No Task Left Behind? Examining the Nature of Fragmented Work

Gloria Mark, Victor M. Gonzalez, Justin Harris
Donald Bren School of Information and Computer Science
University of California, Irvine
{gmark,vmgyg,jharris2}@ics.uci.edu

ABSTRACT
We present data from detailed observation of 24 information workers that shows that they experience work fragmentation as common practice. We consider that work fragmentation has two components: length of time spent in an activity, and frequency of interruptions. We examined work fragmentation along three dimensions: effect of collocation, type of interruption, and resumption of work. We found work to be highly fragmented: people average little time in working spheres before switching and 57% of their working spheres are interrupted. Collocated people work longer before switching but have more interruptions. Most internal interruptions are due to personal work whereas most external interruptions are due to central work. Though most interrupted work is resumed on the same day, more than two intervening activities occur before it is. We discuss implications for technology design: how our results can be used to support people to maintain continuity within a larger framework of their working spheres.

Author Keywords
Multi-tasking, attention management, information overload, interruptions, empirical study

ACM Classification Keywords
H.4.1. [Information Systems Applications]: Office Automation—Time Management; H.5.2. [Information Interfaces and Presentation]: User Interfaces — Theory and Methods.

INTRODUCTION

Multi-tasking in the workplace is a topic that is receiving increasing attention both in the academic and popular press. Engaging in multiple activities appears to be related to the scope of work; as the scope increases so does multi-tasking [3]. Flattening of hierarchies and expansion of work roles are some of the factors proposed to explain increased and broader task responsibility [5]. Some studies suggest a link between firm downsizing, large-scale expansion, increased work activities, and higher levels of stress [24].

Why is managing multiple activities important to study? More and more studies are reporting that information workers experience multiple activities in the workplace. Studies of managers documented how they engage in multiple tasks [4,7,13,23]. It appears that managing multiple activities is becoming more recognized as a basic characteristic of work life for information workers. Understanding the nature and extent of how information workers manage multiple activities in IT-rich environments is important to inform the design of technology to support this type of common work practice.

In a previous study, we discovered that information workers switched work events frequently: averaging every three minutes [6]. This previous study raised a number of questions associated with the nature of how work is fragmented. Whereas in the previous study we focused on the descriptive level of task-switching, in this paper we analyze factors that are associated with the interruption and switching of different tasks. We have expanded our observations to include almost double the number of informants to increase the generalizability of our results on multi-tasking behavior.

WORK FRAGMENTATION

We define *work fragmentation* as a break in continuous work activity. Studies continually describe how the work of information workers is characterized by spending short amounts of time in tasks and switching frequently. This has been found with managers [7,13,23], financial analysts [6], software developers [18], and even telecommuters [8]. Studies have also reported on the interruptions that information workers experience [4,7,16,20].

We consider that work fragmentation has two main aspects: the length of time people spend in a continuous activity, and interruptions of that activity. In general, we consider that work is more fragmented the shorter amount of time one spends on a task, and the more interruptions one has. Task switching may be beneficial. It could serve to refresh one and provide new ideas. On the other hand, too much task switching with too many different activities could be detrimental. It often requires a start-up time to orient oneself to an activity. Spending too short of a time in a complex project could result in a low level of accomplishment.

CHI 2005, April 2–7, 2005, Portland, Oregon, USA.

Though interruptions can often bring relevant information for one's work [7,16] in many cases, resuming work after an interruption involves a cognitive cost to reorient to the task. Interruptions can become nested, leading to stress in keeping track of multiple states of tasks.

These workplace studies have focused on descriptions of work tasks and interruption frequencies. There remains however, a number of questions about the factors that are associated with task interruptions and switching that could explain these phenomena. The purpose of our study is to contribute to explaining *why* task switching and interruptions occur through identifying relevant factors. Guided by our observations, we realized that people's work fragmentation is affected by their interaction with others, how they are interrupted, and how their work is resumed. We therefore developed the following research questions.

Collocation of employees and work fragmentation. There are reasons to expect that collocated workers would experience more fragmentation in their work to a greater extent than distributed workers. Informal interactions in the workplace have been described as spontaneous and opportunistic, providing rich sources of information that aid coordination [10]. On the other hand, distributed workers lack awareness of others' activities and interactions must be more planned and formal [17]. We would also expect that collocated people might engage in more task switching to adapt to the activities of their colleagues. For example, overhearing a neighboring colleague speak on the phone about an application inconsistency might lead one to switch tasks to help review recent changes in that application.

Types of interruptions. We consider that there are two basic types of interruptions, following [14]. External interruptions are those that stem from events in the environment, such as a phone ringing, a colleague entering one's cubicle, or an email signal. Internal interruptions are those in which one stops a task of their own volition. The environment likely affects the influence of external interruptions, e.g. whether one is in a closed office or open office environment. On the other hand, internal interruptions may occur if one needs a break or needs to think about another pressing matter. External and internal interruptions may affect whether and how fast work is resumed. Interruptions may also have different levels of importance. We examine effects of internal and external interruptions on task switching.

Resumption of interrupted work. Why do people resume interrupted tasks? We expect that there are two basic mechanisms by which people can resume work. They can be triggered by interactions, e.g. a manager or colleague who asks about the status of a project. On the other hand, people might take their own initiative to resume a task. We examined the differences between the external and internal resumption of interrupted work.

How often are tasks resumed? O'Connaill and Froehlich found that 41% of the time an interrupted task was not resumed right away [16]. However, it is possible that an interrupted task is returned to at some point later in the day. We examined the extent to which interrupted tasks are resumed at a point later in the day as opposed to immediately following the interruption to find out how much intervening work existed.

In addition, we also examined how work fragmentation occurs as a function of the time of day. Hudson et al. [7] identified that managers prefer not to deal with interruptions at certain points in the day. However, how does time spent in tasks and number of interruptions change between morning and afternoon? We feel that studying these questions can inform the design of technical support to help people manage work fragmentation.

RESEARCH SETTING

While attention has been given to managers' work activities, e.g. [7,13,23], we are instead interested in a broader view of the practices of a variety of information workers. We conducted our study at ITS[1], an outsourcing company providing information technology and accounting services for major financial bond management companies. We chose this field site because it fit the following criteria: 1) the workers are involved in multiple projects with different levels of engagement, 2) it is a technology-rich environment, 3) it is a fast-paced environment, typical of high tech firms where people work under deadlines and pressure, and 4) people were willing to be observed at a high level of detail.

Within ITS, we observed the day-to-day activities of different information workers: software developers, financial analysts and managers. Two groups were observed: the JEB team responsible for the development, testing and production support of major financial modules to be used by the client, and the AUG team responsible for coordinating the settlement of transaction with banks and to keep the accounting records of the client.

We had the opportunity to observe people who were both situated in an open office environment of cubicles and in enclosed offices. Each person has a networked computer, phone unit, and other resources such as file cabinets, reference books, and documentation. Six analysts in the JEB team have financial terminals in their cubes, where they monitor the status of trades and financial operations performed by brokers. The open office setting makes it very easy to interact with co-workers not only because of the proximity and ease of entering one's cubicle, but because it is possible to chat with them through the cubicle walls.

METHODOLOGY

As our goal was to understand as comprehensively as possible how our informants managed their activities, we used a combination of three main ethnographic techniques: observation, long interviews and shadowing of informants

[1] All company names and team references are pseudonyms.

(the latter similar to previous time-management studies [13,23]). A researcher observed the informant at work in her cubicle or office and followed her to formal and informal meetings or other activities whenever possible. Information on the computer display, the phone ID display or in documents on the desk could be read to some extent.

Notes and times taken during the observation were later transcribed into an activity tracking log inspired by Minztberg's structured observation method [13]. The observer used a time watch and notepad to record details of the informants' actions. The observer noted the time (to the second) and other details of the event. For example, the action and the time stamp were annotated when the informant opened a document, made a phone call, engaged in a conversation with surrounding people, or composed email. All interactions were documented, i.e. details of the conversation topic, people participating, duration and documents involved. At the end of the day the researcher asked the informant clarification questions about activities.

The study occurred in two phases over a thirteen-month period. Twenty-four people in total were observed in detail: 7 managers, 9 analysts, and 8 developers. Fourteen members from the JEB team were shadowed and in the second phase ten members of the AUG team were shadowed. The study began by observing a manager for ten days to become familiar with the work context and for the informants to become used to the researchers' presence. Each informant was then formally observed and timed for a period of three and a half days. The first half-day was general observation to understand the context of the informants' work. Formal observations and activity timing were done over the next three days for an average time of 25 hours, 42 minutes per person. Over 700 formal hours of observation were done. Long interviews were conducted after the observation to discuss the informants' activity management strategies, to validate the working spheres, to inquire about further details of interactions, and to clarify observations.

AN ANALYSIS OF FRAGMENTED WORK

A central part of our effort was on identifying appropriate units of work to analyze work fragmentation. We observed that people were engaged in many different events across the day (e.g. phone calls, composing emails, interacting with colleagues). We first coded our data as events defined as *any continuous use of a device or engagement in an interaction with other individuals* [following 23]. We realized that clusters of events were related and oriented towards common purposes. Our analysis focused on how people switched among those clusters or higher level units of work. We refer to these higher level units of work as *working spheres*. Working spheres can be short term tasks such as fixing a problem with a client's application, preparing a proposal, routine checking of equipment, e.g. servers, or long term projects, such as developing a new work process for the client, or the adoption of a quality program over months. Our analysis focused on how people switched among those higher level units of work for which events such as phone calls are a subcomponent. A working sphere is a unit of work that has a unique time frame, persons involved in them, and use of particular tools and applications [6]. This unit of analysis differs from [4] who focused on the interruption of generic tasks such as email and phone calls. In this analysis the units we refer to are actually *working sphere segments*: single events or clusters of events that are part of a particular working sphere.

We used four main sources of information to assign separate events (e.g. phone calls) into appropriate working spheres. First, the informants were aware that we were trying to identify and connect their different work activities. Prior to the observation we explained the purpose of the study in individual conversations (and a group presentation). This influenced some individuals to naturally verbalize some of their activities while conducting them, without researcher inquiry. Such verbalizations typically occurred at the beginning of the day and sometimes during the day as the informant commented what they would be working on. A second source was derived from the comments made by informants while interacting with co-workers as they referred to what they were doing at the moment, e.g. "*As soon as I'm done with the ATRACK stuff I will move over the R6 spec*" or "*I cannot take it right now, I am working on Jim's production issue*". A third source came from informal short interviews conducted with the informants at the end of each day. The researcher asked for clarifications when the purpose or relationships with other events was not clear. For the last ten informants observed, each informant filled a form out at the end of the day in which they listed the different things they worked on. Finally in the post-observation interviews, the researcher validated the working spheres with the informant.

Our data thus lists the start and stop time when an event happened, a short description of the event, the list of people involved in the event and the artifacts used. Based on the above additional information sources, we associated each recorded event with a particular working sphere. This association was also complemented with the analysis of other documents collected (pictures, email, printouts, etc) and with the interviews. Although an effort was made to associate all the events with particular working spheres this was not always possible. For some events we lacked enough information to assign the event and these were categorized into "unknown" working spheres.

We distinguished when working sphere segments were completed and when they were interrupted. For phone and face-to-face interactions, the end of a conversation marked the end of the time devoted to that sphere if the individual turned to some other sphere immediately after. When work in a sphere concerned interaction with artifacts or technology, end of work in a working sphere was determined by any evidence that showed that the informant concluded work in that sphere. For example, with email use, the end of the time devoted to that sphere was the time that the email was sent if the informant changed to work in another sphere. Self-

interruptions were distinguished from finished work in a sphere in two ways: for interactions, when conversations were stopped abruptly, and for artifact and technology use, when work was abandoned in the middle of an event, such as documents left on the screen in the middle of typing them.

RESULTS ON FRAGMENTED WORK

We first present an overview of work fragmentation of our 24 informants, focusing on working sphere segment length and interruptions. Our informants worked in an average of 11.7 (sd=2.4) different working spheres. Based on the ethnographic observation, we realized that work fragmentation could depend on whether one is accountable for their work. We coded working spheres as *central* when a person has main responsibility and is accountable for it and as *peripheral* when she is not accountable for it. In the latter, one generally provides expertise or solves a problem for a colleague. Peripheral spheres were usually treated in an informal basis, either by phone or face to face. We divided the working spheres into three basic categories: central, peripheral, and "other". Work in the "other" category included metawork[2] (avg. of 7.96% of the day), personal work (avg. of 15.24% of the day: lunch, personal breaks, etc.) and "unknown" (avg. of 10.99% of the day: events not able to be categorized). From the ethnographic observations, metawork rarely was interrupted. As we are more interested in working spheres directly related to work, we focus our analysis on the categories of central and peripheral working spheres only. Throughout their workday people switch constantly between central and peripheral working spheres (as well as metawork and personal work).

An overview of interruptions.

Our observations suggest that interruptions may be beneficial or detrimental depending on the context. Three main types of situations are associated with interruptions as negative events. First, the informants describe that interruptions that occur during tasks that require a lot of concentration, e.g. solving a production issue, are disruptive. Second, interruptions that result in losing one's train of thought for the task-at-hand are detrimental, especially when interruptions occur when it is not a natural breaking point for a task. Third, the informants explain that interruptions are most disruptive when they lead them to shift working spheres. The last two situations suggest that when interruptions concern content of a different working sphere than one is currently in, then they are disruptive. One manager referred to interruptions that concern his current working sphere as "interactions" as they help him think about his task whereas interruptions that lead him to switch his working sphere context are "disruptions". Some informants described that interruptions outside of their current working sphere involve a high cost in remembering what they were doing in their interrupted task. In some cases, informants described that they work on another task until they remember what they were originally doing, e.g., "*You forget what you are working on so you kind of do something else for a while and then you remember what you were working on*." Another informant explained that an interruption outside of his working sphere can lead him to do redundant work, "*I forget what I was testing and I might retest the same thing. I'm just repeating….It happens a lot to me*." A developer explained that interruptions outside of his current working sphere that involve solving critical problems particularly impose a high cost, "*…you have your mind on something else and then you have to shift completely. It is disruptive in the sense that if we are going to leave it unattended for a period of time and by the time you come back to it your frame of mind is completely different* …" Thus, our data suggests that interruptions that lead one to switch working spheres are in general far more disruptive than interruptions that concern one's current working sphere, which are even considered beneficial.

In analyses in this paper we focus only on interruptions outside of one's current working sphere context, as they are more likely to negatively affect work. First, we found that 57.1% of all informants' working sphere segments were interrupted, on the average. In considering central and peripheral working spheres only, about 83% of people's working spheres concerned work that was central to them, and 17% was peripheral. Central working sphere segments were interrupted to a higher proportion than peripheral working sphere segments $X^2_{(1)}=44.91$, p<.001, (Table 1).

WS Type	Interrupted	Not Interrupted	(Row avg)
Central WS	60.3% (87.5%)	39.7% (76.8%)	100% (82.9%)
Peripheral WS	41.7% (12.5%)	58.3% (23.2%)	100% (17.1%)
Column avg	(57.1%)	(42.9%)	100%

Table 1. Type of working sphere related to percent of interruptions. Data in parentheses are % within interrupted/not interrupted. N=2246.

We next analyzed the type of interruption. Most interruptions are due to metawork, personal, and "unknown" (45.3%), followed by central working spheres (36.3%), and then peripheral working spheres (18.3%). "Other" interruptions were mostly due to personal work.

An overview of time length of working sphere segments.

The average length of time that the informants spent in central and peripheral working spheres was 11 min. 4 sec., (sd=18 min. 9 sec.) before switching to another working sphere or being interrupted.

We compared the average length of working sphere segments when interrupted and not. As we were concerned about the lack of independence within subjects, we included subjects as

[2] Metawork refers to the high-level management of one's work, e.g. coordination, checking activities, organizing email (as opposed to reading and answering it), organizing one's desktop, and catching up with teammates if absent.

a factor. First, segments that *were* interrupted lasted significantly longer (12 min. 40 sec., sd=14 min. 33 sec.) than those not interrupted (8 min. 58 sec, sd=14 min. 43 sec.), $F(1,1)=26.14$, $p<.001$). We did find a significant difference between subjects, $F(1,23)=2.31$, $p<.001$. This result shows that there are differences in work fragmentation behavior among people. Further, the longer one works in a working sphere segment, the longer is the interrupting event ($r=.132$, $N=1281$, $p<.001$.

Thus, fragmentation of work is a way of life for these information workers. The majority of working spheres are interrupted and people spend about 11 minutes in a working sphere before switching to another. The irony of the work day is that the longer people spend in a working sphere, (and thus we assume become more involved in it) the more likely it is to be interrupted and the longer is the interrupting event.

Collocated and distributed work and fragmentation

Considering that an open office environment affords people the opportunity to "talk through the walls" and quickly stop into others' cubicles, we hypothesized that collocated work would be interrupted more frequently. We divided the informants into two categories: *collocated*, where their office exists in a cubicle in an open office environment and where they had at least one of their team-members sitting in an adjacent cubicle, i.e. sharing a wall, or *distributed*, where their workspace was physically separated from their teammates by being at a distance from them in an enclosed office, across the room, or in another building. Fifteen people were collocated and nine were distributed.

We found that there was a significant effect of collocation: collocated people spend longer, on average, in a working sphere (11 min. 56 sec., sd=15 min. 33 sec.) compared to distributed people (9 min. 56 sec., sd=13 min. 29 sec.) before being interrupted or switching working spheres, $t(1,2244)=3.21$, $p<.001$.

We maintain that fragmentation of work concerns both working sphere length and interruptions. We found that collocated people experience significantly more of their working sphere segments interrupted (62.9%) compared to distributed people (49.3%), $X^2_{(1)}=42.14$, $p<.001$. Therefore, though collocated workers spend longer stretches in working spheres, they are more likely to switch them due to interruptions as opposed to completing work in them. Our observations can help to explain this. Awareness of when to interrupt collocated colleagues due to overhearing them was commonly observed and described during interviews. Informants listened to what their cubicle neighbors were doing and avoided interrupting when they were busy. When in doubt, they asked if they could interrupt. However, when they sensed that their colleagues were available, then they interrupted them. Sometimes people who did not need to be involved in a situation became involved through their collocation. The open office environment affords a culture of participation in solving problems even when people are not directly asked for advice. The informants described that they overheard problems which drew them in. For example, hearing a neighbor work on a system problem led them to check that part of the system that they were responsible for. In other cases, our informants described that they were on alert to offer their expertise to their colleagues, e.g., "*I think my ears are always [alert] to listening to something because I find that my exposure….almost in every case I can lend something that some of the other people are not exposed to, you know they know their knowledge base, but once it passes that boundary they are kind of fuzzy on that.*"

Table 2 shows interruptions broken down by their source. Most interruptions for both collocated and distributed people are due to "other" working spheres. The distributions are significantly different, $X^2_{(2)}=12.88$, $p<.002$. Collocated people experience slightly more interruptions from peripheral work whereas distributed people experience more interruptions from "other" types of work. This could be due to collocated people having more people around them who can interrupt them with issues not related to their central work whereas distributed people may feel freer to take personal breaks.

Interruption Source	Collocated	Distributed	Total / (row avg)
Central WS	58.4% (21.3%)	41.6% (20.1%)	100% (20.7%)
Peripheral WS	67.2% (12.3%)	32.8% (8.0%)	100% (10.5%)
Other WS* (personal, metawork, unknown)	55.0% (66.4%)	45.0% (71.9%)	100% (68.8%)
Column avg.	57.0%%[3]	43.0%	100%

Table 2. Percent of collocated/distributed interruptions according to the nature of the interruption. Data in parentheses are percentages within collocation. N=1282

As managers, analysts and developers were fairly evenly distributed over collocated/distributed settings, work role was not an explanation for these results. We found no effect of role in working sphere length $F(1,2)=.862$, $p<.42$, and no interaction of collocation and role, $F(1,2)=1.31$, $p<.27$. We found no significant difference in amount of interruptions among work roles ($X^2_{(2)}=.98$, $p<.61$).

Thus, collocated people work longer in working spheres before switching. However, when collocated, people are more likely to interrupt each other than when distributed. The types of interruptions that collocated and distributed people experience are slightly different.

[3] Note that this table considers the breakdown of interruptions only in contrast to the previous result which shows the *proportion* of working spheres interrupted.

Types of interruptions: external and internal

Interruptions can be external or internal, as we described earlier. There is a significant difference of internal/external interruptions and work role. Managers are more likely to experience external interruptions (59.2%) than internal interruptions (40.8%), whereas analysts and developers experience internal and external interruptions about equally, $X^2_{(2)}$=.10.1, p<.006.

One reason that could explain internal interruptions is that they occur when people need a problem to incubate. The nature of work for analysts and developers is generally intellective and when a problem is difficult to solve, incubation could help. As one analyst described, "*And even though you are not really spending time on [a problem], you are still sort of thinking about it in the background and understanding the relationships between different pieces of data or different business processes.*" In contrast, managers, who experience a higher proportion of external interruptions, generally perform delegation and coordination activities. Further, managers generally interact in a wider circle of people than analysts and developers and therefore the chances are greater that they experience external interruptions outside of their current working sphere, compared to analysts and developers.

interruption Source	Internal	External	Total (row avg.)
Central WS	38.0% (28.8%)*	62.0% (43.3%)	100% (36.3%)
Peripheral WS	20.0% (7.6%)	80.0% (28.2%)	100% (18.3%)
Other WS (personal, metawork, unknown)	67.3% (63.6%)	32.7% (28.5%)	100% (45.3%)
Column avg.	52.0%	48.0%	100%

Table 3. Percent of internal/external interruptions according to the source of the interruption. Data in parentheses are percentages within internal/external. N=1282.

There is no significant difference in internal or external interruptions for type of working sphere, $X^2_{(1)}$=.14, p<.70, or for collocated/distributed, $X^2_{(1)}$=.94, p<.76. Surprising to us, there is no difference between the length of time spent in working spheres that were internally or externally interrupted, t(1290)=1.29, p<.20.

Table 3 shows interruption type in relation to the source of the interruption. Most internal interruptions are due to personal, metawork or unknown working spheres (63.6%) whereas most external interruptions are due to work related to central working spheres (43.3%), $X^2_{(2)}$=179.24, p<.001.

Resumption of interrupted work

In this section we examine the resumption of interrupted work. We only consider work that was interrupted and resumed on the same day in order to make a uniform comparison among all informants. Some people were observed on nonconsecutive days because they were out a day, or because the weekend intervened. We also do not consider interrupted work during the last work hour, as there is not much chance for it to be resumed that day.

77.2% of interrupted work was resumed on the same day. What type of work was most likely to be resumed? Not surprisingly, of all interrupted work resumed, people's interrupted central working spheres were about twice as likely to be resumed on the same day (82.0%) compared to people's interrupted peripheral working spheres (43.8%), $X^2_{(1)}$=116.46, p<.001. We also found that the length of time that people spent on a working sphere that was interrupted bore no relation to whether the work was resumed later that day or not (t(1280)=.31, p<.76).

When people did resume work on the same day, it took an average length of time of 25 min. 26 sec (sd=54 min. 48 sec.). This may seem like a relatively short amount of time, but it is also important to consider that before resuming work, our informants worked in an average of 2.26 (sd=2.79) working spheres. Thus, people's attention was directed to multiple other topics before resuming work. This was reported by informants as being very detrimental. In some cases, the physical or desktop environment is restructured, which makes it more difficult to rely on cues to reorient one to their interrupted task. For example, a blinking cursor at the end of the last typed word can enable one to immediately reorient to that document, whereas if other windows have been opened, it can be hard to remember even which document had been worked on.

We found a trend that showed more externally interrupted working spheres are resumed on the same day (53.3%) compared to internally interrupted working spheres (47.6%), $X^2_{(1)}$=2.97, p<.09. Externally interrupted working spheres are resumed on the average in a shorter time (22 min. 37 sec., sd=53 min. 52 sec.) than internally interrupted working spheres, (29 min. 1 sec., sd=55 min. 43 sec.), t(987)=1.92, p<.055.

Our observations revealed that sometimes people resumed interrupted working spheres on their own. Other times interrupted working spheres were brought to the attention of the informant, e.g. through phone calls, or by people entering their cubicle speaking about the work. We coded the data into two types of work resumption: *externally-initiated* resumption, where three main kinds of interactions occurred that led people to resume work: phone calls, people showing up in the cubicle, or people in adjacent cubicles talking to them "through the wall", and *self-initiated* resumption where no evidence was observed that another interaction was associated with the resumption of work. Though there may be events in the environment that lead people to resume work (e.g. overhearing through the cubicle wall), we cannot say whether these led to work resumption so we coded these as self-initiated. Of interrupted work that was resumed on the

same day, only a small proportion was due to externally initiated resumptions (9.9%) compared to work that was resumed by one's self (90.1%). The amount of time before working spheres were externally resumed was significantly longer (61 min. 37 sec., sd=95 min. 11 sec.) than working spheres that were self-resumed (21 min. 28 sec., sd=46 min. 47 sec.), $t(987)=7.05$, $p<.001$. Thus, people are more likely to resume work on their own and to do it faster than when interactions with others lead them to do it.

The length of time in a working sphere later affects one's tendency to resume work in it if it is interrupted. People worked significantly longer in working spheres that were interrupted and later self-resumed (12 min. 59 sec. sd=15 min. 4 sec.) compared to those that were externally resumed (8 min. 58 sec, sd=10 min. 22 sec.), $t(988)=2.58$, $p<.01$.

A higher proportion of interrupted working spheres are resumed on the same day when people are distributed (82.1%) compared to when people are collocated (74.3%), $X^2_{(1)}=10.42$, $p<.001$. Collocated workers showed a trend to resume work more due to externally-initiated resumption (11.2%) compared to distributed workers (7.9%), $X^2_{(1)}=2.81$, $p<.09$. Thus, distributed people are more likely to resume work in general, and to do so specifically through self-initated resumption, compared to collocated people.

Work fragmentation during the work day

We next looked at how work is fragmented in the morning versus the afternoon. Based on an examination of the data which showed few working spheres that occurred between noon and 1 p.m. when most went to lunch, we divided the data into morning (until 12 noon) and afternoon (after 1 p.m.). We did not consider data between noon and 1 p.m. One informant who began work at 5 a.m. was eliminated from the analysis as an outlier.

First, there were no significant differences between numbers of interruptions that occurred in the morning or afternoon, $X^2_{(1)}=1.23$, $p<.27$. However, working spheres in the morning (10 min. 72 sec., sd=12 min. 56 sec.) had a significantly shorter duration than in the afternoon (14 min. 40 sec., sd=16 min. 14 sec.), before being interrupted or switching to another working sphere, $t(1191)=4.71$, $p<.001$.

These differences in the duration of the working spheres over the course of the day can be due to a conscious effort by informants to postpone work that demands more concentration. As one informant explained, "*You know, I have some tasks that require a large amount of concentration. I usually put those at the end of the day because you get fewer interruptions…*"

Summary of work fragmentation results

Table 4 shows a summary of the results as they relate to our defined two components of work fragmentation: length of time in a working sphere and interruptions.

Effect	Time spent in WS	Interruptions
Overview	11 min. before switching Avg. of 11.7 different working spheres No effect of work role	57% of WS interrupted Central work interrupted by higher proportion Most interruptions due to personal work No work role effect
Collocation/ Distribution	Collocated spend longer in WS than distributed	Collocated have more interruptions Most interruptions for both colloc./distr. due to personal work Collocated more likely to be interrupted from peripheral work; distributed more likely to be interrupted by personal work
Effect of type of interruption	No difference in WS time due to internal/external interruptions	Most internal interruptions due to personal WS; most external interruptions due to central WS Managers have more external interruptions; no difference for analysts/developers
Resumption of interrupted work	People worked longer in working spheres that were interrupted and self-resumed	77% of work resumed on same day Distributed most likely to resume work Avg. of 2.3 intervening WS before resumption More externally interrupted WSs resumed, and resumed faster More interrupted WS self-resumed and resumed faster Distr. work resumed faster by self
Time of day	WS in a.m. last shorter than in p.m.	No diff in amt. of interruptions

Table 4. A summary of results for work fragmentation.

DISCUSSION

In this paper we have presented data that shows that our informants' work is very fragmented. Our broader concern is to argue that these results demonstrate a paradox in IT support: current IT is designed around supporting distinct applications that relate to separate events (word documents, spreadsheets, etc.). Yet this design paradigm does not consider that such separate events are part of higher level units of work that appear cohesive to information workers. When a working sphere is fragmented it is not only that an event is shortened or interrupted, but rather that a larger framework of work is disconnected.

Our study has shown that context determines whether interruptions are considered to be beneficial or detrimental. In general, we found that interruptions that occur outside of one's current working sphere context are disruptive as they lead one to (sometimes radically) shift their thinking. In

contrast, interruptions that concern one's current working sphere are considered helpful.

We have argued that work fragmentation consists of two components: length of time spent in a working sphere and interruptions. Though others have focused on interruptions during the work day [4,7,16], interruptions are just half the story. We found that even when people are not interrupted, they spend short amounts of time in a working sphere before switching to another. We cannot fully explain why people move on to other working spheres quickly even when there is no evidence of an interruption. Our best interpretation from our observations is that people are responding to the external demands in the workplace. They are continually juggling their priorities according to the work context. When the work context changes, some tasks may take higher priority and workers switch tasks to adapt to these conditions. Most informants report though that they prefer to complete one task before moving on to another.

Our informants experienced a majority of their working spheres interrupted (57%). We found that most work is resumed on the same day (77%), in contrast to [16] who found that only 55% of work was resumed immediately. For our result, we looked at a broader time span of the whole day. The pattern shows that people resume work after first turning to work in more than two other working spheres. This suggests a fairly high cognitive cost to resume work, as people are distracted by multiple other topics, and sometimes even nested interruptions. Our informants report that this can result in redundant work as they reorient.

We are aware of no other study that has systematically investigated the difference between interruption type. Working spheres interrupted externally tend to be more likely resumed, and to be resumed faster. People may have been more involved in working spheres that were externally interrupted. Internal interruptions may be more in people's control, e.g. if people take a break to let a problem incubate. Thus, if people were more involved in a working sphere when externally interrupted, then they may be more likely to try to resume work in these. Studies of managers' interruptions are comparable to our coded external interruptions [7,13,23]. However, in other work roles (developers and analysts), people were just as likely to interrupt themselves as to be externally interrupted. These results suggest that the type of task (intellective) may influence the nature of interruptions.

We expected that collocated colleagues in an open office environment would experience more interruptions, which our results showed. However, they also worked longer stretches in working spheres before switching. One explanation from observations is that colleagues in an open office environment are more aware of when to wait for natural breaking points before interrupting others, e.g. when hearing through the cubicle wall that someone has finished a phone call. The problem with distributed colleagues is that their natural breaking points are not known.

We found that people who resumed interrupted events on their own worked on these significantly longer than when external influences led to task resumption. This result is consistent with the Zeigarnik effect which found that people who worked longer on a task were more invested in it and more likely to voluntarily return to the task to complete it [25]. This suggests that external technological "reminders" could prove useful when people are interrupted after working only brief periods.

Technology support for fragmented work

Two decades ago Bannon et al. [2] suggested a set of requirements for information technology to support multitasking including providing fast task-switching and the easy retrieval of mental context. Our work expands these requirements for multi-tasking. We suggest three main directions for supporting multi-tasking behavior: 1) interruptions ideally should match the current working sphere in order to provide benefits instead of disruptions, 2) one should be able to easily and seamlessly switch between tasks, and 3) interrupted tasks should be easily recoverable by preserving the state of the task when it was interrupted and by providing cues for reorienting to the task.

The requirements of Bannon et al. influenced the development of systems along two distinct approaches: providing support for group and individual multi-tasking. Neither approach truly facilitates the fast switching of tasks and recovery of interrupted tasks though the individual-oriented systems support this better. The group systems provide awareness of where co-workers are located in the virtual space of the system, which allows users to know what working sphere a co-worker is currently involved in. None of these approaches provide cues for reorienting after an interruption.

Group-oriented systems include TeamRooms [21] and Orbit [12]. In both systems the virtual spaces are populated with generic artifacts that all members of the group use. For TeamRooms, individual rooms may be created for a more personalized set of artifacts, but the user must then manage multiple rooms instead of one. Orbit allows users to selectively hide unnecessary artifacts alleviating that problem, but its drawback is that the individual view contains the artifacts from every "locale" the user is involved with.

Individual-oriented approaches to supporting multi-tasking include GroupBar [22], UMEA [10], TaskMaster [3], Kumira[11] and TaskGallery [19]. GroupBar, which is basically an updated version of the Window's TaskBar, does not provide persistence of rearranged items after computer shut-down. TaskGallery appeared to be the most adept at supporting fast task-switching. Using a 3D metaphor each individual task is stored as a separate picture in a gallery. The order of the windows within each picture is maintained between sessions.

We propose that systems should provide both fully customizable, individual, project-specific views as well as providing awareness information on co-workers' virtual locations. We believe that the focus should be on personalized workspaces with consistent naming conventions for working spheres so that the awareness information remains easily understandable. It is important that colleagues clearly understand when an interruption might be disruptive, i.e. when it does not match the current working sphere context. We also propose that systems should go one step further and provide a tag along with the users' virtual location, reflecting what kind of interruptions the user is willing to tolerate when involved in that particular working sphere. For example, tags could be "any interruptions," "no interruptions," or "only interruptions related to this working sphere." The goal of such awareness is to minimize disruptive interruptions while still allowing beneficial interruptions or "interactions" to filter through. Proposals for systems to filter interruptions [7,16] have treated all interruptions as the same. Our study suggests that interruptions outside of one's current working sphere require more careful filtering as our informants view them as disruptive.

We found an average of more than two intervening working spheres before an interrupted activity is resumed. We observed that in some cases these intervening working spheres lead people to restructure their environment, e.g. they open new documents, or close applications. The user requires cognitive effort not only to reconstruct the state of the activity that was interrupted, but also to do so in a work setting that often has changed. This observation suggests that the number of intervening activities after an interrupted task needs to be considered in helping one reorient to the task. The more intervening tasks, the more information needs to be preserved about the state of the interrupted task.

Developing such technical support concerns the effort that a user is willing to invest in defining clusters of events and resources for working spheres. From interviews and observations we can say that our informants have proven that they are quite adept at defining their working spheres. We must consider though how it can be done during real work. Recently we have been experimenting with a prototype which allows fast-retrieval of computer resources associated with working spheres and recuperation of the screen layout [15]. The authors found that six users that have used the system for a period of two months were able to cluster together resources of a working sphere. The users recognized the benefits from fast-retrieval of a working sphere state as it was before switching. These preliminary results suggest it is feasible for users to define their working spheres as they are created. We envision that this form of information organization is not any more difficult than organizing information into current file directories. We propose though that all information associated with a working sphere be clustered together (emails, documents, spreadsheets, voicemail, etc.).

The systems described earlier in this section for supporting multi-tasking impose a very rigid scheme to present information associated with activities (e.g. by contact, by application, by date). Our study suggests instead that technology support for fragmented work should move beyond such rigid displays of information. Systems need to provide *flexible views* of resources in a working sphere: enabling the working sphere to be viewed from the perspective of the people involved or the last action performed in it. These flexible views can help people reorient themselves fast by providing different types of cues to "enter" the working sphere state. Informants in our study were faced with multi-tasking under time pressure. They needed to constantly reevaluate their priorities of what work must be accomplished next. Therefore, research needs to focus on what types of cues can best help people reorient to their interrupted working spheres.

Limitations and generalizability of the study

Our study has several limitations. First, it is very difficult to code activities during ethnographic observation without a video record (recording was not permitted). Though we specified strict coding criteria, e.g. for evidence of an indication that a working sphere was internally interrupted, it is possible that some internal interruptions were really working spheres in which people finished the task. We used multiple sources of data to verify our coding (e.g. speaking with the informants), but the possibility of errors still remain. Our large number of observations should reduce the effect of coding errors. Even with errors in coding interruptions and working sphere type, this does not change our basic result: that people spend short amounts of time in working spheres before switching. We are fairly confident that the assignment of events to working spheres is relatively accurate due to using multiple sources of information to assign them and validate them. Thus, we feel our basic result still holds that people switch rapidly between different working spheres.

The ethnographic observation methodology has other limitations. There are measurement errors, but we assume these are normally distributed. The observer cannot be the source of interruptions and must wait until the end of the day to ask clarifications. We were careful to assign questionable events in the unknown category. Despite the tradeoff of limitations, we do feel our methodology of systematically measuring people's activities with a timer provides useful information about people's work patterns. We believe that one observer is sufficient given the nature of the timing methodology that was used.

Another limitation is in the generalizability of the results. As we observed only one organization, we can only generalize our results to companies with similar characteristics: high pressure firms where many different tools are integral to work, and where people manage multiple activities. Further research is needed to understand work fragmentation in other work environments.

CONCLUSIONS

Our study has shown that fragmented work is common practice for our informants. We argue that two dimensions must be considered for supporting the continuity of work that is fragmented: how long people spend in a working sphere and interruptions. Our data argues that support needs to consider the continuity not of separate events but rather of the state of work in a larger cohesive framework: people's working spheres. Interruptions should be viewed according to whether their content matches one's current working sphere.

We plan in further research to pursue what leads people to internally interrupt themselves. We also plan to develop an index of work fragmentation which can benefit technology support. We are continuing to collect observations in other organizations to better generalize our results.

ACKNOWLEDGMENTS

We wish to thank Aimee Strang for her help. This research was supported by the National Science Foundation under grant no. 0093496 and the Center for Research on Information Technology and Organizations.

REFERENCES

1. Bannon, L., A. Cypher, S. Greenspan, and M. Monty. (1983). Evaluation and Analysis of Users' Activity Organization. *Proc. Of CHI'83*, 54-57.
2. Belloti, V., N. Ducheneaut, M. Howard,and I. Smith. (2003). Taking email to task: the design and evaluation of a task management centered email tool. *Proceedings of CHI '03*, 345-352.
3. Bluedorn, A. C., C. F. Kaufman, et al. (1992). "How many things do you like to do at once? An introduction to monochronic and polychronic time." *Academy of Management Executive* 6(4), 17-26.
4. Czerwinski, M., Horvitz, E., and Wilhite, S. (2004). A diary study of task switching and interruptions. *Proceedings of CHI 2004*, 175-182.
5. DiMaggio, P. (2001). The Futures of Business Organization and Paradoxes of Change. In *The Twenty-First-Century Firm: Changing economic organization in international perspective*. Princeton U Press, 210-244.
6. Gonzalez, V. and Mark, G. (2004). "Constant, Constant, Multi-tasking Craziness": Managing Multiple Working Spheres. *Proceedings of ACM CHI'04*, 113=120.
7. Hudson, J.M., Christensen, J., Kellogg, W.A. and Erickson, T. "I'd be overwhelmed, but it's just one more thing to do:" Availability and interruption in research management. (2002). *Proceedings of CHI 2002*, 97-104.
8. Jackson, M. (2002). *What's Happening to Home? Balancing Work, Life, and Refuge in the Information Age*. Notre Dame: Sorin.
9. Kaptelinin, V. (2003). UMEA: Translating interaction histories into project context. *Proc. CHI '03*, 353-360.
10. Kraut, R. E., R. Fish, et al. (1993). Informal communication in organizations: form, function, and technology. In R. Baecker (Ed.) *Groupware and Computer-Supported Cooperative Work.* Morgan Kaufmann, 1993, 287-314.
11. MacIntyre, B., E.D. Mynatt, S. Voida, K.M. Hansen, J. Tulio, and G.M. Corso. (2001). Support For multitasking and background awareness using interactive peripheral displays. *User Interface Software and Technology 2001*.
12. Mansfield, T., Kaplan, S., Fitzpatrick, G., Phelps, T., Fitzpatrick, M. and Taylor, R. Evolving Orbit: A progress report on building locales. *Proceedings of Group'97*, ACM Press, 241-250.
13. Mintzberg, H. (1973). *The Nature of Managerial Work*. Englewood Cliffs N.J., Prentice Hall.
14. Miyata, Y. and Norman, D.A. (1986). Psychological issues in support of multiple activities, in *User Centered System Design*, D.A. Norman and S.W. Draper (Eds). Lawrence Erlbaum, Hillsdale, N.J., 265-284.
15. Morteo, R.; Gonzalez, V.; Favela, J., Mark, G. (2004). Sphere Juggler: fast context retrieval in support of working spheres. *Proc. of IEEE Mex. Inter'l Conference in Computer Science 2004*, IEEE Press, 361-367.
16. O'Connail, B. & Frohlich, D. (1995). Timespace in the workplace: Dealing with interruptions. *Proc. Of CHI '95* Extended Abstracts, 262-263.
17. Olson, G. M., & Olson, J. S. (2000). Distance Matters. *Human-Computer Interaction*, 15(2/3), 139-178.
18. Perlow, L.A., The time famine: Toward a sociology of work time. *Admin. Science Quarterly*, 44, (1999), 57-81.
19. Robertson, G., M. Van Dantzich, D. Robbins, M. Czerwinski, K. Hinckly, K. Risden, D. Thiel. (2000). The Task Gallery. *Proceedings of CHI'00,* 494-501.
20. Rouncefield, M., Hughes, J., Rodden, T., and Viller, S. (1994). Working with "constant interruption": CSCW and the small office. *Proc. CSCW'94*, 275-286.
21. Roseman, M. and Greenberg, S. (1996). TeamRooms: Network Places for Collaboration. *Proceedings of ACM CSCW'96*, ACM Press, 325-333.
22. Smith, G., P. Baudisch, G. Robertson, M. Czerwinski, B. Meyers, D. Robbins, and D. Andrews. (2003). GroupBar: The TaskBar Evolved. *Proc. of OZCHI'03*.
23. Sproull, L.S., The nature of managerial attention. *Advances in Information Processing in Organizations*, 1, (1984), 9-27.
24. Vahtera, J. (2004). Finnish Institute of Occupational Health. *The New York Times*, Sept. 6, 2004.
25. Zeigarnik, B. (1938). On finished and unfinished tasks, in W. D. Ellis, *A Source Book of Gestalt Psychology*, NY: Harcourt-Brace.