

# The Effect of Interruptions on Knowledge Work

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## Abstract

*Interruptions are an omnipresent part of the workplace and have the potential to be especially harmful in cognitively intensive knowledge work environments. Using a within-subjects experimental design, this study assessed the effect of interruptions on knowledge work while manipulating how that interruption was conveyed to the participant. In addition, it explored how those interruptions were subsequently managed. Fifteen workplace participants were treated to three interruption modality types: interruption by Telephone, In-Person, and via Instant Messaging (IM). Results indicate that interruptions affect the effort required to complete a task, but not its outcome. There was no effect of modality except with regard to initial response to the interruption; people responded faster to the Telephone, but were able to resume their original task as quickly.*

**Keywords:** *workplace interruptions, knowledge work, information searching, interruption modality, interruption management strategies*

## 1. Introduction

The modern workplace is characterized by interruptions, precipitated by new technologies and an increase in collaborative work practices. Today's workplace provides multiple opportunities for multiple types of interruptions – from cell phones, personal digital assistants, and email to a host of other technologies such as instant messaging (IM) and VOIP (Voice Over Internet Protocol), and naturally, interruptions by colleagues. Previous research has shown that workplace interruptions tend to be frequent with considerable work time spent managing them (O'Connell and Frohlich, 1995). At the same time, workplace activities have shifted from procedure and production to knowledge work. Unlike procedural and production work tasks, knowledge work includes cognitively intensive tasks in which people actively seek meaning (Kuhlthau, 1991) in masses of information; few tasks have clearly delineated goals at the outset, and few have predictable outcomes. Notably little research has examined the effect of interruption on this type of task. In this research, we experimentally tested the effect of interruptions on knowledge work and assessed the effect of that interruption when it was conveyed in different ways.

## 2. Previous Work

### 2.1 What is an Interruption?

There are several definitions of an interruption: a) "... any disturbance to the normal functioning of a process in a system" (Cooper & Franks, 1993); b) "... the process of coordinating abrupt change in people's activities" (McFarlane, 1998); and, c) "a synchronous interaction which was not initiated by the [individual], was unscheduled and resulted in the recipient discontinuing their current activity" (O'Connell & Frohlich, 1995). In the workplace, an interruption may be conveyed by the telephone, a fire alarm, or a colleague stopping by to chat.

Notably, an interruption may have a positive or negative effect on workplace outcomes. After 150 hours of observation in a commercial telecommunications office, Eyrolle and Cellier (2000) found a time cost associated with interruptions, even when accuracy of task performance was not affected. Similarly, in a simulated flight deck study, recorded voice interruptions had deleterious effects (Latorella, 1999). The study concluded that "[i]n a relatively realistic task context, even simple, routine interruptions significantly and operationally degrade performance of an ongoing procedure and appear to motivate compensatory strategies" (p.115). Hudson, Christensen, Kellogg, and Erickson (2002), however, found a different effect in their examination of the work habits and time management of 12 middle and upper managers who used Blackberry (PDA) devices for a week. During that period, participants received brief surveys about the type of activity they were engaged in and how receptive they were to an interruption at that particular moment. Notably, while most participants agreed that interruptions could be quite annoying, they also stated that they are an expected and often quite beneficial part of their jobs.

An interruption is a complex phenomenon with multiple dimensions (see McFarlane & Latorella (2002) and Toms et al (2005) for a detailed list). An interruption has a source, such as self, or another person or object. It may be conveyed using a variety of mechanisms, and may be delivered in a verbal (auditory), or non-verbal means. An interruption may be managed by the receiver in different ways (e.g., immediate, negotiated, mediated, and scheduled) (McFarlane, 1998), and it may have an immediate effect on the user and/or on the task that the user is performing. In addition, there may be mitigating or exacerbating circumstances regarding the workplace including the physical facility and the manager that affect the interruption's impact on workplace activities. To date, interruption research has examined the effect of interruptions in a variety of settings, including home (Nagel, Hudson & Abowd, 2004; Monk, Boehm-Davis, & Trafton, 2004) and workplace (Dabbish & Kraut, 2003; McFarlane & Latorella, 2002; Miller, 2001; O'Connell & Frohlich, 1995; Eyrolle & Cellier, 2000; Fisher, 1998) settings. Often interruption research is associated with multi-tasking, but multi-tasking may occur once an interruption is managed. In this research we focus on two aspects of interruptions: modality and management strategy.

### 2.2 Interruption Modality and Interruption Management Strategies (IMS)

*Modality* indicates how the interruption was conveyed or introduced to a person. A modality may involve direct communication (e.g. face-to-face), or mediation by a person, machine or other object (McFarlane, 1997). Prior research has shown that the way an interruption is conveyed can affect how interruptions are managed as well as work outcomes. For example, in air-traffic control environments, operators postponed visual interruptive tasks longer than those that were auditory or tactile in nature

when their primary task was visual (Ho et al., 2004). The results of this study concluded that the modality of an interruption has an affect. No other studies of modality were discovered in our research.

In addition to modality, *interruption management* also has the potential to impact interruption effects. Interruption management "... entails, detecting the annunciation stimulus, interpreting the stimulus in terms of the interrupting task performance requirements, and integrating the interrupting task and the ongoing procedure tasks for performance" (Latorella, 1999, p.19). Thus, an interruption is handled in a set of stages: *detecting* the interruption, *interpreting* what the interruption consists of, *integrating* the interruption into the current work task and then *continuing* with the ongoing task. The benefits and costs of performing the interruption requirements immediately, or not, may be weighed by the individual: should I complete it now, or schedule it for the future? The point of detecting an interruption is usually referred to as the *interruption point*. After dealing with the interruption, the person returns to the original task. This is the *resumption point*.

Interruption management has been addressed in multiple prior studies (see McFarlane & Latorella, 2002; Burmistrov & Leonova, 1996; Eyrolle & Cellier, 2000). Eyrolle and Cellier identified four main Interruption Management Strategies (IMS) in their field study: 1) process the work task completely before beginning to process the interruptive task; 2) delay processing the interruptive task in order to complete the work task (i.e. asking a caller to wait on hold); 3) identify the content of the interruptive task and then complete the work task before processing the interruptive task; and, 4) process the interruptive task immediately, leaving the work task to be completed later (p.539). The first two IMS reduced the effects of the interruption the most, but were used the least. Burmistrov and Leonova (1996) developed a slightly different set of IMS in their study of the effect of interruptions on task performance of text editors. The challenge thus in managing an interruption is in how to deal with it such that it causes the least damage and has the greatest benefit; the strategy must not be more disruptive than the interruption (McFarlane & Latorella, 2002).

### **3.0 Objectives and Research Questions**

Previous work indicates that interruptions may have either a positive or a negative effect on the work task. But, we do not understand the effect of modality except in a limited fashion with a single characteristic of modality: auditory versus visual, and in particular not with regard to office workers performing knowledge tasks.

The primary purpose of this research was to assess whether interruptions impact a knowledge work task and how people manage interruptions when those interruptions are introduced using different modalities (e.g. in person, over the telephone and via instant messaging). In addition, this study explored (but did not control) the types of IMS used to handle interruptions, and investigated the relationship between interruption modality type and the IMS. The key questions guiding this study were:

1. Do interruptions affect effectiveness and efficiency of the task?
2. Does the modality of interruption affect effectiveness and efficiency of the task?
3. Does the modality of interruption affect interruption management strategies?

## **4. Methodology**

### **4.1 Overview**

This study employed an experimental within-subjects design. Fifteen participants were interrupted by three different interruption modalities while performing a series of information tasks. Both modalities and tasks were counter-balanced to control for learning effects. Multiple types of data were collected to assess the effect of the interruption which was introduced in a simulated workplace environment.

### **4.2 Participants**

No formal sampling was done. Ideal participants were web users who had significant experience working in an office environment. Participants were recruited by targeted email and distribution of recruitment flyers through friends and colleagues. Participants were given a \$20 honorarium for their participation.

About half of the 15 (f=11 and m=4) participants were under 35 and half were older with an age range from early twenties to late fifties. All but two of the participants either held undergraduate degrees or were enrolled in one. Six of the 15 participants were senior students, all of which had completed a minimum of three work terms in their specialty. Three of them also reported holding part time positions doing what would qualify as knowledge work. The remaining nine participants' job titles were classified as: Healthcare (22%), Administration (33%) and Management & Marketing (45%). All of the participants reported using the web for more than five years. All used email daily and searched the web either daily (67%) or weekly (33%). In addition, participants indicated that they spent their time writing documents (22%), responding to e-mail (18%) and searching for information (17%). The remainder of the time was split relatively evenly between making and accepting phone calls, face-to-face meetings and other tasks.

### **4.3 Independent Variable**

Three modalities of interruptions were used:

- a) Instant Messaging (IM);
- b) In-Person;
- c) Telephone.

The interruptions were introduced using a standard script. Interruptions were administered at 15, 30 and 45 minutes into the study, and were counter-balanced by participant. Each interruption task conformed to a likely workplace activity: What is the phone number of a person? Help me identify an appropriate product to purchase? Go to a particular URL and summarize the intentions? The order of the modalities was balanced across the set of participants.

### **4.4 Workplace Scenario and Knowledge Work Tasks**

#### **4.4.1 Workplace Scenario**

We simulated an office setting following Borlund's (2003) guidelines for workplace scenarios. Participants were informed about the scenario using the following script:

*You work as an assistant to Pat Jones, the director of A.I.M. Consulting Ltd., in Halifax, Nova Scotia.*

*In this role you carry out typical office tasks such as:  
Answering the telephone  
Reading and responding to email  
Sending and receiving faxes  
Attending both scheduled and impromptu meetings  
Documenting and filing work  
Communicating with and to others, and more.*

*The Director also relies on you to search for and gather information critical for decision-making and report writing.*

*The Director has left six folders on your desk. Each contains a piece of paper that identifies the needed information. Use Google to find one or several websites that contain the needed information. Summarize the info and include the URLs of each page used in your answer. Use Word, and print the answer and place it in its respective folder. The Director has numbered the folders 1-6, in order of importance, 1 being the most important. Please complete them in order of importance.*

*While you are doing these search tasks you will also be assigned other tasks. You also have a meeting at 0h00 (1 hour after start time) that you must attend. Please manage your time as you would normally.*

This scenario which was read to participants before they began the study achieves the two goals for appropriate scenarios in laboratory studies: “1) it triggers and develops a simulated information need by allowing for user interpretations of the situation, leading to cognitively individual information need interpretations as in real life; and 2) it is the platform against which situational relevance is judged” (Borlund & Ingwersen, 1997: 227-228). The scenario sets the stage, telling participants their role, tasks and what they will be doing during the study and how.

The tasks contained in the folders were estimated to take 15 minutes each, or 90 minutes total, to complete. However, participants were given 60 minutes to complete the study. They were asked to complete the search tasks, but were not told that they were not expected to be able to complete all six tasks. This was done to simulate a demanding work environment.

#### **4.4.2 Knowledge Work Tasks**

To simulate the knowledge work environment, a set of information search tasks were selected as the vehicle. Information search tasks are elemental to knowledge work and have never been interrupted in prior studies. Yet, searching for information has become a mainstream work task with 20 to 50% of work being devoted to finding information.

The six tasks used in the study can be summarized as: Flu shot; Global warming; Kyoto, Japan; Second-hand smoke; Rex Murphy; and, Sao Paulo, Brazil. These tasks were derived from earlier studies and selected from that set according to difficulty and complexity, so that all six tasks were homogeneous (see Hersh & Over, 2001). Since the intention of this study was to simulate a workplace setting, small modifications to the wording of the chosen tasks were made to bring them in line with the “simulated work task” guidelines (Borlund, 2003). For example the first was provided as follows:

*The Human Resources Department is putting on a flu shot clinic next week and has asked the Occupational Health & Safety Committee to put together a short pamphlet on the risks and*

*benefits of having a flu shot. Can you please find information about the categories of people who should not get a flu shot and why. Please ensure it's from a reliable source.*

#### 4.5 Dependent Variables

Each task was assessed using the metrics contained in Table 1. In addition, selected metrics were used to assess the effect of the interruption on that task. The set of task measures are derived from other studies such as Toms et al (2003); the interruption measures are quasi-standard measures used in general in interruptions research (see Altman & Trafton, 2004; Miller, 2001; 2002).

Table 1 - Task Completion Measures

Measure	Operational Definition
<b>Task</b>	
Query Number	Number of queries used in the task
Query Size	The number of keywords per query
Task Time	Total amount of time spent on each search task
Completeness	Task completeness was evaluated based on a five point scale; one indicating that 0% of the problem had been answered or responded to and five indicating that 100% of the problem had been answered. Tasks were assessed by two independent assessors, and an average taken to assign a result.
<b>Interruption</b>	
Interruption Lag	Interruption lag: The amount of time the user takes to transition from the search task to the interruption; this is measured from the point the interruption appears and the point the user engages with the interruptive task.
Resumption Lag	The amount of time the user takes to transition from the interruption back to the search task; this is measured from the point the user disengages from the interruptive task to the next webpage change
Interruption Time	Total amount of time spent on the interruptive task

#### 4.6 Procedure

Before participants arrived, several preparatory steps were taken including setting up an IM account, setting the telephone on call forward, and blanking the cache of all browsers, as well as any other files not for use in the study. When participants arrived, they were first met in an adjacent meeting room to review and sign the consent form and complete the demographics form. This was done to separate the study from its administration and to help participants engage with the “simulated work scenario” (Borlund, 2003) while in the study room. Discussions in the study room were intentionally kept to topics related to the actual performance of the study.

Each participant was processed individually. On entering the usability lab, they were oriented to the room which had been especially set up to resemble an office complete with telephone, printer, files, plants, and office desk paraphernalia. At this point the clock started and participant began work on the search tasks. While the participants worked on the search tasks, they were observed from the adjacent

room which contained a one-sided mirrored window, and via Morae Remote Viewer, a usability software package. As previously described, at 15, 30 and 45 minutes, an interruption was introduced and administered using one of the modalities. In the meantime, participants responded to each information task, entered a response to each question in a word processing file, and printed the answer when finished which was inserted into the file folder. At the end of the 60 minutes, the study ended and a brief interview was conducted.

#### **4.7 Data Collection and Analysis**

While participants responded to the tasks, an external digital video camera, Canon zr100, connected to the participant room computer using a FireWire or IEEE-1394 port recorded the activities. The camera was discretely set up on a tripod in a corner of the room to avoid distracting the participant. The frame of the camera was set up to capture participants' behaviour as well as their interactions with the computer. The video data was used to assess participants' reaction to the interruptions. These reactions were observed and subsequently coded.

The post-session interviews were recorded using a digital voice recorder. During the short interview which lasted on average between 4 to 8 minutes, participants were asked about the similarity of the study scenario to their current working situation, the level of interruptions generally received and by which modality in their jobs. They also indicated their perception of the level of task complexity and task completion for each task they had finished. Finally they were asked questions about each interruption modality. Interviews were transcribed professionally and then analyzed using qualitative data analysis software (Qualrus). An inter-rater reliability assessment was done; a random sample equalling 1/3 of the interviews were recoded by an independent coder whose results were checked for agreement with the original coding, with an agreement rate of 93%.

The rest of the data was collected by Morae (<http://www.techsmith.com/morae.asp>). The video feed discussed above was integrated with the user actions as recorded by screen capture and transaction log. Thus the physical reaction to the interruption was integrated with screen capture. The resulting transaction log which included time-stamped web page changes, screen activity, keyboard entries and mouse clicks was linked with the video. This enabled the coding of the point of interruption, and the point of resumption, as well as the point in the task, the type of interruption directly with the transaction log. All of these data were exported to SPSS for analysis of variance using SPSS' GLM module.

### **5.0 Results**

#### **5.1 Tasks**

Six information search tasks composed the activities of the work task in this simulation. Out of a possible 90 tasks, 81 were completed. Each of these tasks was assessed according to: a) completeness, b) time taken to complete, and c) number of queries taken to complete the task. The average completeness rating across all tasks was 3.73 out of 5. This rating indicates that approximately 75% of the problem had been answered. Task time was calculated from the moment participants read the task instructions to when they printed their answer page, minus interruption time if task was interrupted. The average time it took participants to complete the tasks was approximately 8 ½ minutes (512.85 seconds). The Number of Queries measure indicates number of queries per task entered into the Google search engine. Across participants and tasks, the average number of queries per task was 2.38. No

significant differences were found among the search tasks by any of these measures. Thus, we concluded that the tasks equalled in difficulty and complexity with no unusual tasks among the set.

## 5.2 Effect of Interruptions on Task

Of the 81 completed tasks, 45 were interrupted by one of the three modalities. Because the interruption was introduced at a particularly point in the study, we could not control exactly which tasks were interrupted; potentially, although this did not happen in this study, a task could be interrupted twice. Uninterrupted tasks had an average completeness rating of 3.53 out of five and interrupted tasks, an average rating of 3.90 ( $F(1,80)=2.344$ ,  $p=.130$ ). Interrupted tasks took more time to complete than those that were not interrupted. Interrupted tasks took over three minutes longer to complete than uninterrupted tasks ( $F(1,80)=9.568$ ,  $p=.003$ ). The average number of queries for uninterrupted tasks was two, while the average number for interrupted tasks was approximately three. This was however a marginally significant difference ( $F(1,80)=3.756$ ,  $p=.056$ ).

While interruptions do not affect the completeness of tasks, they do affect the length of time required to complete the tasks, and possibly the number of queries used to complete the task.

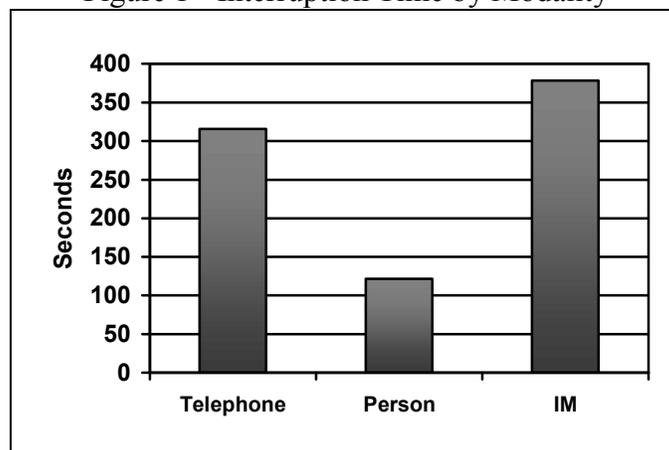
## 5.3 Interruption Modality

The three interruption modalities compared in this study were: Telephone, In-Person and IM. To determine the effect of modality, the 45 interrupted tasks were isolated for further analysis. Those interrupted by the Telephone rated 3.63, In-Person rated 4.37, and IM rated 3.70 in completeness, a marginally significant difference ( $F(2,44)=2.666$ ,  $p=.082$ ). There was no effect by Task time ( $F(2,44)=1.102$ ,  $p=.342$ ) or average Number of Queries ( $F(2,44)=1.054$ ,  $p=.358$ ). With the exception of marginal effects for Completeness, tasks in general were relatively unaffected by the type of interruption.

## 5.4 Interruption Time

The average time taken to complete the interruptive task varied by interruption modality ( $F(2,44)=5.235$ ,  $p=.009$ ): Telephone (5 ¼ minutes), In-Person (2 minutes), and IM (6 1/3 minutes) as illustrated in figure 1. Pair wise comparisons among the modalities showed significant differences between the In-Person and, Telephone ( $p=.024$ ) and IM ( $p=.003$ ). Thus, those interrupted In-Person spent significantly less time on the interruptive task than those interrupted by the Telephone or by IM.

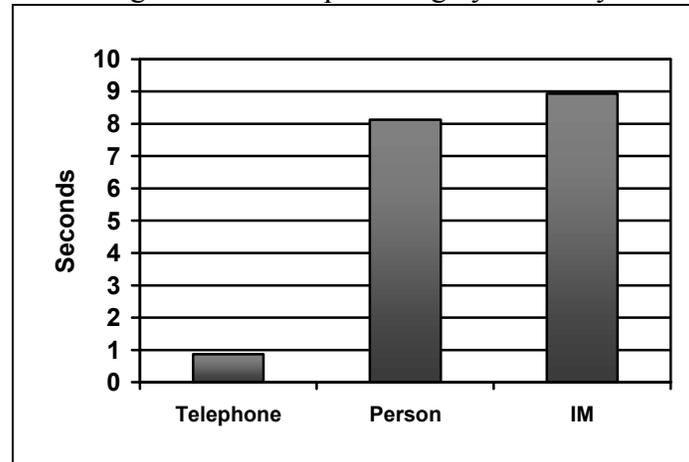
Figure 1 - Interruption Time by Modality



## 5.5 Interruption Lag

Interruption lag is the time from awareness of the interruption (e.g. telephone rings) to engagement with the interruption (e.g. picks up the telephone). As illustrated in figure 2, when interrupted by Telephone, the response was almost immediate – one second. Tasks interrupted In-Person and via IM took significantly longer, at approximately eight and nine seconds respectively ( $F(2,44)=3.691$ ,  $p=.034$ ). Pair wise comparisons confirmed these differences. Participants tended to respond faster to the Telephone than to the In-Person or IM interruption.

Figure 2 - Interruption Lag by Modality



## 5.6 Resumption Lag

Resumption lag is the time from completion of the interruptive task to re-engagement with the original task. For this study, re-engagement with the original task was defined as the first webpage change after completion of the interruptive task. Resumption lags ranged from one, to one and three-quarters minutes, but these differences were not significant ( $F(2,44)=.270$ ,  $p=.765$ ). Thus regardless of the type of interruption participants were able to resume the original task with about the same time lag.

## 5.7 Interruption Management Strategies (IMS)

Using the combined video and transaction log data, we identified a two-stage model of interruption management which we call a primary stage and a secondary stage. During the primary stage of interruption management, a person receives and becomes aware of the annunciation stimuli of the interruption (e.g. telephone ringing, flashing IM pop-up) and receives the contents and requirements of the interruption. The next or secondary stage of interruption management is when a person decides how to deal with or integrate the interruptive task into their work. Primary strategies were: Immediate and Delay. Immediate indicates that participants reacted immediately to the annunciation stimuli. So, when the telephone rang they picked it up immediately; when the person came into the room they immediately stopped what they were doing and engaged with the researcher; as soon as they noticed the flashing IM pop-up they clicked on it and read the message. Delay indicated that they waited to address the annunciation stimuli after they became aware of it. Approximately 93% of those interrupted by telephone responded immediately compared with 67% In-Person, and 73% to IM.

The Secondary Stage refers to how participants dealt with the interruption after they became aware of its contents and requirements. These include:

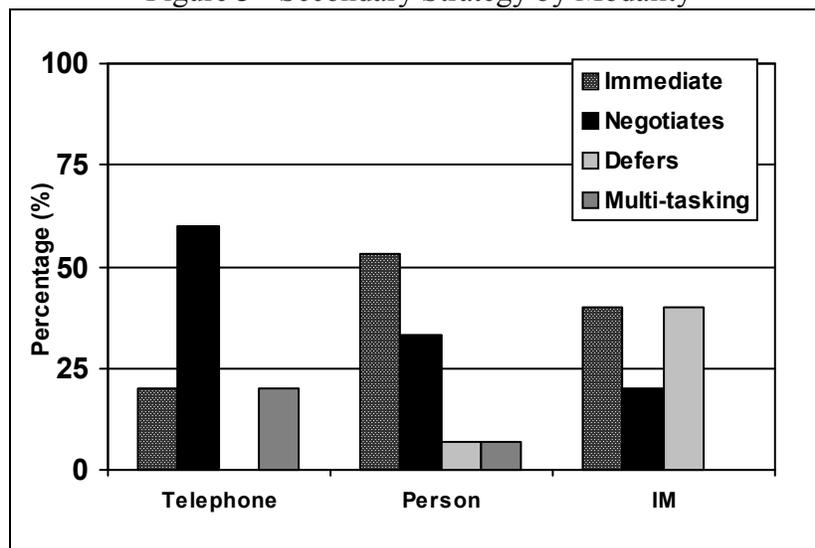
- 1) Immediate: completed the requirements of the interruption immediately after becoming aware of its contents and requirements;
- 2) Defers: continued to work on their primary task after they became aware of the contents and requirements of the interruption;
- 3) Negotiates: after becoming aware of the contents and requirements of the interruption, negotiates with the interrupter to find a better time to complete the interruption;
- 4) Multi-tasking: after becoming aware of the contents and requirements of the interruption, completes both primary task and interruptive task simultaneously.

How the secondary strategies were used by modality is illustrated in figure 3. In 60% of cases, when interrupted by the Telephone, participants negotiated with the interrupter. The remainder was split evenly between completing the interruption immediately and multi-tasking. When interrupted In-Person, many different secondary IMS were observed. In 53% of cases, participants completed the interruptive task immediately. The next most common secondary IMS when interrupted In-Person was negotiate; this was true 33% of the time. Multi-tasking and deferring was only used 6.7% of the time, respectively. When interrupted via IM, most participants completed the interruptive task immediately or deferred completing it. Each was used 40% of the time. The remaining 20% of the time, participants negotiated a deadline with the interrupter.

Cross tabulations showed an association between the modality in which the interruption was delivered and the strategy used by the participant (Chi-Square=17.887, df=6, p=.007). A closer look at the cross tabulations, by examining the expected counts and adjusted residuals for evidence of this association, suggests that the secondary IMS and modality of the interruption are dependent variables. The IM and Telephone interruptions are deferred more than one would expect if the variables were independent.

So, when interrupted In-Person, more people deal with the interruption by completing it immediately. Those interrupted by the Telephone tend to negotiate a deadline for completing the interruptive task with the interrupter, while the IM interruption's secondary IMS are split between dealing with it immediately and deferring it.

Figure 3 - Secondary Strategy by Modality



## 5.8 Participant Perception of Interruptions and IMS

At the end of the experimental session, participants were interviewed about how they would have dealt with a particular interruptive task differently if it had been introduced via another modality. Nearly half indicated that they would not have changed their behaviour. Attitudes towards IM and email alerts as methods of communication in the workplace are relatively divergent. Several participants commented that they were likely to assume the information or request contained in IM communication to be less urgent than if it had been delivered another way, such as in person or by telephone. When asked how they would have dealt with a particular interruption if presented through IM, one participant responded: “I probably would have put you off a little bit longer. I maybe [would have] completed what I was doing instead of just stopping immediately and saying I’ll deal with this now.” Another expressed her annoyance with IM communication, saying: “If it’s important enough to talk about it right now, come see me.” Of course this could only work in co-located work environments. However, many also expressed that they found IM communication easier in some cases. Mostly these comments arose when being asked about the IM interruption in which a web link to an article was supplied. These participants indicated that using IM in this way was much easier than having to write down a URL or work from a paper copy of the article. Another participant admitted that they would feel more comfortable asking clarifying questions over IM, but less so in-person or over the phone.

Some viewed In-Person interruptions as more urgent than others. One participant admitted: “I think if [the researcher] had walked in, I might have assumed it was more urgent...” Another said that had they been interrupted in-person, they would have dropped everything they were doing and just focused solely on completing the interruptive task. Some also mentioned that they found the in-person interruptions easier. This could be due to the fact that the researcher brought into the study room information to help the participants complete the interruptive task; another possibility is that they felt they were at more liberty to ask questions and assess the needs of the interrupter. This latter point would likely also be true of the telephone interruptions. Participants rarely commented on telephone interruptions during the interviews.

## 6.0 Discussion and Analysis

This study examined the effect of multiple types of interruptions on work tasks when those interruptions were conveyed by telephone, in person and via IM. Of the 90 possible tasks, 81 were completed, and 45 were interrupted by one of the three modalities.

Notably, interruptions did not affect the completeness of tasks, but they did affect the length of time needed to do the tasks, and marginally, the amount of effort required to do the task as measured by the number of queries needed to do the task. This finding supports that of Eyrolle and Cellier (2000) who also found a time cost associated with interruptions, and additionally no effect on the accuracy (in their case) of the task. Previous research (e.g., Hudson, Christensen, Kellogg, and Erickson, 2002) has found that workplace interruptions can be beneficial to the interrupted person. Our results show that in knowledge work, an interruption has an associated efficiency cost. Unknown from our work is whether the increase in effort needed to complete the primary task was a worthwhile trade-off for the potential benefits that the interruption might offer. This is an area for future research.

When the interrupted tasks were isolated, and examined by modality of interruption, there was no effect on the task except for a marginal effect on task completeness. Interestingly, tasks interrupted by

the telephone had a significantly shorter interruption lag than those interrupted in person or via IM. People responded immediately – instantaneously – to the telephone, but not to the person walking into the room, nor to the IM. Perhaps this accounts for a more persistent, auditory, and difficult to ignore “annunciation stimulus” (Latorella, 1999) presented by a telephone ringing. Notably, the fast reaction had no effect when the original task was resumed. Those who dealt with the telephone interruption took as long to pick up the threads of the original task as those interrupted in person or by IM.

One additional and unexpected finding was present in the modality comparison. When interrupted in person, people took less time to do the task, but needed as much time as the other interruption modalities to re-engage in the task. One might conclude that the interruption task completed in person was so cognitively intensive that it took longer for the participant to get back to the original task. But this was not the case. The in-person task was merely looking up an item in a products catalogue which does not take more effort than providing a summary of a webpage, the IM task. One could speculate about this finding from a communication theory perspective. Face-to-face is considered the richest and most efficient form of communication. Possibly this form of information exchange could result in a higher cognitive load, making it more challenging to return to a previous task. This is also an area for future research.

The IMS observed in this study parallels Latorella’s (1999) stages and sub-stages of interruption management. The primary stage identified in our study is akin to the detection and interpretation stages while the secondary ones are analogous with the integration phase. At the awareness stage in our study, there was one key initial response to an interruption – deal with it immediately, although that was not practiced by all people. But this may be due to the artificiality of our study, and/or due to the fact that participants were ‘behaving like administrative assistants’ and dealing with all interruptions from the presumed superior. This effect is unlikely to be present in all workplace scenarios and environments.

At the execution stage, there were four secondary strategies: immediate, negotiates, defers, and multi-tasking. These differ from other studies of IMS (cf. Eyrolle & Cellier, 2000; Burmistrov & Leonova, 1996). Three of the secondary strategies are accounted for in prior research, but there is no reference to negotiation. Prior research was done in different work domains (e.g., text editing and telecommunications operators). Perhaps the strategies used are related to the type of work, and not generic to interruptions. Notably, there was a relationship between the type of strategy used and the type of interruption modality. Those interrupted by telephone were more likely to negotiate a deadline, whereas those interrupted via IM usually either dealt with the interruption immediately or deferred it. When interrupted in person, most people responded immediately to the interruption. Regardless of the type of interruption, participants were likely to react instantly. Once participants were aware of the contents and requirements of the interruption, several strategies for dealing with the interruptive task were observed. These findings have implications for workplace policies and guidelines that could help facilitate peoples’ interruption management strategies and ultimately increase workplace productivity.

While the way an interruption is conveyed had little effect on the work task, an interruption in general increased the amount of time needed to complete a task, even though the interruption did not affect the success of doing that task. Within the work environment, an interruption may be much more costly. In this study, participants spent an average of 84.36 seconds or 1.4 minutes transitioning to and recovering from each interruption. An earlier study found that workers were interrupted an average of four times every hour (O’Conaill & Frolich, 1995). Thus, an employee who works an eight hour work day spends an average of 45 minutes of that time adjusting to and recovering from an interruption, not counting the

time required to complete the interrupting task. At \$20/hour, this could cost employers over \$4,000 per year per employee. Thus, interruptions may be costly to the workplace. This information should not be rigidly assessed, as there is significant evidence also to suggest that an interruption may also be beneficial.

As is the nature of this form of study (and despite the efforts we made in re-creating a life-like workplace situation), the reader is advised that this study was conducted in a controlled environment with fifteen participants who work in an office administrative capacity. Replication and a larger sample size are required to generalize these findings.

## **7.0 Conclusions**

In this study, we examined both the effect of interruption on knowledge work and the effect of delivering that interruption using three different mechanisms. Clearly interrupted tasks took more effort than those uninterrupted without any differences in completion. Thus knowledge work tasks have similar affects to other workplace environments. Since workplaces are, almost by definition and often by necessity, interruption-riddled, knowing that task outcome is not affected by interruptions is significant for managers and administrators. From this study, two stages of interruption management were identified – an immediate and a secondary. The secondary response differs from previous research and is affected by the way the interruption was conveyed. Although preliminary (and the work needs confirmation with replication), these results are suggestive of workplace policies and procedures for dealing with interruptions. For example, what is the best method for urgent ‘interruptions’ versus routine matters?

Knowledge work was the task domain examined in this study. Other research studies have examined the effect of interruptions and interruption management in procedural and predictive environments, e.g., text editing, telecommunication operators, air traffic controllers. This study is the first to consider an aspect of knowledge work, in which the tasks are complex, cognitively intensive activities with multiple dimensions. That said interruptions seem to have similar effects as in other work domains.

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