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The Cultural Ecology of Intraogranizational Space

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INTRODUCTION

Although there is an entire branch of organizational science that is dominated by ecological theory (*i.e.* population ecology; see Aldrich, 1979), past research has been limited by a focus on 1) the relationship between the organization as a whole and its external environment, and 2) the macro-level correlation of abstract variables (*e.g.* structure, technology) in different environmental contexts. Further, since the heyday of past ecological research was in the 1960s and 1970s — prior to the "discovery" of organizational culture — past ecological studies of organizations did not incorporate a concept of culture.

The approach presented in this paper will break new ground by applying the theory and method of ecology to the small-scale work group. Using the writings of Julian Steward, Amos Hawley, and the population ecology school of organizational theory as starting points, the paper will demonstrate the use of ecological concepts and methods to explain variability in work group responses to new computer-aided technology (CAT). Our approach differs from earlier work in three ways: 1) our focus will be on relations between the work group and its immediate environment, which is largely comprised of things *inside* a complex organization; 2) our database will be structured not around abstract variables, but around detailed descriptions of actual work group behaviour in its natural setting; and 3) we will incorporate the concept of culture as an adaptive system, including locally distinctive ideas, meanings, values, norms, behaviours, and material artifacts. In this paper we will explicate our approach, discuss the ways in which we were required to adapt ecological theory for application to work group behaviour, and postulate a process by which the perceived meaning, value and instrumental utility of new technology is shaped by differential resource allocations and resulting ecological patterns within local areas of the organization.

BACKGROUND: DATA BASE AND METHODOLOGY

The data from which our theoretical understanding emerges have been gathered in the course of a problem-oriented industrial research project. A multidisciplinary team of university-based researchers was commissioned to investigate the role of culture in the implementation of new computer-aided technology (CAT) within a large manufacturing enterprise. The implementation was intended to enhance the client's product development process by introducing a unified CAT system that would enable integration of various product development functions through the sharing of electronic data. Our research client was concerned that cultural factors at the work group level could present barriers to the introduction of a new technology aimed at cross-functional integration.

The importance of social, organizational, and cultural factors in shaping the outcomes of new CAT implementation has been well documented in the literature (Adler, 1989; Majchrzak et al., 1987; Tornatzky and Fleischer, 1990). The socio-cultural and organizational systems of corporations and work groups present many complex challenges to, and constraints on, effective utilization of CAT, resulting in suboptimal results from large technological investments (*e.g.* see Majchrzak, 1992). The purpose of our investigation was two fold: 1) to identify social, organizational, and cultural factors in the client organization that could influence the implementation of new CAT; and 2) to recommend culturally-appropriate strategies that would facilitate technology integration within the framework of the humanistic tradition (*i.e.* technology in the service of developing human potential versus other non-humanist objectives described by Braverman [1974]). Following our research, it was intended that we would enter into a separate phase of activity in which we would apply the knowledge we had gained by providing consultative advice to work groups involved in new technology implementation. Additional knowledge gained from these consultations would enable the development of a process guide that could be used all over the corporation to support humanistic technology integration. It was our hope that this work would give work group members a stronger voice in technological decision-making, as we intended to build the views of work group members into the process guide.

To achieve these objectives, our eight-member, multidisciplinary team (including anthropologists and engineers) selected eleven work groups within five major corporate divisions for ethnographic study. The sites represented a range of different work functions, including component engineering and design, prototype manufacturing, manufacturing engineering, and a diverse array of engineering support functions (*e.g.* purchasing, transportation) — all places where the new computer-based technology would be introduced as an integrating mechanism. Over an eighteenth month period, the study team spent over 400 hours in the field at the eleven work sites, conducted about 200 ethnographic interviews, and engaged in many hours of observation focused on work group activity and the use of new technology. We custom-designed our methodology, in cooperation with client management, to enable unobstrusive observation of work activities. All interviews were confidential and voluntary, and took place at times that were mutually agreeable to management and to the individual being interviewed. The ethnographic data gathered during this research served as the empirical base from which our theoretical observations are derived. [The study team also designed a comprehensive questionnaire which was administered to 150 work group members.]

When we began the project, we deliberately did not adopt any particular theoretical model of culture. We wanted our explanations to be grounded in empirical data emerging from field work. In keeping with such a generalist orientation, we developed a field protocol that emphasized capture of a broad range of different types of data pertaining to CAT, including: 1) direct observation of individual work behavior and the physical setting of work and technology; 2) direct observation of work group interaction (*e.g.* CAT demonstrations, problem-solving); 3) site visits (including observation and interviewing) to other work groups that interact with our focal groups; 4) verbal descriptions of individual and work group behavior, and the role of CAT; 5) verbal descriptions of individual attitudes and values pertaining to CAT; 6) observation and participation in CAT-related meetings with members of the focal group; and 7) documents produced by the focal groups (*e.g.* organizational charts, business plans for CAT). Field notes from these experiences were transcribed into a computer-based data file, and content analyzed using Talley 3.0 software.

THE ARRIVAL OF CULTURAL ECOLOGY

Although our study team was committed to induction, we realized that we needed some kind of overarching conceptual framework if we wanted to compare work group cultures across the large number of sites in our study, and explain their behavioural and attitudinal differences and similarities with respect to CAT. Our field protocol ensured that we had gathered comparable types of data, but we still needed comparable conceptual categories to guide data analysis. [Indeed, a struggle unfolded within our study team as we grappled with the issue of how to conduct cross-site analysis in the absence of a theoretical model; some members wanted to stick with a totally emic approach to analysis and let the comparison fall where it may, others wanted to develop an etic framework before analysis began.]

Our atheoretical posture became increasingly untenable as the result of a promise we made to our sponsor following the initiation of research. We had agreed to develop (after data analysis) a means to translate our findings into some concrete action steps that work groups could use to identify and address key cultural issues related to CAT implementation. To develop diagnostics and intervention strategies clearly would require a theoretical model of culture that would enable some ability to project anticipated outcomes based on an assessment of the existing social and organizational system. We needed to agree on what a culture is, and how it interacts with CAT. Otherwise, how could we possibly know what our diagnosis should be looking for and what we should recommend for work groups that we had not yet seen?

The idea of using cultural ecology as an explanatory framework emerged after we had completed data collection and were engaged in the process of trying to make sense of work group response patterns. As we began this process, we found that there was enormous variability in the responses of different functional groups to new CAT. Some groups were eager to receive the new technology and had already successfully completed large-scale implementations. Other groups were cautious in their acceptance, adopting the new technology on a small-scale pilot basis. Still other groups were highly resistant, displaying quite negative attitudes with some even going so far as to reject the new technology altogether.

As we studied our field data, it became clear that each of these response types — eager acceptance, cautious trial, and open resistance — represented logical extensions of long-term group patterns of adaptation to local environmental situations. Groups that were eager to receive new technology had a history of assuming technological leadership, and of taking technological risks. Such behavior was most typical in product design groups where there was an abundance of technology and a strong dependence on computer tools in the work process. Groups that were cautious in their adoption and utilized small-scale pilots often had no internal need for the CAT applications that were being deployed, but felt they had to be conversant with the new technology in order to interface with the design groups. They also argued that they needed to be flexible technologically in order to interface with a large number of other units, some of which used other types of CAT systems (not the ones being implemented) or did not use CAT at all. These kinds of responses were most often seen in groups that supported the design and manufacturing process. Finally, work groups that were highly resistant to CAT often were technological laggards generally. They argued that they did not need the new technology in order to do their work, and that its adoption would severely cripple their work capacity. Most of these groups (which were found both in design and in support) were using obsolete technologies to do their work. For these groups, use of obsolescent technology represented the conscious choice of doing work in a traditional way, as opposed to risking the switch to a new mode of work that might jeopardize their ability to do work at all.

What was most striking about these responses was that, despite their diversity, their basic logic was the same. Each group seemed to be saying: we are responding to new CAT in the same way that we have always responded to new technology, in a way that we believe will enhance or protect our ability to do our work in the way that we want our work to be done. Most importantly, the groups' responses appeared to be an extension of meanings, values, and norms that had developed over time, within the context of different functional missions and different internal organizational environments. Or, phrased differently, work group responses to new CAT seemed to be a function of long-term adaptive (or, possibly, maladaptive) processes inside the corporation.

CASE STUDY ILLUSTRATION

An illustration of one such adaptive response pattern is provided by our study of the Transportation Support Group (TSG). This was a work group of nine "engineers" (not all of them had formal training in engineering) and one supervisor who were responsible for the design, construction, and maintenance of large containers used to ship the company's parts from manufacturing to assembly plants. Because this group did not perform a core function, much of their activity was out-sourced to external suppliers who would design and build the containers under contract. The "engineers" in the TSG did not have the skills necessary to design and construct the containers themselves; it was their job to manage the external suppliers.

Over the years, the TSG had carefully selected and developed long-term relationships with a diverse group of external supply firms that had talented people with the requisite skills. Among these skills was the ability to use computer-aided design (CAD) equipment to design the containers. Each external supply house used whatever type of CAD equipment it desired, and the TSG group would purchase one workstation of that equipment type so that they would be able to access and read all of the designs created by the various supply houses. In all, the TSG had collected more than seven types of computer and non-computer tools for creating container designs, based on the diverse capabilities of their external suppliers.

The corporation in which TSG was located had developed a strategy to commonize the technologies and work processes used throughout the product development process. This strategy was aimed at ensuring that all of the many groups involved in product development would have access to a single up-to-date master copy of each part being designed. This would enable better coordination of the many parts needed to construct the company's complex product, and also speed up the time needed to design the parts. The TSG also was expected to adopt the strategic technology and to require its suppliers to do the same. Even though the TSG did not actually design parts, it used the designs of parts to create the containers that carry parts. Therefore, the new strategic technology was relevant to the TSG's work process.

While the TSG eagerly adopted the strategic technology and hired new engineers (with degrees) to operate the equipment, they refused to abandon any of the seven different types of design tools and methods they had collected previously, and they refused to force their suppliers to adopt the new strategic tools. According to TSG members, they (TSG) were not expert in CAD technology — the supply houses were the experts. If the supply houses did not choose to adopt the strategic technology, then the TSG did not believe that it (TSG) had a legitimate right to force the suppliers to comply; after all, the TSG followed the suppliers advice when it came to technology selection. Furthermore, if the supply houses would not comply (and many of them would not, since the strategic tools were very expensive and often were not compatible with the computer systems used by the suppliers' other customers), then the TSG would need to retain all of the previous design tools in order to be able to continue to interact with the suppliers using compatible technology.

The end result was that the TSG increased the diversity of its design tools by adding the strategic technology, but refusing to part with the other tools. This was exactly the opposite result intended by the strategic technology program of TSG's corporate parent. The addition of the strategic technology conformed with the TSG's habit of collecting all of the tools used by "significant others" (*i.e.* these new tools would be needed to communicate with other groups inside TSG), while its refusal to part with its pre-existing collection of tools enabled TSF to continue its historic relations with external exchange partners. In other words, long-term adaptive patterns were maintained and extended, while the corporation's objective of commonization was thwarted.

Once we recognized the potential importance of long-term adaptive responses and local environmental conditions to the explanation of our data, we began to conceptualize each work group as an adaptive subculture, existing within a specialized niche in a larger organizational environment. Each group's response to new CAT was the logical outgrowth of a long-term adaptive pattern. To explain variability in responses to CAT, we therefore needed to understand variability in work group niches and in long-term adaptive patterns. This conception was immediately compelling to our study team; intuitively, we sensed that this approach fit the data.

CONCEPTS OF CULTURAL ECOLOGY

Our understanding of human and cultural ecology is drawn from the work of Steward (1955), Harris (1968), and Hawley (1986). In this literature, culture is viewed as a system of adaptive responses (including ideas, meanings, values, and norms) to environmental opportunities and constraints which emerge over time. For the cultural ecologist, adaptive group responses (*i.e.* culture) and their environmental contexts form a larger interacting system, one in which cultural and environmental subsystems continuously influence one another.

Environment and Ecological Niches

The cultural ecology perspective begins with an analysis of the effective environment in which a social group operates. The effective environment includes both *objective* conditions and entities, as well as *perceived* conditions and characteristics of the organization's context. It is necessary to include both objective and perceived characteristics to ensure a robust conceptualization of environmental forces (Kaplan and Manners, 1972).

An important goal of environmental analysis is to define the specific ecological niche in which a particular social group functions. Several objective dimensions of effective environment may be considered in defining the niche for any particular group. The literature of organizational ecology includes dimensions such as resource abundance/scarcity, environmental heterogeneity/ homogeneity, environmental stability/instability, environmental concentration/dispersion, degree of domain consensus, and degree of turbulence (Aldrich, 1979). These dimensions have been developed primarily in studying the relationship between an organization and its external environment. Operational definitions of these dimensions may be developed contingent on the specifics of the research problem. The dimensions are sufficiently objective to enable comparative analysis of a wide variety of environments, although not all of the dimensions are equally important in all situations. Different configurations of dimensions are needed to describe niches in different environmental settings.

Adaptive Cultural Responses

In the theory of cultural ecology, a social group adapts (*i.e.* responds over time) to its environment through a cultural system that contains several interrelated dimensions (Steward, 1955). The economic system and technology used by the group constitute one important dimension of cultural adaptation; these constitute an adaptive techno-economic grounding with respect to the environment, *i.e.* that part of the culture that links most directly with the physical aspects of the ecological niche. A second dimension of cultural adaptation is the social organization and behaviours of the group, *i.e.* the quality and quantity of social roles, relationships and interactions within and between groups. This organization allows the group to utilize its technology and enact its economic system in response to environmental demands and pressures. A third dimension of adaptation is ideology, *i.e.* ideas, meanings and values. A group's ideology also can be viewed as part of an adaptive response — it supports the shared interpretation of events and circumstances, and helps to coordinate group activity within an adaptive framework.[1]

Over the long term, the techno-economic dimension influences the other two dimensions of cultural adaptation (social organization and ideology); that is, certain key elements of these latter dimensions (but not necessarily all of them) appear to adapt themselves to the demands and constraints of technology and economy, which in turn adapt to a changing organizational environment. There are, however, important feedbacks from social organization and ideology that influence and constrain technology and economy over the near and intermediate terms. Differences in adaptive patterns (defined by different configurations of techno-economic, socio-organization, and ideological dimensions) that reflect different types of niches are expected to explain a substantial amount of variability across cultures. Differences in relationships *among and between* adapting systems also should explain some of the observed variability.

ADAPTING CULTURAL ECOLOGY FOR THE STUDY OF WORK GROUPS

The application of ecological theory to work groups within a complex organization posed some difficult theoretical and practical problems. Most difficult was the translation of concepts and definitions from literatures focused on entire societies and large organizations to small functional work groups within a complex organization. Here we review some of these problems and discuss ways in which we coped with them.

Nature of the Focal Group and Its Ecological Context

The literature of human, cultural, and organizational ecology has focused almost exclusively on levels of organizational phenomena that are larger in scope and scale than the small functional work groups we were studying. Earlier work has concentrated primarily on non-literate bands and tribal societies (Steward, 1955), cities (Hawley, 1986), and complex organizations (Aldrich, 1979). Few studies have applied an ecological perspective to the *inside* of an organization, while simultaneously viewing the work group as an adaptive system within that setting. One exception is Lawrence and Lorsch (1967), who examined the degree of differentiation and integration between different organizational subsystems within complex organizations.

Our rationale for applying the ecological perspective to the inside of an organization is grounded not so much in the argument that organizations may be viewed as ecological systems as it is grounded in the idea that work groups may be viewed as culture-bearing units. Functional work groups do appear to constitute culture-bearing social groups since they display the following characteristics: a) a fairly stable membership over time; b) membership boundaries; c) a distinctive realm of shared collective work experience; d) geographical co-location; e) engagement in joint problem-solving; f) a set of shared social roles and relationships; and g) distinctive work behaviours, social roles/relationships, and beliefs which are taught to new members. Indeed, many functional work groups have been viewed explicitly as subcultures by anthropologists and sociologists (see for examples Trice, 1993). We suggest that if this application of the culture concept is correct then functional work groups also may be viewed as adaptive subcultural systems existing within an ecological setting. Because the environment of most work groups within complex organizations is the inside of the organization itself, then we submit that the internal environment should be viewed as the ecological context for evolving adaptive responses.

The Environment

The ecological literature on small-scale societies has characterized the environment and its niches primarily in terms of physical geography, climate, and flora and fauna. The literature on complex organizations has defined environments and niches largely in terms of other organizations and the control that such environmental entities have over resources and resource configurations (*e.g.* resource abundance, stability, diversity). Clearly, the first conceptualization of environment is not appropriate for modern industrial work groups in a manufacturing firm: most of these have little if anything to do with the natural environment. The second type of conceptualization, on the other hand, appears to be quite appropriate. Inside a corporation, the environment will consist largely of other work groups, both inside and outside the corporation. Further, the nature and availability of resources within organizations certainly is an important consideration in the adaptation of work groups over time.

Dimensions of Environment and Niches

Some problems arise, however, in trying to transfer the conceptual baggage of organizational ecology to the task of defining the dimensions of the environment within an organization. In much of the organizational ecology literature, the environment has been defined largely in terms of its objective dimensions, particularly resources — what kind, how many, how available, how stable, and who controls them. The focus on these resource-related dimensions has been driven largely by contingency theory in organizational science. Contingency theory has established the goal of determining whether and to what extent different environments and niches within environments influence other organizational variables (*e.g.* structure, interorganizational relations). Resources are one aspect of the environment that is more or less consistent across organizational settings and can be measured objectively.

In our research, however, we were not interested strictly in statistical correlations among abstract variables (although such correlations may make a contribution to ecological analysis). Rather, we were trying first of all to understand in the broadest descriptive terms *how* groups respond to new technology and, even more importantly, *why* they respond as they do. In other words, we had an inductive agenda, one which did not preclude the discovery of new variables that might be unique to a particular group, and/or might involve subjective perceptions.

As we approached our data from an ecological perspective, we first looked for objective, resource-focused dimensions of environment used by other organizational scholars. This approach proved fruitful. We found that relative resource abundance/scarcity over time was an important consideration in understanding how and why groups respond to new technology. Work groups that have greater access to technological resources over time tend to display a greater interest in new technology, and also have a stronger tendency to encourage all (or more) group members to use new technology. Thus, work groups which were far forward in the product development process — for example, engineering design groups that created the proprietary designs for the companies' core products — had access to virtually unlimited technological resources, with human resources being relatively plentiful as well. This was because management policy designated the work of these groups as critical to the company's success in the marketplace, and spared no expenses to ensure that these groups had the tools and skills they needed to keep ahead of the competition. Groups in such niches often had advanced computer design tools, with each group member having his or her own workstation as well as access to training to keep them abreast of the state-of-the-art.

Conversely, if technological resources are scarce, the work group will of necessity need to develop ways of dealing with tasks that do not rely on having the most advanced technology, or on having everyone use advanced technology. Adaptive responses in technologically scarce environments emphasize the need for maintaining a range of work methods that include older technologies, shared technologies, and reliance on the technological resources of others. This was the situation faced by the TSG. Management policy designated their work as less critical to the company's success, and so they were not given access to the technology or the human resources to enable them to do all of their work themselves. Most of their work was outsourced to a large number of external suppliers. To enable interaction with the supplier community, the TSG had managed to cobble together a suite of tools and methods that matched those of the suppliers. Sometimes TSG members had to use their own personal funds to purchase needed equipment, and sometimes they opportunistically took advantage of chances to expand their suite of tools when that possibility arose. The range of tools collected was not dictated by the TSG, however, but by the suppliers. Further, many members of the TSG did not have the skills to use the full suite of tools; only a couple of members could use the most advanced computer workstations. Management did not believe that all members of the TSG needed to be completely computer literate, since the computer design work was not handled by the TSG. Thus, resulting from resource allocation decisions inside the firm, the TSG developed a set of ecological relationships that coped with internal resource scarcity. Maintenance of these ecological relationships engendered certain values and meanings, namely that a) it was desirable to maintain a full suite of technologies rather than commonizing to one strategic system, and b) that technology was more a means to maintain external relations that a means to do design work (which in turn meant that the primary objective of the new strategic technology — to integrate design work — was not acknowledged or recognized as important in this group).

Two other, interrelated dimensions of the environment that proved useful in under- standing the adaptive responses of work groups were those of environmental stability/instability and heterogeneity/homogeneity. We defined these dimensions in terms of the nature of inter-group linkages; that is, how stable or unstable were a group's exchange relationships with other groups, and how homogeneous or heterogeneous were these relationships? Both of these dimensions are resource-related, since it is resources that are flowing through the linkages with other groups. However, we are interested in measuring the nature of the linkage, as well as the nature of the resources. Here, we discovered that groups which had stable exchange relations with a limited number of other groups appeared more likely to adopt technologies that were compatible with their exchange partners, particularly among groups that were primarily exchange recipients (rather than senders). In other words, part of the groups' adaptive response to stable exchange with one or a few partners involved the establishment of technological compatibility. On the other hand, groups that have unstable or fluctuating exchange relations with a large set of partners had a greater tendency to maintain technological autonomy and flexibility, *i.e.* the right to determine technological solutions that allowed the greatest ease of use and compatibility with the largest number of potential partners. Thus, when we examined the technology practices of a large number of manufacturing plants, we found that those who produced parts for a single large customer tended to favor a single type of technology that was compatible with that customer, while plants that interacted with a large number of different customers favored heterogeneous technological systems. [The stability and homogeneity variables may not be independent of one another, since a large number of different exchange partners might be caused by, or cause, fluctuations in exchange relations.]

Unfortunately, the other resource-related dimensions provided by the literature were not of much use. Either we did not have sufficient data to enable their application (*e.g.* domain consensus), or the variable did not seem appropriate when applied to a work group (concentration/dispersion, although this might be relevant if defined in terms of time or location of exchange partners), or there was insufficient variability to explain differences in a group's adaptive responses (*e.g.* degree of turbulence; all groups were highly interconnected and appeared to face a relatively high degree of turbulence).

One disadvantage of the resource-related variables is their high degree of abstractness. Saying that a group has rich resources or heterogeneous exchange partners doesn't tell us much about the nature of the group's work, or how it does what it does. Because we were committed to ethnographic description of work group responses to new technology, it seemed appropriate to look for variables that describe differences in the actual work niches of different groups. In conceptualizing such variables, we received help from biological ecology. In biology, an organism's ecological niche is conceptualized as the organism's "address" (*i.e.* where it lives) and it's "occupation" (*i.e.* what it does for a living).

Conceptualizing Corporate Ecology

Thinking about biology, we began to imagine the inside of the corporation as a map or grid, arranged along certain key axes, with each group's niche located at specific coordinates on the grid (see Fig. 1; see Baba, 1995a). Because we were interested in the product development process, our map of the organization used that process as the X axis in defining our map. The point closest to the point of origin was the beginning of the product development process (concept formation and design); the point farthest away from the point of origin was the end of the process (manufacture/marketing). This made it relatively simple to plot each group's location along the X axis; design groups first, development groups next, then manufacturing. Clearly, work groups at each of these locations share certain work niche features in common, not only with respect to what they do, but how they do it. For example, there will be certain work processes and technologies that are unique to design groups and are not shared with manufacturing groups.

The Y axis was more difficult to define. Since the X axis had already been defined as the product development process, our initial concept was to define variables that would place the work group closer to or farther from the X axis; that is, closer to or farther from the product development process. Thus, groups that were close to the point of origin on the Y axis would be those that participated most directly in the product development process (*e.g.* design or manufacturing), while support groups would be farther away from the Y axis point of origin.

This concept proved fruitful, with one modification. We decided to make a three-fold distinction in the degree to which the group impacted product development. Groups with "direct design authority" were those with the authority and clout to alter the design of the product. Both design and manufacturing groups have such clout. Groups with "indirect design authority" were those which could modify design indirectly, by convincing another group of the need. Materials- handling groups have indirect authority, because they can argue for design changes based on materials considerations. Groups with no design authority were simply labeled "support"; they had no impact on design at all. Work groups that check the accuracy of parts against design specifications represent this third group.

With these two axes defined, we now had a two-dimensional grid on which all of our work groups could be plotted. Clearly, other dimensions could be determined which would produce different maps. For example, time could be added as a third dimension which would indicate different relative start times for groups clustering in each of the different areas of the map. Or, internal political and/or economic power, or organizational status, could comprise one or more of the axes. The nature of the X and Y axes (and Z axis, if appropriate) should depend upon the nature of the research question.

The interesting thing about an internal, work-related map of the company is that it provides a reasonably objective, empirical, graphic means by which to demonstrate the internal corporate environment of work groups and the relationship of different work groups to each other. Each group's placement can be thought of as a distinctive niche. Placements were based on a combination of etic and emic factors; that is, if we found that the group was located in a manufacturing plant and people in the work group viewed themselves as members of the plant community whose work was plant-based, then we would place that group relatively far downstream on the X axis (even though the management of the organization might believe that, ideally, this particular group should be involved far upstream in the design process). Groups will cluster on the map contingent on the nature of their work. We call such clusters zones; we defined three zones based on the clusterings of our work groups (see Fig. 1). Theoretically, such placements and clusterings in zones should suggest something about their adaptive responses to technology.

Once such a map has been developed, it is possible to use it to think about the resource related variables described above and to determine whether there are resource gradients on the map. Indeed, we discovered that it was possible to connect resource variance to map locations; generally, zones that were closest to the point of origin for both the X and Y axis, and/or to the X axis, were more likely to have resource rich (or non-scarce) environments. Zones that were farthest away from either of the axes had fewer technological resources. We also believe that stability and homogeneity of exchange partners decreases as one travels away from the X and Y axes. Since the X axes represents the technological core of the corporation, it stands to reason that groups located along this axis will be protected from the instability that can accompany heterogeneity of exchange partner relations. The tendency of the map to define resource and linkage gradients suggests that the dimensions of the map (*i.e.* location in, and proximity to, the product development process) may be causal to the distribution of resources and the formation of linkages.

Adaptive Responses of Work Groups

In ecological theory, adaptation is defined as the responses that a group develops over time to environmental challenges. In its evolutionary sense, of course, adaptation suggests differential fitness against natural selection, resulting in differential reproduction (or survival/growth), with consequently increasing or decreasing frequencies over time. We are not using the term

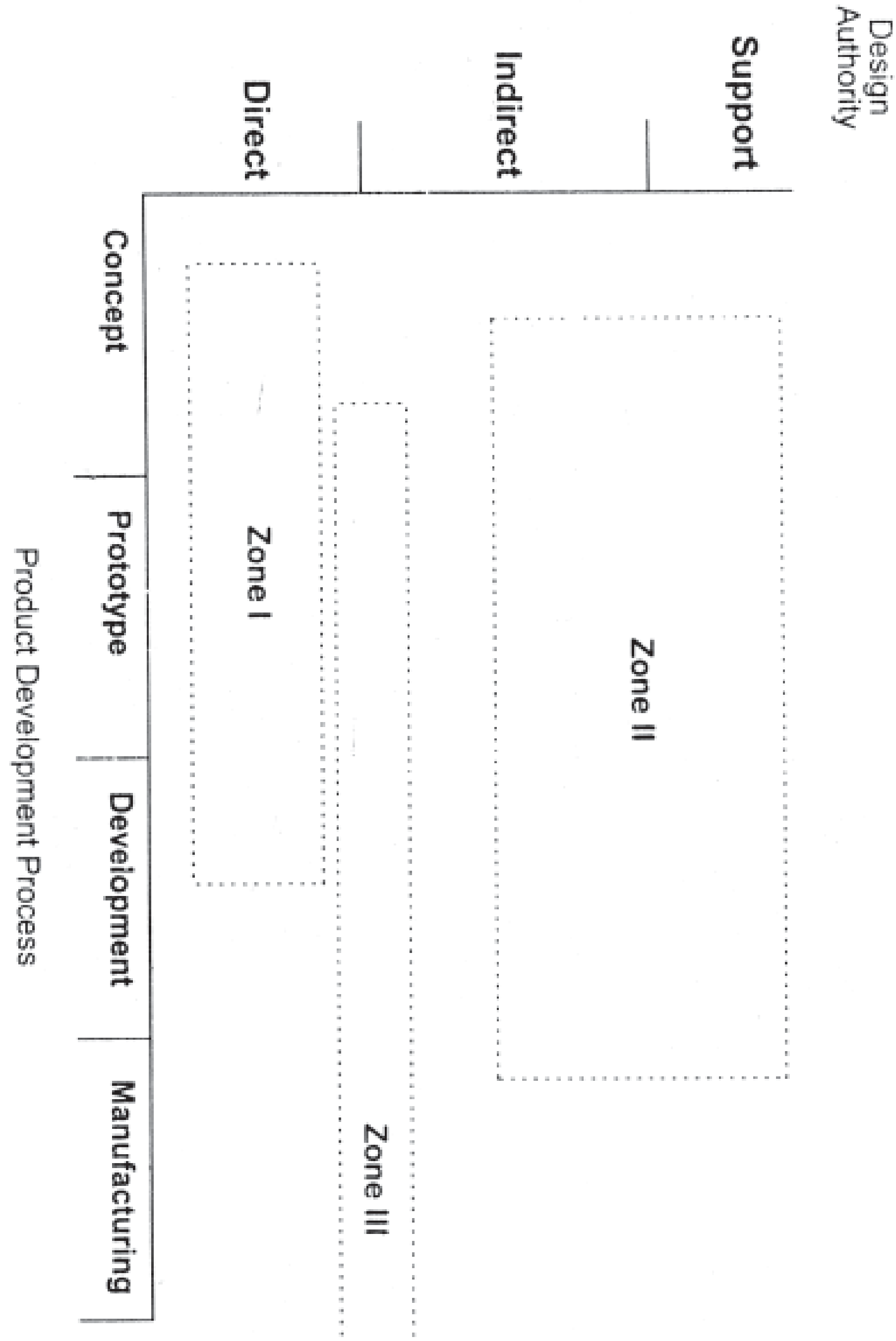

Fig. 1. Map of work niches

adaptation in its evolutionary sense, however, given the many theoretical difficulties involved in demonstrating that a group's behavior was the cause of its survival (Kaplan and Manners, 1972). Evolutionary arguments often turn out to be tautologies. The use of adaptation to mean fitness and survival within a corporate setting is particularly problematic given the fact that internal units within a corporation may not be exposed to the pressure of natural selection. While some corporations may subject their sub-units to tests of market fitness as a prerequisite to survival, others may subsidize unfit sub-units for years or even decades. Thus, survival and even growth do not necessarily mean fitness.

To avoid the pitfalls of the evolutionary concept, we confined our meaning of adaptation to that of a process in which sub-units learn to respond over time to certain patterns embedded within the environment. Thus, if the environment is technologically scarce, the sub-unit will develop certain expectations regarding technology and will learn to make do with scarce resources (*e.g.* the TSG). The coping mechanisms developed by the group as a response to technological scarcity will constitute its adaptation to this feature of the environment.

Contingency theorists argue that the features of an organization must match its environmental requirements; *i.e.* the organization must adapt to its environment. Most typically, organizational ecologists have looked at abstract categories of organizational behavior as dimensions of adaptation — technology, structure, inter-organizational relations. There is a large literature that demonstrates the sensitivity and responsiveness of such variables to differences in environmental context (*e.g.* degree of turbulence). Again, the standard categories of variables used in organizational ecology have been selected because of their generalizability and measurability.

Despite their grand theoretical utility, there is something dissatisfying about these abstract organizational variables as applied to human work groups (just as we were dissatisfied with an abstract conception of the environment). Like abstract environmental dimensions, these macro-level variables do not give us a sense of the detailed differences between work groups. For example, two work groups that do very similar kinds of work may do their work very differently and respond to technology in highly distinctive ways (see illustration provided in section VI of this paper). Such subtle differences may escape detection when focusing solely on abstract variables. Those who are committed to an inductive approach want adaptive dimensions to emerge from the data, and thus to be empirically grounded rather than theoretically pre-determined.

One way to avoid some of the limitations of abstract theoretical categories and to ground our concepts in empirical data is to focus on the *process of work* itself as the *basic adaptive mechanism*. After all, the work group exists to do work, and the work is a crucial component of its ecological existence (*i.e.* what the group "does for a living"). By looking closely at how the group does its work, we can develop a detailed description of the group's natural adaptive responses, as they have emerged historically through interaction with a set of environmental conditions.

Indeed, in our research we had "instinctively" grounded our observations and conversations with work group members in detailed descriptions of the work process. I say "instinctively" because we did not have an ecological paradigm when we entered the field, yet — because we were in a work organization and focusing on work-related behavior — it seemed intuitively correct to begin our investigation from the details of the work process. As we examined our descriptions of work process, it became clear that we had captured a fundamentally adaptive process.

Group members' descriptions of what they did on their jobs from day to day represented nothing more nor less than individual and group responses to environmental demands and constraints. The environment — comprised primarily of other groups — set standards and conditions to which the focal group was forced to respond. Task quotas, deadlines, and standards were laid down; certain finite resources were provided to do the job. If the group failed, it could face negative sanctions — management reprimands, budget cuts, personnel reductions, career penalties. The things that the group did as part of their response to these demands and pressures can only be described as adaptive;

indeed, they were adaptive by definition (if we define adaptation as a response to environmental opportunities and constraints).[2]

We began to think about the work process as the key to understanding a group's adaptation to an environmental niche, and as the key to understanding its response to new technology. Like the economic system of a small-scale society, the work process is largely (although not exclusively) the means by which the environment of the group is exploited. Through the work process, the work group gathers environmental resources, modifies these for its own purposes, and in so doing enables it own continuation. As in a small-scale society, technology is enmeshed completely in the economic system (*i.e.* the work process); the utility of technology, its impact on the social group, cannot be understood apart from an understanding of its role in the work process.[3] We see the work process as analogous to the economic system of a small-scale society in another sense as well. It is within this work process that the social relationships and social organization of the group are made manifest. The sociology of the group cannot be separated from its economic behavior; they are one and the same.

Thus, from a description of the work process, it is possible to extract detailed descriptions of each of the other adaptive dimensions discussed in the literature of cultural and organizational ecology. The work process establishes the type of technology used, and more importantly, the way in which technology is used. As seen in the case of the TSG, the work process — the steps undertaken to transform information and materials from one state to another — embeds the roles, relationships and organization of people inside the group, and of exchange linkages between groups. For the TSG, the work process involved managing external suppliers, not doing design work. The work process also provides the material context for many of the ideas, meanings, values, and norms of the work group. Indeed, the meanings and values that are most important to an understanding of new technology responses grow directly out of the preexisting work process. Thus, for the TSG, the meaning of new technology was not that hoped for by managerial elites (*i.e.* an efficient way to maintain the technical integrity of mathematically-based designs throughout a long, complex process). This meaning would have required the TSG to be staffed primarily by personnel with the technical expertise to operate the equipment as a design tool. Rather, the meaning of the new technology was an extension of the work group's traditional way of working — using technology as a way to mediate relations with other groups.

OTHER THEORETICAL CONSID ERATIONS

Causal Relations Among Variables

We can model the relationships among these variables much as Steward (1955) would model a socio-cultural system, with the caveat that causal relations *over the near term* are not determined strictly by the influence of the work process on other parts of the system. Clearly, the work process and the technology set mutual limits on each other, and on the range of appropriate social organizations and ideologies of the group. Work process and technology, in some ways, thus constitute a framework for the rest of the cultural system. But the social organization and ideology also set important limits on the work process and technology, and over the near term these limits may be determinative. In other words, we view the various social and technical dimensions of the work organization as mutually causal.

Further, there appear to be different types of adaptive patterns that are linked to different types of work niches. These patterns involve distinctive configurations of work process, technology, social organization, and ideology. Our data shows that in a resource-rich design niche, for example, the work process will be heavily dependent on some type of computer-aided design (CAD) technology, and there will be a tendency for the social organization and ideology of the group to be mediated or influenced by the nature of human-CAD interaction (see for discussion Baba, 1995a). In a resource-scarce support niche, on the other hand, CAD will not be as prominent (it may not even be present) and technology generally will play a less central role in the work process. This means that the social organization of the group will be less contingent on computers and material technology generally, and will be more likely to be shaped by other factors.

While such distinctive configurations are related to a group's basic location on the ecological map (Zone I *vs.* Zone II), alternative configurations within a given zone are possible based on the existence of different niches. For example, in Zone I, the choice between 2D or 3D CAD systems — a choice influenced in part by a group's specific work niche — will reflect fundamental differences in work process, and is likely to influence strongly the nature of the group's social organization, and the group's beliefs and value system. Groups in a 2D work niche are less likely to use their computers for electronic communication, and use them more as a production tool. This results from the fact that the functionality of 2D technology is that of an electronic drafting board, not a communications device. This means that a whole dimension of potential interaction based on electronic communication is absent. Groups in a 3D niche, on the other hand, will be engaged in a 3D work process where mathematical models of a design are created for the specific purpose of electronic sharing with other groups; this is so because the functionality of 3D technology embeds the capability for electronic communication. Our data suggests that such 3D groups are likely to develop a new set of reciprocal, inter-group linkages based on a mutual interest in such electronic communication.

A focus on the work process shows clearly the difficulty of separating empirically phenomena such as "technology," "work behavior," "skills," "social organization," "structure," and "ideology." Although these concepts are still crucial to analysis and explanation, their respective empirical indicators interpenetrate each other, and they appear to be mutually causal over the near term. A designer who operates a 3D CAD system to transmit a 3D math model of a product component to a manufacturing group in another building is simultaneously 1) exercising a technological capability, 2) enacting a vital part of the work process, 3) using technical skills, 4) affirming his role as a champion of electronic communication, 5) building an emergent structure that may not yet exist on paper, 6) solidifying trust with an exchange partner, and 7) acting on the basis of new ideas about advanced manufacturing. Into which analytic box do we place the phenomenon? What are its causal antecedents, and what are its systemic consequences? Under what conditions are certain facets of this phenomenon more powerful than others, and how do they exert their influence? What are the long term effects of short term adaptive responses? Clearly, we need an even sharper focus on the process by which various aspects of the phenomenon shape one another, and may actually *become* one another (as technology becomes structure, and vice versa; see Baba, 1995b). These are some of the theoretical challenges that face the ecologist who descends from the macro-plane of abstract variables to the concrete ground of human practice.

Nested Quality of Work Culture

One final, yet crucial, theoretical issue deserves mention. Unlike small-scale societies studied by cultural ecologists, the work group of a complex organization does not exist in a cultural vacuum, but is part of a larger cultural context. The work groups we studied were each part of larger corporate divisions that had long-standing traditions of operational autonomy. Although we did not examine work process at the divisional level, it was clear that various divisions had fairly distinctive managerial philosophies which affected the local work group. For example, different divisions rewarded different types of work group behavior, with one division encouraging and rewarding risky technological gambles, and another rewarding the ability to do everything super-fast, even if this meant postponing technology upgrades (see for discussion Baba et al., 1996). Such differences had a direct impact on work group responses to technology. Work groups in different divisions appeared to evaluate new CAT through the lens of their divisional reward system and to respond based in part on their assessment of the CAT's ability to perform according to divisional culture requirements.

Our observations suggest that the larger level of organizational culture acts as a causal environmental force in shaping work group responses to new technology. Because work groups grow up inside of larger organizations, these higher order structures are powerful shapers of adaptive response. Yet, because large work organizations are complex and, in the case of our study, culturally heterogeneous, the potential for diverse and conflicting influences from the cultural context is great. The possibility for diversity and conflict suggests that work groups may not always be in harmony with their "host" organization, or with their work group neighbors. Since managers often rotate through large companies, new managerial philosophies may migrate into a local scene and stimulate work groups to act in ways that contradict their historical settings. We discovered the difference between 2D and 3D design culture, for example, by noticing the conflict that developed between two work groups that were literally sitting next to each other in the design area of a single corporate division. Although these two groups worked together on the same projects every day, they had been influenced by two very different managerial philosophies, one in keeping with the history of the division and one representing a new wave of manufacturing thought. Although these groups at one time had been joined technologically and organizationally, they were now evolving in different directions under different leadership, largely due to the influence of higher order cultural forces. This example suggests strongly that the cultural ecology of work organizations should not focus strictly on the behavior of the local work group, but must take into account the history and work traditions of overarching organizational structures.

SUMMARY AND CONCLUSION

This paper suggests that ecological theory is a rich source of concepts and methods that can enhance our understanding of work group responses to new technology. From an ecological perspective, these responses reflect historically evolved adaptive patterns that are shaped by local and global organizational forces. Adaptation is enacted through a group's work process, which embeds a particular role for technology, a set of social roles, relationships and linkages, and a body of work-related beliefs and values. The adaptive work process responds to local demands and constraints, but also is influenced by higher order organizational forces.

Efforts to intervene in new technology implementation must recognize the systemic character of a work group's response to new technology. Such responses are not likely to be affected by interventions that treat technology as a disembodied artifact, and/or ignore the culturally embedded quality of technology use. Effective new technology implementation must proceed from an understanding of the pre-existing work process of the local work group, recognizing that this work process will be supported by long standing social roles, relationships, and belief systems. Changes in technology that imply or require a change in work process are likely to threaten pre-existing social relationships, values and meaning. Such threats must be addressed in a manner that satisfies the needs of work groups for mutually beneficial exchange relations with other groups. If the threats are left unchallenged, they may stimulate social resistance movements that mobilize human potential against change in organizational contexts where fundamental change is desperately needed if the organization is to survive.

NOTES

1. The literature of organizational ecology utilizes a similar set of constructs to describe the adaptive responses of an organization to its environment. Technology is viewed as an important organizational subsystem that orders and controls input-output relations between the organization and its environment. A "technological imperative" (Fry, 1982) is thought to shape organizational structure, with a proper technology-structure match needed for successful performance. Other variables such as interorganizational linkages and exchange relationships also play important roles in enabling environmental adaptation.
2. For reasons given earlier, we leave aside here the question of whether or not responses that are "adaptive" in a short-term sense are also adaptive from an evolutionary perspective, i.e. whether or not the responses increase the fitness of the group.
3. Two advantages of a focus on small-scale work groups as the primary unit of adaptation are a) an ability to define the group's technology in precise terms, and b) the availability of a broad range of technological types within a single corporation. Studies of organizational ecology have been plagued by the problem of trying to categorize whole organizations on the basis of a single technology type, when in fact there are many different types of technology within the organization.

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