking persisted even after the technologists gained experience. The key to the pattern's stability lay in a subtle shift in its social purpose.

All three scripts therefore affirmed the radiologist's dominance and created a work environment that the technologists perceived as arbitrary. To make sense of the seeming caprice, the technologists formulated an interpretive framework, a constitution of work, whose preamble was to uncover and cater to the radiologists' idiosyncratic preferences. If the world of CT was ruled by personal preference, then the fact that acts could not be codified made sense. Tellingly, by the third week of operation techs ceased to inquire what should be done and instead began to ask each other, "What did he say he wanted?" The technologists therefore continued to seek directions from radiologists not only because they did not know what to do, but because they were convinced that radiologists could potentially say what they wished. Over time, direction seeking became both a reaction to the radiologists' authority and a guarantee of the technologists' dependency. Perversely, however, by continually seeking directions the technologists fostered a perception among the radiologists that the technologists were not attempting to learn, a perception that encouraged the radiologists to exert even greater control. Thus the evolving interaction order drew heavily on institutional patterns of action common in the x-ray area to recreate the technologists' traditionally dependent and the radiologists' traditionally dominant role. All that was left was for the interaction order to be sealed.

Phases 2 and 3: Constructing and Ensuring Ineptitude

Since the technologists were not learning as rapidly as the radiologists had hoped, at the end of the fourth week of operation the department instituted a new duty system. Rather than rotate duty on a daily basis, each technologist would run the scanner on a staggered two-week shift. At the same time, the radiologists resolved to spend more time in their office to break the technologists' dependency. Ironically, the radiologists' retreat signaled a second phase of structuring that actually amplified the technologists' dependence.

Unexpected criticisms. In the radiologists' absence, the technologists experienced no sudden infusion of confidence and no remission in their conviction that scanning protocols were capricious. However, since they were physically separated from the radiologists, they could no longer seek directions spontaneously. The technologists now confronted their formerly tacit dilemma explicitly: to act independently and risk making a poor choice or seek advice and risk seeming ignorant. That the dilemma had become salient could be seen in the technologists' open debates over whether a radiologist should be consulted before they acted. Given the perceived trade-off, the technologists usually chose to consult.

However, since the radiologists were no longer in the control room, direction seeking required the technologists to walk to the radiologist's office. When the technologist arrived, the radiologist was invariably involved in another activity. Consequently, the technologists' questions breached the flow of the radiologist's experience, thereby amplifying direction seeking's salience. Since the radiologists were now more than ever conscious of the technologists' dependency in routine matters,

they became increasingly irritated and began to respond to the technologists' questions in a derisive manner.

Direction seeking was thus transformed into a new form of interaction, unexpected criticism, whose script had the following twist: (1) a technologist asked a radiologist how to proceed and (2) the radiologist responded with a sarcasm. Since technologists' questions now elicited ire as well as information, after being approached several times in the course of a scan, the radiologists became exasperated and often left their office to see what was going on. Once in the control room, the radiologist usually remained for the rest of the scan, and subsequent interaction reverted to patterns typical of earlier weeks.

Accusatory questions. As the radiologists became increasingly perturbed at the techs' continuing dependency, they began to claim that the technologists were incompetent, an account that fueled their proclivity to intervene when technologists sought directions or made mistakes. Moreover, since the radiologists expected ineptitude, they often found it, even when it did not exist. The self-fulfilling aspect of the radiologists' perceptions underwrote accusatory questioning, a second interactional pattern that congealed during the second phase of structuring. The accusatory question's script was marked by (1) a radiologist's accosting a technologist with insinuations of incompetence after (2) a technologist took action without seeking direction.

A telling example of accusatory questioning involved a technologist who had spent fifteen minutes successfully puzzling through a computer problem. The problem arose when the radiologist on duty requested that the technologist use parameters the scanner was not programmed to accept. As the technologist finished solving the problem, the radiologist entered the control room and demanded: "What have you been doing all this time?" As was usually the case in such encounters, the tech responded meekly. She told the radiologist that she had encountered a technical problem, but she did not mention that she knew the problem arose from his earlier request. Such encounters rapidly extinguished tentative steps toward initiative and reinforced the tendency to seek direction. At the same time, the technologists' failure to rebut the accusations strenghtened the radiologists' suspicion of incompetence, since they read the technologists' deference as guilt.

Unaware of how their own actions contributed to the situation, by the end of the sixth week the radiologists concluded that the technologists were indeed inept and that scans were taking too long to complete. From their vantage point, the experiment of granting the technologists autonomy had failed. To resolve these difficulties, on the fortieth day of operation the radiologists dropped all pretense of aloofness and resumed their former habit of remaining in the control room while patients were being scanned. This decision marked the beginning of a third phase of structuring during which scripts developed in the first phase became firmly ensconced in an interaction order that closely replicated the traditional roles of radiologists and technologists in an x-ray area.

Phase 4: Toward Independence

Urban's interaction order remained stable until the sixteenth week, when four technologists whom the radiologists labeled as least competent at body scanning were permanently transferred to the head scanner. At the same time, the experienced radiologists resumed duties in other areas of the radiology department so that the inexperienced radiologists could rotate through CT. By redistributing the relative balance of practical experience in favor of the remaining technologists, these changes triggered a fourth phase of structuring during which new patterns of interaction emerged reminiscent of those that developed at Suburban.

Technical consultation. Whereas the technical education of Suburban's inexperienced radiologists took place clandestinely beneath a veneer of self-assurance, Urban's inexperienced radiologists made no pretense that they were not ignorant in technical matters and openly turned to the technologists for aid. These consultations inverted the interaction order established during Urban's earlier structuring. In stark contrast to what had gone before, radiologists now became seekers and technologists givers of directions. The script of a technical consultation resembled direction seeking's script except that the actors' parts were switched: (1) the radiologist inquired about an appropriate course of action and (2) the technologist provided the radiologist with an answer.

Rad: *(Referring to the computer's repetitive display of alternate images)* How do I stop this?

Tech: *(Leaning over the radiologist's shoulder to type at the keyboard)* You type L . . . R . . . O . . . to turn "Load Review Off."

Rad: That's good, LRO. Now, how do I get the 512? *(He types a command into the computer.)*

Tech: Wait!!! That's not what you want. *(She pushes the correct button.)*

Rad: Oh! I see! Wonderful! Thank you.

Mutual execution. Although technical consultations inverted scripts institutionalized in previous months, the inversion did not threaten the radiologists' authority. Unlike role reversals at Suburban, where radiologists sought interpretations, in mutual consultations radiologists merely sought technical information from technologists. Though uncommon, such reliance on technologists was not taboo, since radiology's occupational rhetoric had always touted technologists to be technical experts. Perhaps for this reason, Urban's novice radiologists did not withdraw from the scanner's daily operation as did their counterparts at Suburban. But since the inexperienced radiologists could not issue minute-by-minute directions and since they willingly acknowledged the technologists' skill in technical matters, interactions between members of the two groups acquired a novel form.

The new interaction pattern, mutual execution, was more complex than any discussed so far. Mutual execution involved a balanced display of direction seeking and direction giving on the part of both technologist and radiologist. Moreover, the technologists began to offer suggestions about how to proceed, and the radiologists began to compliment technologists on their acumen:

Rad: *(Looking at the scan on the monitor)* How far are you going?

Tech: I was going to go to the top of the pancreas.

Rad: Only do ten more millimeters.

Tech: After you do the bolus you want to try a dynamic scan?[6]

Rad: Oh! Can You?

Tech: Well, I did one yesterday on a phantom.[7]

Rad: So you're prepared to do it! Great! What are you doing now?

Tech: Waiting on two more scans to process.

Rad: Oh good! Bring the table back ten millimeters and we'll start her. Now, how does it work with the lights? How does she time her breathing?

Tech: The lights [inside the gantry] will blink red three times and stay solid.

In such interchanges the identity of the lead actor shifted as both parties pooled their knowledge. Because instances of direction seeking and direction giving were interspersed with their inverses, the interaction pattern maintained the radiologists' authority. But the shifting lead also allowed technologists to demonstrate expertise, which was confirmed by the radiologists' acceptance of their suggestions. The turn taking of mutual execution therefore constituted an interaction pattern with greater equanimity than existed in earlier phases of structuring. As technical consultations and mutual execution became frequent, technologists began to exercise more discretion and radiologists loosened their control over day-to-day operations. Thus, role relations became less rigid, and Urban's interaction order moved toward a role structure in which radiologists and technologists behaved as if each possessed valuable, complementary skills.

THE SEDIMENTATION OF ALTERNATE ORGANIZATIONAL FORMS

Figure 2 displays the number of times the scripts discussed in this paper appeared in field notes taken during each period of structuring in both hospitals. The solid vertical line separates Suburban's and Urban's scripts, while the solid horizontal line separates each department's phases of structuring. Dotted vertical lines cluster the scripts from each site into sets corresponding to the phase in which they gained ascendancy. By reading across the rows of the table one can ascertain the number of times a given script occurred during a particular phase of structuring in one of the two hospitals. Columns record the frequency of a specific script during all phases at both hospitals. The quadrants on the main diagonal formed by the solid lines show the occurrence of scripts in the hospital where they were central to the evolving interaction order. Off-diagonal quadrants represent the frequency of each hospital's scripts in the field notes collected at the other.

The pattern of frequencies in the upper right quadrant of Figure 2 substantiates the claim that Suburban experienced two phases of structuring and that each sired a qualitatively different interaction order. No instances of clandestine teaching, role reversal, or blaming the technologist were observed during the first phase of structuring. However, once the inexperienced radiologists assumed CT duty, these scripts became frequent, and instances of scripts common during the first phase of

6

"Bolus" is a term for a rapid injection of iodine dye. The "dynamic scan" was a software routine that allowed a series of scans to be taken in extremely rapid succession. At this point, Urban had rarely used the software.

7

A "phantom" is an object used to tune and practice with the scanner.

Occasion for Structuring

Figure 2. Frequency in field notes of scripts that gained ascendancy during phases of structuring at Urban and Suburban hospitals.

		SUBURBAN							URBAN							
		Phase 1			Phase 2				Phase 1				Phase 2		Phase 4	
HOSPITAL	PHASE	UV	AQ	PS	CT	RR	BT	DG	CM	UC	DS	UCrit	AcQ	TC	ME
Suburban	1	6	9	0	0	0	0	10	0	0	5	0	0	0	0
	2	2	3	2	13	14	7	11	0	0	5	0	1	9	7
Urban	1	0	0	10	0	0	1	47	12	12	21	0	2	0	0
	2	0	0	1	0	0	2	14	1	7	13	11	6	0	0
	3	0	0	1	1	0	0	50	4	9	33	4	7	0	0
	4	0	0	0	0	1	0	13	0	3	11	1	0	11	10

Legend:
UV = unsought validation
AQ = anticipatory question
PS = preference stating
CT = clandestine teaching
RR = role reversal
BT = blaming the technologist
DG = direction giving
CM = countermand
UC = usurping the controls
DS = direction seeking
UCrit = unexpected criticism
AcQ = accusatory question
TC = technical consultation
ME = mutual execution

structuring declined. In fact, the few cases of unsought validation, anticipatory questioning, and preference stating observed in the second phase occurred in the first few days after the transition when the experienced radiologist was called to the CT area to assist inexperienced radiologists.

The shift in Urban's interaction order in Phase 4 is substantiated by the lower right quadrant of Figure 2 which displays the frequency of Urban's scripts during the four phases of the department's structuring. In field notes from the first three phases of Urban's structuring, no instances of technical consultation or mutual execution were recorded. Instead, most encounters between radiologists and technologists were patterned as direction giving and seeking, as countermands, as cases of usurping the controls, or as unexpected criticism and accusatory questioning. However, with the inexperienced radiologists' arrival, instances of these earlier scripts decreased dramatically, while technical consultations and mutual executions became as common as the other forms of interaction.

Both scanners upset the distribution of expertise that undergirds radiology's traditional division of labor. Both also occasioned dynamics that transformed role relations to yield CT techs more discretion than was typical of technologists in an x-ray area. Yet, the interaction orders differed. As the off-diagonal quadrants of Figure 2 attest, scripts prevalent at Suburban were uncommon at Urban, and those common at Urban were rare at Suburban. Preference stating was the only script from Suburban that occurred with frequency at Urban. In fact, preference stating actually appeared more often in field notes from Urban's first phase of structuring than it did in notes from Suburban's initial phase. To understand why preference stating was nevertheless more figural at Suburban, one must consider the interactional distinction between the two scripts as well as their relative frequency at

each site. While both scripts enabled radiologists to make demands, only when stating preferences did the radiologists justify their demands. Preference stating therefore implied that technologists deserved reasons for action while direction giving merely presumed that technologists should do what they were told. As can be calculated from the data in Figure 2, the ratio of preference stating to direction giving was 1 to 1.7 during Suburban's first phase. The same ratio was 1 to 4.7 for Urban's initial phase. Thus, by mere frequency, direction giving overshadowed preference stating at Urban and thereby strongly reinforced the technologists' perception of radiologists' professional dominance. Because the two scripts were more evenly balanced at Suburban, direction giving's bold enactment of the radiologists' dominance was moderated by preference stating's emphasis on collegiality.

Technical consultation and mutual execution also appear as exceptions to the larger pattern in Figure 2. Both scripts occurred almost as frequently at Suburban after the inexperienced radiologists began CT duty as during Urban's corresponding phase of structuring. However, at Suburban the two scripts were interspersed with instances of clandestine teaching, role reversal, and blaming the technologists. These latter scripts were not only more salient for Suburban's personnel, they almost never occurred at Urban. Consequently, the two sites appear to have evolved different interaction orders, even though the two CT areas' scripts did not form mutually exclusive sets.

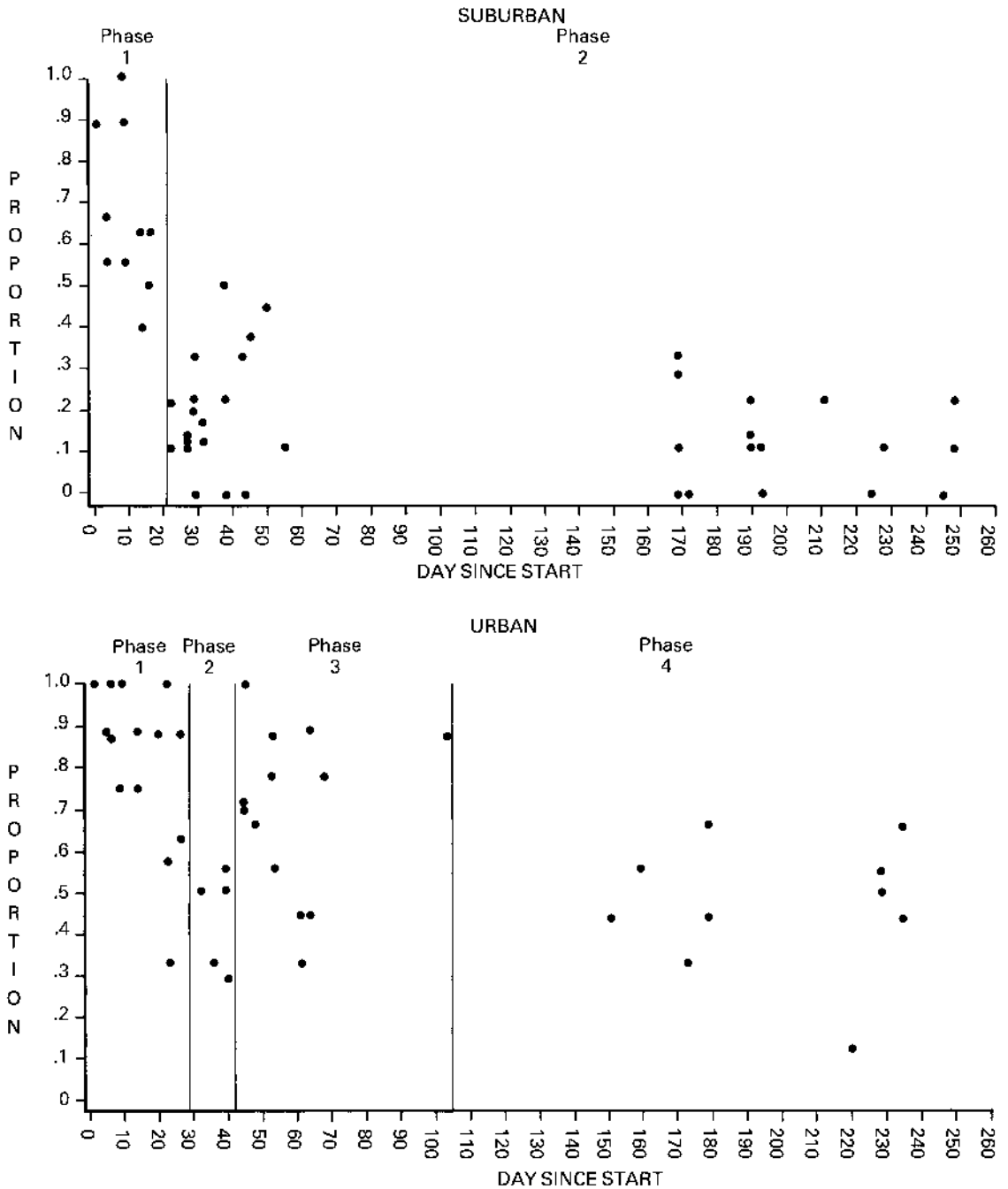
However, from the perspective of the sequential model of structuring, identical technologies lead to different organizational structures only when they occasion interaction orders that vary in a consistent and coherent manner. For alternate organizational structures to arise it is insufficient for two interaction orders to be composed of different scripts. The scripts in each interaction order must also consistently embody overarching properties that differentiate the two systems. Thus, if structure is viewed as a grammar of scripts, the two scanners can be said to have occasioned different structures if and only if each department's scripts inscribe alternate, coherent blueprints for action.

Institutional patterns of interaction between radiologists and technologists were predicated on the radiologists' dominance, which was legitimated by the authority of expertise. As a formal property of interaction, dominance by expertise is encoded by the direction in which information flows. As Blau (1964) and Emerson (1972) have argued, to possess and send information is to enact power over its recipient, at least for the duration of an encounter. Defined in terms of communicative exchange, dominance finds expression as a structural property of organizations in the concept of centralization. In centralized organizations, decisions are not only made by actors with superior hierarchical status, but information and decisions also flow, by definition, down the status hierarchy.

In terms of the direction of information flow, the scripts that compose the two interaction orders coherently and consistently display quite different formal patterns. Suburban's scripts indicate that structuring progressed from an interaction order characterized by mutual exchange to an interaction order

in which technologists became the senders and radiologists the recipients of most information. In contrast, Urban's structuring moved from an interaction order in which radiologists possessed and sent all information to an interaction order marked by a more balanced sharing of information. Consequently, on the basis of scripts, it would appear that the scanners not only occasioned a more decentralized structure at Suburban but that Suburban's interaction order thereby departed more significantly from tradition than did Urban's.

Figure 3. Proportion of operational decisions made by radiologists at Suburban and Urban hospitals.*



*The missing data between days 80 and 145 represent weeks during which no fieldwork was conducted.

Independent verification that Suburban was more decentralized can be obtained by examining the proportion of a scan's routine decisions made by a radiologist. Figure 3 plots these indices for Suburban and Urban as a function of the day of operation on which the scan was conducted. The postulated phases of structuring at each site are indicated by vertical bars. The figure shows that the proportion of decisions made by radiologists was generally much lower at Suburban than at Urban. In 78 percent of Suburban's 49 scans radiologists made less than half the decisions, while the corresponding percentage for Urban's 42 scans was 26 percent.

Moreover, the plots suggest that each department moved toward a more decentralized structure at rates intimated by the analysis of structuring at the two sites. Although radiologists initially made most of the routine decisions in each CT area, their involvement at Suburban fell, at what appears to be a geometrically declining rate. On the other hand, the radiologists' involvement at Urban appears to have declined gradually in a linear fashion. By regressing the proportion of routine decisions made by a radiologist first on a linear model specified by the day of operation on which the scan was conducted and then on a quadratic model constructed by adding the square of that value, one may test whether the visual differences are significant. If structuring progressed as suggested, then a quadratic model should predict Suburban's data better than a linear model, while in Urban's case no improvement should be found. The regression analysis displayed in Table 1 shows precisely such a result: addition of the quadratic term to the linear model significantly increases the proportion of explained variance only for Suburban's data.

Table 1

Linear and Quadratic Trends in the Proportion of Operational Decisions Involving Radiologists*

Hospital	Model	Intercept	Day	Day²	R^2	Df	F
Suburban	Linear	.40	−.001				
		(9.14)**	(−4.20)**		.27**		
	Quadratic	.53	−.006	2.15(10⁻⁵)			
		(8.94)**	(3.67)**	(2.88)**	.38**	(1,46)	8.36**
Urban	Linear	.77	.002				
		(17.29)**	(3.60)**		.24**		
	Quadratic	.86	−.005	1.41(10⁻⁵)			
		(13.38)**	(−2.63)**	(1.83)	.30**	(1,39)	3.33

*$p < .05$, **$p < .01$
* Numbers in parentheses are t-tests for corresponding parameters.

The plots also show the adequacy of the phases of structuring identified for each department. Suburban's plot suggests that an inflection point occurs shortly after Suburban's second phase was alleged to have begun. The plot therefore appears to verify a rapid increase in the CT techs' discretion shortly after Suburban's inexperienced radiologists assumed CT duty. Urban's data also trace the alleged sequence of phases. Note that Urban's radiologists' involvement in routine decisions fell briefly in the second phase of structuring when the experienced radiologists momentarily withdrew from the control room. However, involvement rose during the third phase when

the radiologists abandoned their strategy of restraint. Finally with the arrival of Urban's inexperienced radiologists during the fourth phase, Urban's scores once again fell.

To determine if the centralization scores support each site's alleged phasing, the proportion of decisions radiologists made at each site was first regressed on a series of dummy variables that coded each scan's date in terms of the phase during which it allegedly occurred. Since Suburban was said to have experienced two phases and Urban four, Suburban's data were regressed on one dummy variable representing the first phase of structuring while Urban's data were regressed on three variables representing Urban's first three phases. Each site's data were then regressed on all four dummy variables in a combined analysis. If each site's phasing was adequately defined then the combined model should predict radiologists' involvement no better than the model constructed to depict the site's own phases of structuring. Table 2, which presents the regression analysis, shows such a pattern of results: in neither case did the combined model substantially increase the proportion of variance explained by the hospital's own model. Consequently, the data are consistent with the claim that Suburban evolved through two phases of structuring while Urban experienced four.

Table 2

Adequacy of Each Department's Own Model of Structuring for Predicting the Proportion of Operational Decisions Involving Radiologists*

Hospital	Model	Intercept	Suburban Phase 1	Urban Phase2	Urban Phase2	Urban Phase3	R^2	Df	F
Suburban	Suburban	.17	.50						
		(7.46)**	(9.96)**				.67**		
	Combined	.13	.53	.01	.07	.14			
		(3.99)**	(6.91)**	(0.21)	(1.31)	(2.12)*	.71**	(3,44)	1.43
Urban	Suburban	.47		.36	−.04	.22			
		(8.20)**		(4.77)**	(0.39)	(2.90)**	.45**		
	Combined	.47	.22	.21	−.04	.22			
		(8.66)**	(2.34)*	(2.19)*	(0.41)	(3.06)**	.52**	(3,37)	1.54

*$p < .05$, **$p < .01$
*Numbers in parentheses are t-tests for corresponding parameters.

CONCLUSIONS

If nothing else, the foregoing analysis demonstrates that by treating technology as an occasion for structuring, researchers will confront contradictory results head-on because of structuring's central paradox: identical technologies can occasion similar dynamics and yet lead to different structural outcomes. Despite the fact that both structuring processes conformed to the sequential model of reciprocal articulation and despite the fact that roles in each department changed in similar directions, one department became far more decentralized, because formal properties governing the scripts of the two interaction orders diverged. One suspects that traditional cross-sectional studies that seek large sample size and ignore contextually embedded dynamics would risk concluding that scanners have no implications for the social organization of radiology because differences in formal structures would tend to cancel each other

in correlational analysis. However, to view technology as an occasion for structuring is not to deny the worth of previous work on technology's relation to structure, but rather to modify and specify that work.

A materialist, for example, might argue that the CT scanners' physical properties occasioned structural change by impinging on the organization of radiological work. In the literature on technology and structure, technical complexity is often considered relevant in this regard. Materialists would likely point to the scanner's technical complexity and to the complexity of its diagnostic signs to argue that role structures loosened because the scanners introduced uncertainty into a world hitherto well understood. The present approach would concur. At both hospitals the scanners' technical complexity and the radiologists' lack of familiarity with CT's diagnostic signs threatened the inexperienced radiologists' authority and forced them to rely more heavily on the technologists. However, from the perspective of structuring theory, complexity and uncertainty are functions of how the machine merged with the social system; they are not attributes of the machine itself. That is, the scanners occasioned change because they became social objects whose meanings were defined by the context of their use. Suburban's scanner generated more uncertainty and mounted a greater challenge to professional dominance because Suburban hired experienced technologists and because the inexperienced radiologists assumed CT duty at an early date. At Urban, the scanner's threat was mitigated because the department staffed the scanner with novice techs and relied longer on knowledgeable radiologists.

These differences surely influenced the relative distribution of expertise that constrained the structuring process. But the constraints only partially account for Urban's greater centralization. If the actors at each site had negotiated their roles differently, if, for example, Suburban's radiologists had assumed a stance similar to Urban's novices, then structuring would have evolved differently in spite of the distribution of expertise. Alternately, had Urban's radiologists realized the self-sealing aspect of their behavior, the interaction order they helped create might have been transformed. Furthermore, if all radiologists had studied CT scanning prior to adoption, then the scanners would have surely occasioned other interaction orders and, by implication, other formal structures. In short, structuring theory holds that technical uncertainty and complexity are social constructions that vary from setting to setting even when identical technologies are deployed. Although this phenomenological point was stressed by Perrow's (1967) classic paper on technology and structure, its implication for a diversity of outcomes has never been fully appreciated.

A voluntaristic theory of technology's ramifications, such as the one found in Child's (1972) work, might claim that the data show how decision makers actually determine technology's implications, since structuring unfolded as radiologists made staffing decisions. Staffing decisions did signal the beginning of each phase of structuring and were indeed influential in shaping structuring's dynamics at each site. But that the radiologists intended the consequences of their decisions is questionable. While the radiologists hired and assigned personnel in certain sequences, the data do not suggest that they

intended to affect the degree of centralization. Suburban's radiologists hired experienced technologists to reduce the odds of exposing patients to incompetence and themselves to malpractice suits. Urban used inexperienced technologists because of the hospital's policy of promoting insiders. There is even evidence that some staffing decisions shaped the structuring process in directions opposite of what was intended. For example, Urban's radiologists withdrew in the second period of structuring to discourage rather than encourage the technologists' dependence. Thus from the perspective of structuring theory, decision makers may in fact influence the evolution of interaction orders, but the structural consequences of their decisions are likely to be unanticipated.

Structuring theory thus departs from previous approaches to the study of technology by postulating that technologies are social objects capable of triggering dynamics whose unintended and unanticipated consequences may nevertheless follow a contextual logic. Technologies do influence organizational structures in orderly ways, but their influence depends on the specific historical process in which they are embedded. To predict a technology's ramifications for an organization's structure therefore requires a methodology and a conception of technical change open to the construction of grounded, population-specific theories. For example, to devise a theory of how technology alters radiological work, one would need not only to account for relative distributions of expertise but to develop a taxonomy of scripts to explain how distributions of expertise can be accommodated differently in daily interaction. Structuring theory is a form of soft determinism that searches for regularity by looking down time lines to see how diversity is occasioned by specifiable social processes. Such an idiographic approach is warranted, because structure is viewed as the abstract of a social history written by ongoing interaction. No one is surprised that families are constrained by histories and ritualistic patterns that relatives unwittingly author and sustain in systematic ways. Why should the structures of larger collectives be different in kind?

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