# THE TEMPORAL STRUCTURE OF COOPERATIVE ACTIVITY[1]

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## INTRODUCTION

Developers of group-support technology often base their designs on tacit assumptions about the nature of group work. At the same time, social scientists, tell us that cooperative work involves complex social and linguistic interactions among team members [Krau90]. The research reported here considers one important facet of these interactions: what is the nature of the relationship between individual work and group work activity? In particular, how is the characteristic temporal and spatial patterning of behavior in the work environment related to the modes of cooperative behavior? We are attempting to develop a theoretical framework which addresses such questions in an empirically verifiable way. The framework begins with the observation that individuals in office settings must routinely resolve conflicts between (1) having uninterrupted periods of time in which to get their own work done and (2) being accessible for communication with others with whom they work.

Our approach to the study of these issues has several sources. The first source is the work of technology developers and impresarios. Bullen and Johansen [Bull88], in a review of emerging commercial trends in groupware technology, point out that evolving commercial groupware products may be categorized according to whether they are designed to support groups which are (1) dispersed vs. non-dispersed in physical space and (2) interacting synchronously vs. asynchronously. This categorization is relevant to our approach in that it clearly recognizes the predominant role of spatial and temporal factors in designing technologies for computer supported cooperative work.

The second source is careful behavioral studies of how individuals and groups use time and physical space in their collaborative activities. Social scientists such as Edward Hall [Hall66] make clear there are profound and widespread cultural differences in the ways in which individuals utilize physical space in their interactions. At the same time, anthropologist Frank Dubinskas [Dubi88], among others, has argued that there are widespread differences among cultural and even occupational groups (e.g., physicians, business entrepreneurs, nuclear physicists) in the ways in which time is understood and structured in work activities. Both lines of research suggest that the careful observation and analysis of space and time utilization in the microstructuring of workgroup activities would be a productive approach. The power of these techniques is exemplified by Mintzberg's [Mint73] classic studies of managerial behavior and Sproull's [Spro84] depiction of managerial attention.

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The third source is our own informal observations of some profound occupational and sub-occupational differences in the ways in which workgroups share space and structure activities in their work environments. Without providing details at this point, we observe that some occupational groups, such as artists, architects and mechanical engineers (designers of physical objects whose development is shared in posted drawings or sketches), tend to prefer open workspaces through which colleagues are encouraged to browse. Other occupational groups (e.g., software engineers, academics, writers) tend to prefer more enclosed and private workspaces which offer fewer intrusions and interruptions. In our ongoing work we are developing a theoretical framework in which the nature of work, the characteristics of the physical environment, and the temporal structuring of time and interaction patterns are seen to be closely related.

## FIELD SETTING AND METHODOLOGY

The study described below was conducted among workers in a Division of a Fortune 500 corporation made up of approximately 500 employees distributed throughout a multi-state region. One hundred of these workers were stationed in the Division headquarters with the remaining personnel distributed among regional field offices. Three groups within the Division were selected for intensive study: the Senior Management, Sales Development, and Marketing Groups.

The Senior Management Group was composed of nine individuals including the heads of the Sales, Marketing, Human Resources, Finance, and Legal sections. Though all but one of these individuals were located in the Division headquarters, members of this group traveled frequently. As a result, they were often unavailable for face-to-face interaction with other members of the group. Though they spent time attending to strategic planning and Division operations, most of their time was spent attending to the operation of their own sections; thus, the workgroup members were relatively autonomous.

The Sales Development Group contrasted sharply with the other two groups in that its eight group members were dispersed among five cities and three time zones. The group had no home base, and members were distributed among sales offices throughout the region. Though closely involved with regional sales staff on a day-to-day basis, they reported to a single manager who reported directly to the Vice President of Sales. The role of members of the group was to support sales of targeted products or services. Within this group the emphasis was on facilitating and accelerating the sales process, and workers assisted regular sales personnel with locating and cultivating potential sales.

The Marketing Group was composed of three members, all located in the Division headquarters. The nature of their work required very infrequent travel. The group was stratified with two product managers reporting to one mid-level manager who in turn reported to the Vice President of Marketing. Though the group supervisor's role involved overseeing the activities of the group, individuals functioned on a day-to-day level very much as a group of peers. The group was charged with developing new product applications. Though each of the three workers had individual areas of market responsibility, their desks were in close proximity and they worked together to a greater degree than did the members of the other two groups. Furthermore, because they traveled relatively infrequently, they were usually accessible to one another.

Participant observation was at the core of the multi-method approach employed in this study and provided a means whereby we were able to observe and record both foreground and background activity in the field site. Over a period of several months, we spent full working days with the subjects and attended meetings and staff retreats. Eventually, our presence was

accepted by workers as a normal part of the work environment. We kept written notes about people, activities, behaviors and other details of the work environment. These field notes were as much a physical record of our individual observations as a reflective process through which we attempted interpretive penetrations of the world of the research subjects.

Interviews focusing on communication and workstyle patterns and preferences were conducted with workers in the field site from the earliest days of the study. As the study progressed, informal interviews were linked to observations and became an ongoing feature of the data collection process. In addition, samples of hardcopy documents and incoming and outgoing electronic mail messages were collected, and sound recordings were made of a limited set of workgroup interactions.

A cornerstone of the study was "shadowing", an observational method involving extended and detailed observation and documentation of the work activities of individuals in selected workgroups. The goal was to understand how the members of these groups accomplished their work and how the work activities themselves were accomplished through coordination and collaboration over a period of days, weeks or months. This methodology provided a unique means to quantify the activities of individual workers, to identify and track a variety of tasks and communications, and to identify channel use throughout an individual's work day.

Field research was conducted with varying degrees of intensity over a period of 9 months, with two distinct phases of data collection. The first phase involved selecting the organization to be studied, identifying a range of possible target groups for indepth study, conducting background interviews and informal observations, and field testing data collection instruments and protocols. Whereas the first phase was informal and exploratory, the second phase was more rigorous in method and more finely focused in observation. During this period 12 members of the three workgroups were shadowed for a total of 224 hours over a period of 34 days. The shadowing sessions were conducted at Division headquarters for the Senior Management and Marketing Groups, and in the remote sites for the Sales Development Group. The subjects provided access to their daily activities, and we systematically observed and recorded both communicative interactions and periods of solitary work. Additional detail was documented in field notes.[2]

## FINDINGS

### Basic Activity Measures

Two descriptive measures of activity in a day are the number of distinct tasks[3] in which a person is engaged and the number of distinct individuals with whom a person interacts. Each of these measures tends to increase substantially on workdays perceived as "busy" and

2 Additional and more detailed discussion of the methodology, findings, and implications from this study appear in Reder and Schwab [Rede90].

3 We define *tasks*, from the perspective of the subject, as discrete work objectives (e.g., a project report). Tasks are accomplished by workers through *events*, which we define as observable actions. Viewed within the context of collaborative work, we discriminate between events which are communicative (e.g., speaking to a co-worker over the telephone) and those which are non-communicative (e.g., using a calculator). Tasks may begin and end with a single event or may continue over time. Tasks and events cluster in particular ways; these clusters we refer to as episodes. *Episodes* are defined as units of temporally bounded activity, and can be further divided into simple and compound forms. A *simple episode* is defined as a unit of temporally bounded activity involving a single task and event which may or may not involve communication with other individuals. If the simple episode is

decrease markedly on workdays perceived as relatively "quiet." Figures 1 and 2, respectively, display the daily averages of these measures for members of the three workgroups. In Figure 1, we see that members of the Senior Management Group were engaged in substantially more tasks per day than members of the other workgroups. Indeed, the Senior Group members averaged about twice as many tasks per day as members of the other workgroups. Figure 2 illustrates the number of distinct interactants per day with whom workgroup members interacted. This is an *unduplicated* count of the individuals with whom group members met face-to-face, talked on the telephone, corresponded, etc. If a person attended a meeting with four individuals in the morning the count would be increased by four; if that person talked on the phone with one of those individuals later in the day, the count would not increase.

The Senior Management Group members interacted with a significantly larger number of individuals per day than did members of the other workgroups. There was little overlap among the daily measures for individual members of the Senior Management Group and the measures for individual members of the other workgroups. These relationships can be seen in Figure 3, in which individuals' average numbers of tasks per day are plotted against their average numbers of distinct interactants per day. Each point in the scatter plot is an individual member of one of the three workgroups. The groups are plotted with different symbols. The distinctiveness of the Senior Management workgroup, in terms of these activity measures, can be readily seen . Although the shape of the scattergram indicates a positive correlation between these two measures of activity, the figure also indicates that the two measures are substantially independent; for a given number of tasks per day, there is quite a range of number of interactants, and vice versa. Intuitively this makes sense; an individual may be busy in terms of number of tasks or number of interactants, or both.

## Distribution of Activity Among Workgroup Members

Observed tasks were sorted by observers into sets of recurrent *key tasks* related to major workgroup objectives. From the observations of the Senior Management, Sales Development and Marketing groups, eleven, eight and thirteen key tasks were identified, respectively. Figure 4 exhibits the percentage of time members of the three workgroups were observed to be engaged in these key tasks. Overall, individuals spent about one-third (32.6%) of their time engaged in key tasks, although the data plotted in the figure exhibit sharp differences among the three workgroups. As noted in the figure, these data are based on simple episodes only. The Marketing group spends substantially more of its time on its key group tasks than do either of the dispersed workgroups on their key tasks. The Marketing group spends over half of its time (53.8%) on key group tasks, whereas the Senior Management and Sales Development workgroups spend, respectively, only 13.3% and 22.5% of their time on their key tasks. This quantitative difference is consistent with the observers' sense that the Marketing group went about its key tasks in a manner that was qualitatively distinct from that of the other workgroups. Members of the smaller, more collocated and less travel-dispersed Marketing group found it easier to communicate and collaborate on key tasks; they spent more time working on parallel aspects of the same tasks.

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communicative, it is restricted to a single channel. A *compound episode* is defined as a unit of temporally bounded activity which may involve more than one task and/or more than one event (e.g., a face-to-face conversation [the first event] pertaining to a management plan [the first task] in which the subject creates for the other interactant a pencil sketch of the plan [the second event] followed by further discussion of an unrelated design problem [the second task]). As this example shows, compound episodes may involve more than one channel (i.e., information is carried simultaneously through face-to-face conversation and documentation). Similarly, multiple tasks can be addressed through a single event (e.g., a face-to face conversation may involve discussion of several discrete tasks).

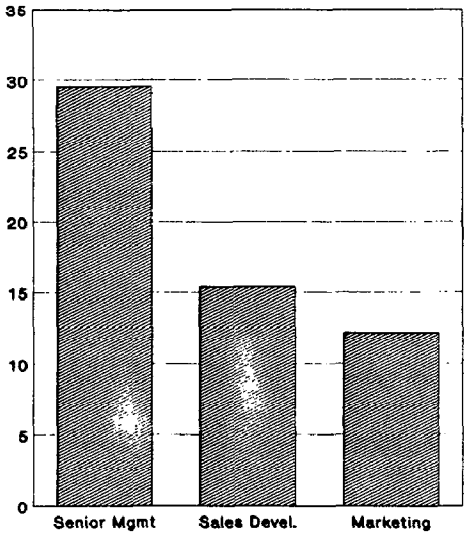


Figure 1 Tasks per Day

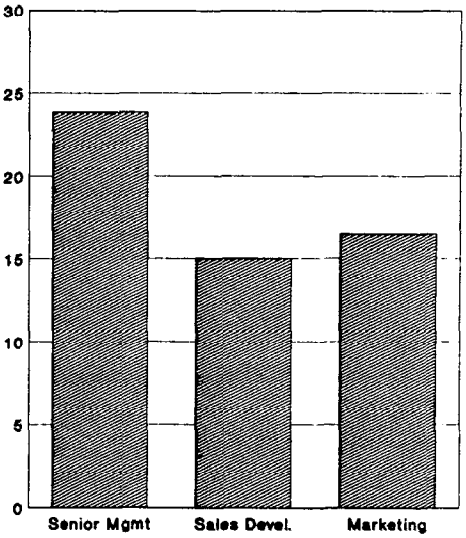


Figure 2 Distinct Interactants per Day

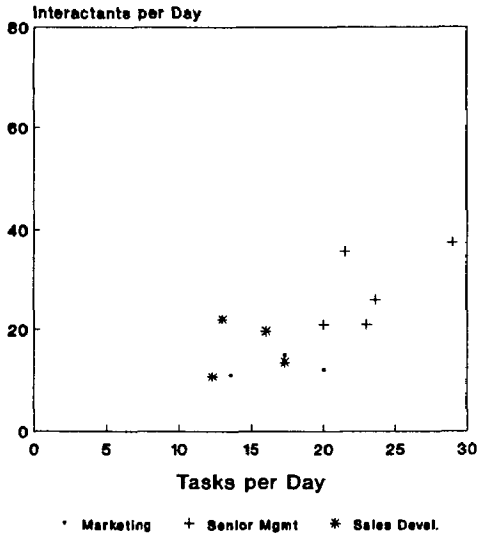


Figure 3 Scatter Plot of Tasks/Day x Interactants/Day

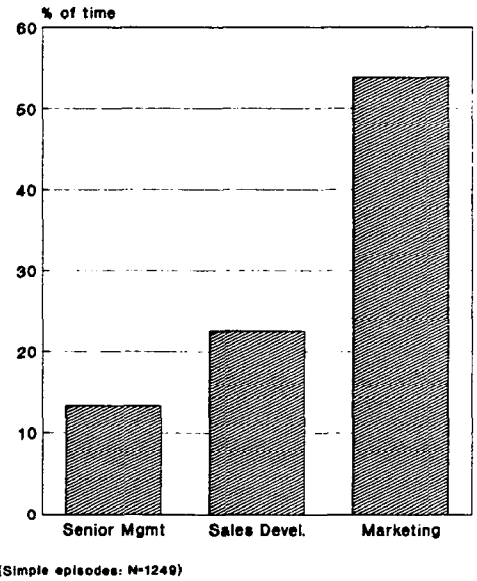


Figure 4 Key Task Activity

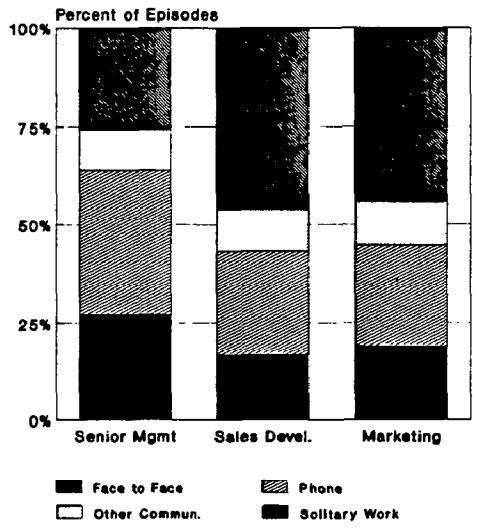


Figure 5 Workgroup Activity: Episode Distribution

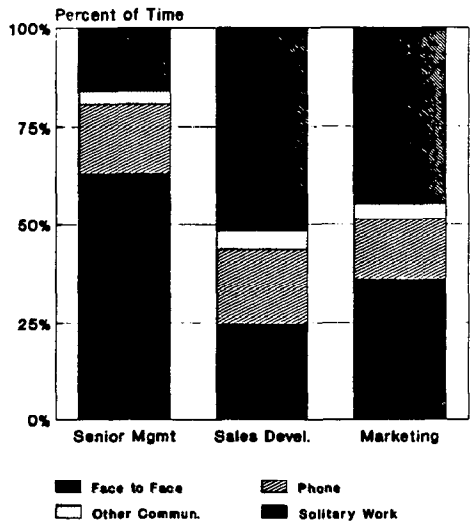


Figure 6 Workgroup Activity: Time Distribution

## Work Activities

This section examines the microstructure of time and activity. Parallel sets of data which pertain to three aspects of the fine temporal structure of activity will be scrutinized: the number of observed episodes which comprise an activity, the aggregate time of those episodes, and their average duration. Although these three ways of assessing time are closely interconnected, they offer distinct perspectives on the fine temporal organization of activity.

Figures 5, 6 and 7 display, the distributions among four categories of each group's activities: solitary work, face-to-face communication, telephone communication and communication through other channels (including written communication as well as the "new" communication channels of electronic mail, voice mail and fax). Sharp differences among the workgroups can be seen in each figure. In terms of the episode distribution (Figure 5), the Sales Development and Marketing groups appear quite similar, whereas the Senior Management Group has a substantially smaller percentage of solitary work episodes. Other, smaller inter-group differences suggested by these episode distributions are more clearly revealed in the time distributions shown in Figure 6. Members of the Senior Management Group spent much more of their time in face-to-face interaction (63%) and much less of their time doing solitary work (16%) than did members of the other workgroups. All groups spent about the same percentages of their time on communication by telephone (15-19%) and by other channels (3-5%). The amount of time members of the Senior Management Group spent communicating (84%, combining face-to-face, telephone and other channels) is consistent with other studies of executives and managers (cf [Mint73], [Spro84]).

In Figure 7, the mean durations of episodes for the various activities are plotted for the three workgroups. The one striking inter-group difference is for the solitary work activities. Whereas the mean duration for solitary work activities is more than 9 minutes for the Sales Development and 7 minutes for the Marketing groups, the mean duration is less than 4 minutes for the Senior Management Group. Considering the start-up times necessary for complex activities like reading and writing reports, having an average of less than four minutes available at a time to complete these activities would seem to impose a formidable constraint on the type of activities which members of the Senior Management Group can carry out efficiently.

## Interactional Chains and Channel Switching

Cooperative work is often accomplished in part through a series of interactions among collaborating participants. The periods of solitary work which individual participants devote to accomplishing their parts of a cooperative task are intertwined with meetings, the exchange of written information and other interactions among task participants. To highlight the role of communication in the observed activities of the studied workgroups, the concept of *communicative chains* was developed. A communicative chain is operationally defined as a sequence of distinct interactions between the same individuals on a given task. In our data, such chains are identified as a series of communicative events (within the same day) between the subject and another individual (or set of individuals) pertaining to a particular task. Of course, many such sequences include events over multiple days; our analyses, however, are limited to those parts of such chains which could be observed within a given day.

Figure 8 displays the occurrence of such communicative chains in the observation data. The frequency of the chains is plotted as a function of the chain length. Such chains are fairly frequent overall, considering the fact that we are examining only a small (within-day) segment of the totality of ongoing chains. Not surprisingly, as the length of the chains increase their frequency diminishes (within a single-day of observation). If we look at the channels used in the constituent communicative events ("links") of these chains, and calculate

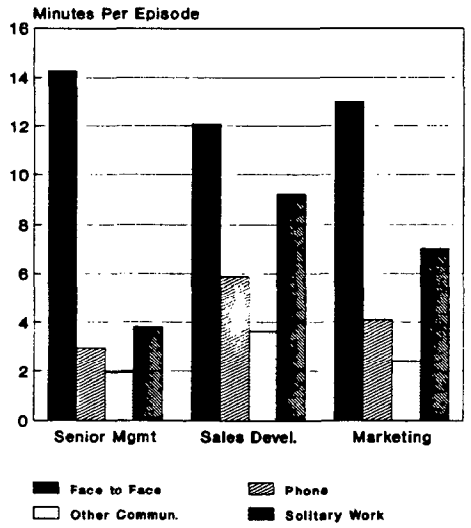


Figure 7 Workgroup Activities: Episode Duration

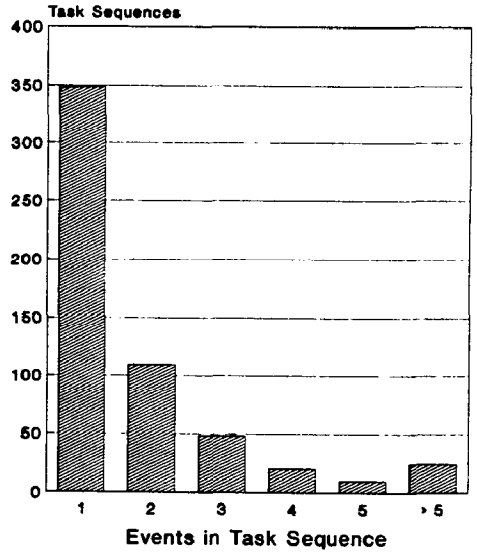


Figure 8 Communicative Chains

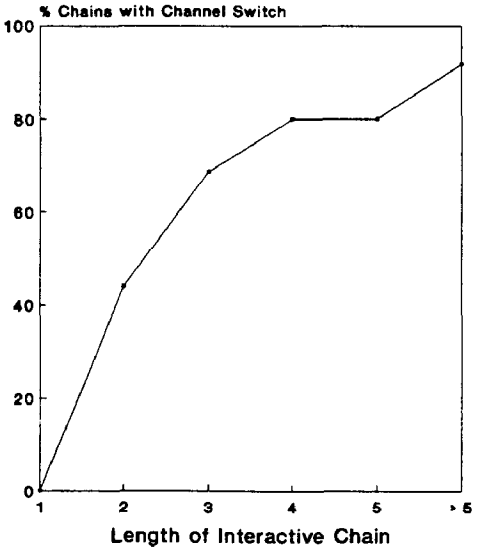


Figure 9 Channel Switching

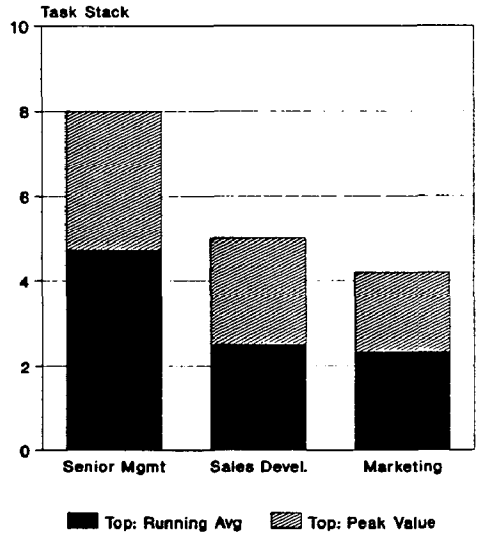


Figure 10 Workgroup Levels of Multitasking

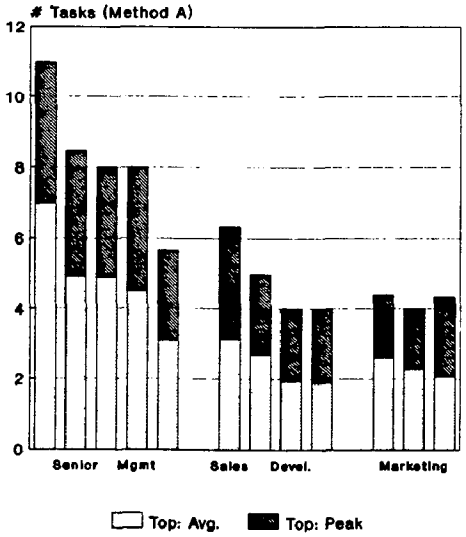


Figure 11 Individual Task Stacks

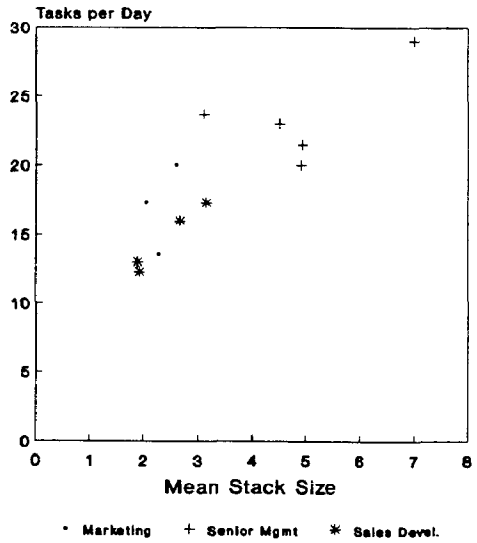


Figure 12 Tasks/Day x Stack Size

the number of chains which involve a *channel switch* (e.g., from telephone to face-to-face) among its links, the results can be plotted as shown in Figure 9. Overall, 60.2% of all communicative chains involve a channel switch. When the chain length is only two communicative events, nearly 50% of the chains involve a channel switch; as the chains progres-sively lengthen, the percentage having a channel switch steadily increases, rising to 80% in chains of 4 links.

These results indicate that not only are communicative chains common features of the accomplishment of cooperative tasks, but they involve frequent channel switches over time among collaborating individuals. Therefore, using a technology which can support the use of only a single channel (a limitation of most current groupware products) would not fit with the natural activity and communication patterns of workgroups such as those studied here. Findings of Reder and Schwab [Rede89] indicate that such conclusions apply to both technical and managerial workgroups. The implications of this important result for the goals and design of group-friendly interfaces will be considered later.

### Multitasking

As indicated above, individuals are engaged in a large number of tasks in a given day and interact with a large number of individuals as well. The results of this study indicate that many of these activities and interactions are structured into communicative chains which likely crisscross each other in the temporal sequence of an individual's busy day. Mintzberg [Mint73] has characterized the activities of the executives he observed as having a high degree of "brevity, variety and fragmentation." This description is exactly what would be observed as an individual participates in multiple, temporally overlapping activities. To participate in multiple tasks involving other individuals a worker must alternate between tasks on a moment by moment basis, creating a situation with which many office workers are all too familiar: having too many jobs to do at once, too many interruptions, not enough hours in the day, and in tasks getting "stacked up." These observations suggest that a *multitasking metaphor* [Spro84] may provide a useful way to conceptualize and analyze the activities of individuals and workgroups.

To identify multitasking in our shadowing data, we measured on an ongoing basis the size of the task "stack" of an individual being shadowed. A given task was defined as being on an individual's "stack" whenever the individual (1) was not working on it at the moment; and (2) had worked on it previously in the day; and (3) worked on it again later the same day. This definition had the advantage of being based entirely on observed activities, but had the drawback of measuring only that fraction of an individual's task stack visible within the frame of a single day; thus, tasks that began one day and ended on another were excluded from this measure.

The number of tasks in a subject's stack was computed at the beginning of each episode in the shadowing data. Both peak values and running averages of this measure were then computed for each shadowing session. These per session measures were then averaged to yield both per individual and per workgroup values. Figure 10 displays workgroup averages of the size of individuals' stacks. The tops of the hatched and solid portions of the bars represent, respectively, the mean peak and running average of the stack size for a day. Sharp differences can be seen between the Senior Management Group and the other two groups. Tasks are substantially more "stacked up" for individual members of the Senior Management workgroup. Looking at the running averages portrayed by the solid parts of the bars, members of the Senior Management Group average twice as many tasks in their stacks as do members of the other workgroups (which do not differ in these terms). It is important to note that the linear scale of measurement displayed in these figures does not do full justice to the likely impact of these differences. Just as juggling four balls is substantially more than twice

as difficult as juggling two balls, so may "juggling" (i.e., multitasking among) four tasks be more than twice as difficult as "juggling" two.

The corresponding data for individual participants are displayed in Figure 11. The substantial workgroup differences seen above are also readily apparent here at the individual level. Only one member of the Senior Management Group has lower peak or average stack size than the highest-valued member of either of the other two groups. We are struck by the extent to which these data suggest the immediate workgroup may shape the multitasking among its individual members.

Since there is good reason to expect a positive relationship between number of tasks per day and measures of multitasking activity, the two are cross-plotted in the scattergram shown in Figure 12. Each point plotted is the average mean value over an individual's days of being shadowed. Members of the three workgroups are plotted with different symbols. Several observations can be made about each figure. First, the distinctiveness of the Senior Management Group is again very clear. Second, the general shapes of the scattergrams reflect an anticipated positive correlation between the number of tasks per day and the average stack size for the day. Third, even though there is a positive correlation between the measures, they do measure different things. Imagining a horizontal line drawn across Figure 12 at Tasks/Day = 20, for example, we see a wide range of average stack sizes associated with a given number of tasks/day. The ways in which individuals sequence and manage a given set of tasks (i.e., their multitasking behavior) influences the size of their task stack.

Our qualitative data leaves little doubt about the generally negative impact of excessive multitasking. There were constant conversations and reminders in this environment -- as in many business environments -- about the importance of task prioritization and efficient "time management." One of the effects of excessive multitasking is to reduce the size of the time slices available for conducting a task. The substantially larger average stack size of members of the Senior Management Group is closely linked to their markedly smaller durations of solitary work (see Figure 7). Those mean episode durations are the average "time slices" available for accomplishing tasks. Recalling that members of the Senior Management workgroup average less than four minutes per "time slice" of solitary work, one can appreciate the difficulties of completing tasks under such temporal constraints.

### Self-Management Activities

Given this picture of the temporal organization of activity among workgroup members -- of multiple, ongoing and highly intertwined (i.e., "stacked up") tasks -- individuals clearly must expend considerable effort on managing their own time and task load. Activities such as going through one's inbox, sorting through a stack of phone messages, reviewing one's calendar, and filing a series of documents were frequently observed. Such self-management and self-organization activities are termed here *non-specific* tasks. Their distributions across the three workgroups are shown in Figures 13 (percentage of episodes of non-specific activity), 14 (percentage of time in episodes of non-specific activity) and 15 (mean duration of episodes of non-specific activity). As might be expected from their higher rates of multitasking, members of the Senior Management Group spend about twice as much of their time on these non-specific tasks as do members of the other groups (Figure 14). For the Senior Management Group, self-management activities consume about 20% of the day!

### Compounding of Time and Activity

Thus far we have seen many indications of the extent to which multiple activities and interactions with numerous individuals are intertwined and "stacked up" over the course of a workday. Viewed against the temporal panorama of the workday as a whole, the individual

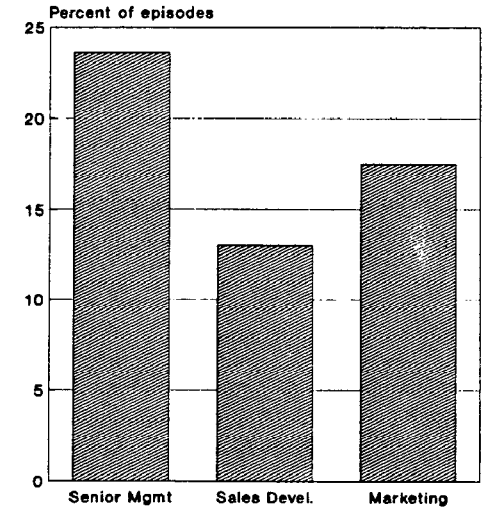


Figure 13 Non-Specific Activity: Episode Distribution

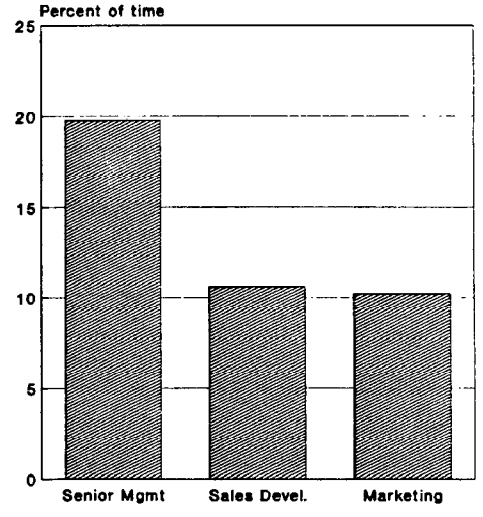


Figure 14 Non-Specific Activity: Time Distribution

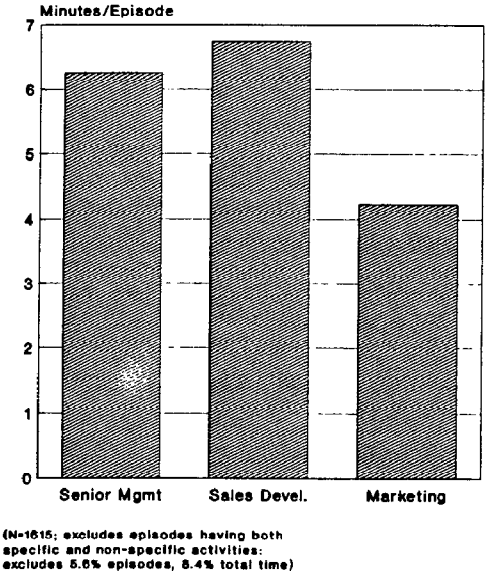


Figure 15 Non-Specific Activity: Episode Duration

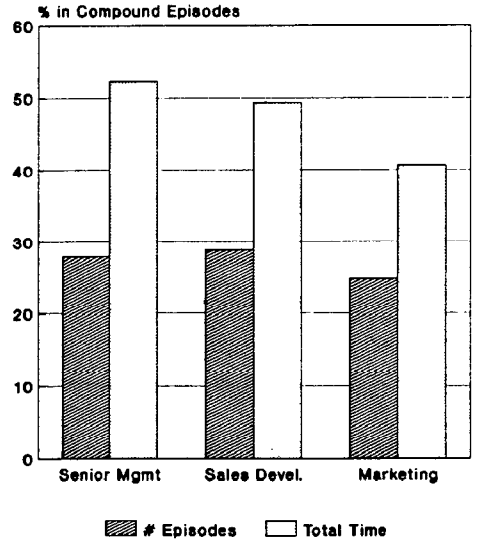


Figure 16 Simple vs. Compound Episodes

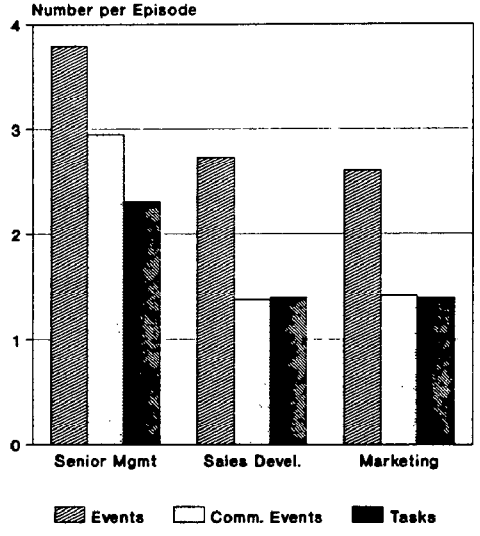


Figure 17 Features of Compound Episodes

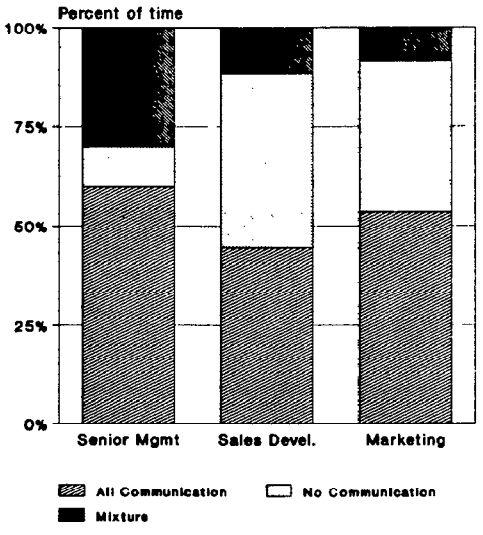


Figure 18 Communicative Structure of Episodes

workgroup member is enmeshed in and moves through a dynamic flux of people and activities. But we cannot fully appreciate the richness of the temporal fabric of a workday by looking only at the compounding and intertwining of activities at the level of the day taken as a whole. Our analysis of individual multitasking, in which multiple ongoing tasks are in a state of suspension within the individual's activity "stack", suggests that there is a moment-by-moment richness and complexity in the fine structure of time and activity that constrains the individual in an ongoing way. In this section, we will look for indicators of this rich ongoing mix of activity in the characteristics of compound episodes (see footnote 3).

Overall, 27% (461 of 1710) of the observed episodes are compound, but comprise 47.1% of the observed time (105.68 of 224.22 hours). Figure 16 displays the incidence of these compound episodes for each of the three workgroups. The hatched bars exhibit the percentage of all episodes which are compound, and the dotted bars show the percentage of time which these compound episodes comprise. To look more closely at the type of compounding going on in these episodes, examine Figure 17, which displays several dimensions of compounding within the compound episodes of the workgroups. The leftmost bar in each cluster displays the mean number of events per compound episode; the middle bar shows the mean number of communicative events per compound episode; and the rightmost bar in each cluster exhibits the mean number of discrete tasks per compound episode.

Although the three workgroups have roughly the same percentage of compound episodes (as a percentage of all episodes), this figure shows that the groups' compound episodes differ qualitatively. The Sales Development and Marketing workgroups appear quite similar in terms of these data, in sharp contrast with the Senior Management Group. The Senior Management workgroup has a richer compounding within its compound episodes: more events, more communicative events, and more tasks per compound episode than the other workgroups. The "fabric of time" for members of the Senior Management Group is much more rich and highly intertwined than for the other groups, a result quite consistent with their previously noted higher rates of multitasking, tasks per day, interactants per day, and so forth.

As a final illustration of the relatively rich, complex fabric which characterizes the microstructure of the Senior Management Group's activity, consider the data displayed in Figure 18. Plotted for each workgroup is a time distribution for all episodes (simple and compound). Episodes are sorted according to whether they are comprised of communicative events (bottom portion of each bar), non communicative events, or a mixture of communicative and non-communicative events (top portion of each bar). Of particular interest is the topmost portion of each bar, which represents (necessarily compound) episodes comprised of a mixture of communicative and noncommunicative events. The Senior Management Group spends about 30% of its time in such episodes, nearly three times the percentage spent by the other groups. As we saw above, the Senior Management workgroup spends about the same percentage of its time in compound episodes as the Sales Development Group; the difference clearly reflects more time spent in episodes specifically compounded by both communicative and non-communicative activities.

## IMPLICATIONS

### The Structure of Group Work

Microstructure of Activity and Time. Individuals engage in numerous tasks and interact with many individuals during the course of the workday. The intertwining of these tasks and interactions weaves a fine fabric of activity for both the individual worker and the workgroup as a whole. Our methodology examines the fabric of an individual's typical workday -- at the level of tasks, events and episodes -- as well as the wider, dynamic context within which the individual continually acts and makes choices in order to accomplish his or her work.

Several measures were developed for tracking the richness and complexity of this fabric of activity as the individual moves through a workday. Using the event as a basic unit of observation and analysis, marked workgroup differences were found in the extent of the "compounding" of time into "episodes" in which the threads of multiple activities, interactions and communication channels cross. Other measures of ongoing activity characterized the extent to which individuals "multitask". Variations in the extent of both individuals' multitasking and time-compounding enable and constrain the ways in which they organize and manage their time and activities.

Group Work "Style" and the Organization of Individual Activity. The measures of activity described above not only captured important temporal dimensions of how individuals organized their activities, but also exhibited patterned differences among the members of the studied workgroups. We propose that these patterned differences among the observed workgroups reflect important qualitative differences in the "styles" with which the groups perform their work.

Our quantitative measures seem to capture the dimensions of temporal organization and communication channel usage underlying group work "style". There are, to be sure, other important dimensions of group work "style" to which these measures are not sensitive (e.g., workgroup "values", "leadership style"), but what is of central interest here is the fact that our measures are sensitive to factors at the interface of the organization of activity at the individual and workgroup levels. The individual-level multitasking results, for example, clearly reflect differences in the workgroups to which individuals belong.

Individuals in office settings must routinely trade off having uninterrupted periods of time in which to get their own work done against being accessible for communication to others with whom they work. Individuals are frequently observed attempting to manage or alter this tradeoff. Asking a secretary to screen one's calls, closing one's office door, forwarding one's phone, and so forth, are all strategies (requiring enabling technologies or individuals) for managing the tradeoff. It is this interplay between communication and solitary activity which our analyses of the shadowing data portray so closely, and, we argue, it is exactly at this level that major differences among group work styles may be readily characterized.

One factor constraining the relationship between the group and the individual is the nature of the work itself. The work which groups carry out varies widely and this in turn influences the ways in which it is (or might be) divided up among group members. The nature of the work also determines in part how problematic interruptions may be to its accomplishment; some tasks, such as copying numbers onto a chart from a table, are less degraded by interruptions than are other tasks, such as writing a complex report.

There are thus strong mutual constraints among (1) the nature of the group's work; (2) the ways in which it is divided up among workgroup members; (3) the modes of coordination and collaboration required to make that division of labor effective; and (4) workgroup members' conflicting needs for both communication and solitary activity to accomplish their assigned portions of work. Information system and communication technologies play a crucial role in these tradeoffs. There are several other factors that also affect the "fit" of a technology to a workgroup design (e.g., travel patterns, other channels available, accessibility of the system, etc.). We are not overlooking such factors in this discussion, but adding a new one that must be considered as well.

Channel Switching. The ubiquity of multichannel communicative chains, not only in our shadowing data, but probably throughout activity in most office settings, is an important feature of workgroup activity and communication. The very high rate of channel switching observed for all three workgroups in this study (as well as for other workgroups reported by

Reder and Schwab, 1989), is fundamental to understanding workplace communication patterns. For interface designers, this finding is particularly important. It indicates that the multimedia approach to workstation design is definitely the right development model. Technological support for workgroups likely will not be useful if workgroup members must radically alter their natural patterns of communication just to take advantage of the support available for a limited range of channels. The results further indicate that the design of such technologies must consider *asynchronous* integration of channels and interactions as well as the *synchronous* integration now being developed for multimedia workstations.

Individual Multitasking. The conceptual framework for and measurement of individuals' multitasking behaviors is an important empirical and theoretical outcome of the research. Our measures, rough as they are in this initial invocation, capture both variations in individuals' organization of activities as well as major qualitative differences among the organization of activity within workgroups. The variations in the extent of and need for such multitasking behavior need to be mapped out across a much broader range of workgroup, office environment and industry contexts.

New Methods for Analyzing Communication. The frequently observed temporal compounding of tasks is consistent, at the activity level, with Bowers and Churcher's [Bowe89] conception of conversations being a patchwork of temporally intertwined "strips", each of which is *locally managed* (and analyzable by existing discourse analytic methods), but the totality of which is structured on a more global level. This higher level, according to our findings, is structured in part by the dynamics of multitasking, temporal compounding, workgroup design and usage of multiple communication technologies. Thus we suggest there is a need to reexamine the fundamental relationship between language and action in the workplace. Existing techniques, based on a tacit assumption that conversation may be sorted into a sequence of "strips", each of which is focussed on a single task, are inadequate. These techniques will not be able to handle the many switches and intertwinings of task and channel that our data indicate are fundamental features of workplace communication.

## System Design

Support remote access to communication and information technologies. Given the extensive travel, complex schedules and tendencies to work from home which some workgroups exhibit, facile remote access to office-based communication and information technologies will be essential for purposes of work continuity across environments.

Support channel switching. The frequent switching over time among channels as individuals work together on a given task has sharp implications for the design of supportive technologies. In addition to the synchronous integration of multiple media now being developed for advanced workstations, capabilities must be developed for transposing communication from one medium to another and for integrating multimedia events across time (i.e., asynchronous integration).

Support individual multitasking. Although an array of commercial computer software is currently being developed to support individual and workgroup-level scheduling and project management, none of these products addresses a major need identified in our research: behavioral (as opposed to a computer operating system's) multitasking. Although calendar/scheduling tools can assist individuals to manage their time (in principal), they do not assist workgroups to manage members' time so as to provide sufficient periods for both solitary work and communication for needed coordination and collaboration. New constructs and constraints need to be represented in order for software to be useful for such purposes.

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