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The Effect of interruptions on prospective memory in the emergency department

Kate Walders

Rochester Institute of Technology
College of Liberal Arts
Department of Psychology

THE EFFECT OF INTERRUPTIONS ON PROSPECTIVE MEMORY IN THE EMERGENCY DEPARTMENT

A Thesis

By

Kate Cushman Walders

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IN THE EMERGENCY DEPARTMENT

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Faculty Advisor and Chair of the Thesis Committee:	Dr. Nicholas DiFonzo Professor, RIT
Reader:	Rollin J. Fairbanks, MD, MS, FACEP Assistant Professor of Emergency Medicine & of Community and Preventive Medicine University of Rochester, Rochester, NY
Reader:	Dr. Lindsay Schenkel Professor, RIT

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Correspondence concerning this paper should be addressed to Kate C. Walders, kcw@rochester.rr.com.

Abstract

Using the activation goal memory framework, this study categorized 256 separate emergency department interruptions in a large research hospital setting. Prior to and following their shift, twelve physicians completed a semi-structured qualitative survey about their experiences with, and perceptions of, interruptions at work. During their shift, these physicians were shadowed and the interruptions they experienced were documented. Frequencies of four types of interruptions were tallied: Direct reminders, indirect reminders, memory lapses and no reported memory change. Memory events were a significant proportion of interruptions (47%). Direct reminders comprised the largest majority, followed by memory lapses, indirect reminders and combination memory events. Both prior to and following their shifts, physicians overestimated both the harmfulness of interruptions to themselves and the helpfulness of interruptions to the interrupter. Physicians perceived the majority of interruptions they experienced as justified.

The Effect of Interruptions on Prospective Memory

in the Emergency Department

A recent flurry of interruption research has focused on the potential negative effects of interruption in aviation, nuclear power, and healthcare work activities. This research has suggested that interruptions can occur frequently (Brixey, et al., 2008; Chisholm, Collison, Nelson, & Cordell, 2000; Chisholm, Dornfeld, Nelson & Cordell, 2001; Coiera, et al., 2002; Fairbanks, Bisantz & Sumn, 2007), extend the time required to perform a given task (Eyrolle & Cellier, 2000; Monk, Boehm-Davis & Trafton, 2004) and negatively affect performance (Speier, Vessey & Valavich, 2003). In addition, interruptions can increase the chance of errors, thus increasing the potential for adverse consequences (Dismukes, Young & Sumwalt, 1999; Latorella, 1996; Peterson, Wu & Bergin, 1999). It has been reported that stress, poor quality care, and inefficiency stem from interruptions in the workplace (Carayon, 2007). Perlow (1999) found that engineers were distracted merely anticipating potential interruptions.

However, not all research is in agreement on the negative effects of interruptions, and more importantly, in the healthcare field, only one study on medication dispensing errors showed a direct causal relationship between interruptions and subsequent errors (Flynn, et al., 1999). In 2008, Grundgeiger and Sanderson reviewed interruption literature in healthcare and determined that, other than the above-mentioned study, there is no solid evidence that interruptions jeopardize patient safety. In fact, interruptions by mobile phones were found to reduce medical errors in the Emergency Department (ED) by reducing delays in communication (Soto, Chu, Goldman, Pampil, and Ruskin, 2006). The continual reshuffling of priorities is a potent characteristic of the ED, and successful job performance depends on the clinical staff's ability to constantly monitor their changing information

environment, and communicate with other staff. The ED staff must shift focus to optimize care and interruptions may provide a means to gather and disseminate important information. For example, in the hospital's ED used for this study, they have instituted a "planned" interruption. Any patient who enters the ED exhibiting any heart attack symptom is promptly administered an EKG. Because of the urgent need for immediate care for a potential heart attack victim, an EKG technician is required to have an attending Emergency Physician, immediately interpret and sign off on the patient's EKG results, regardless of what activity she is engaged in. This often involves the EKG technician interrupting the attending physician. This interruption may be beneficial to the patient as well as possibly disruptive.

In the business domain, Dabbish & Kraut (2004) found that spontaneous communication, including interruptions, plays an important role in organizational continuity and results in benefits such as the transfer of knowledge and establishment of new work routines. Further, O'Conaill and Frohlich (1995) analyzed the content of 129 interruptions and determined that the initiator benefitted 33% and the recipient 21% of the time from the interruption. 43% of the time, the interruption benefitted both parties. "Thus, in 64% of the interruptions the recipient received some benefit from the interaction having taken place" (O'Conaill, B. & Frohlich, D., 1995, pg. 263).

The present research sought to study ED interruptions within the *activation goal memory* (AGM) framework (Altmann & Trafton, 2002), which is based on the *spreading activation model* of memory and uses the constructs of activation to advance understanding of intention/goal directed behaviors. This study specifically investigated whether interruptions contained reminder cues to help reorient a physician to a previously forgotten or suspended task,

(which may have been the result of a previous interruption), and whether interruptions caused a physician to experience memory lapses. In addition, this research gathered physician's perceptions of the justification and helpfulness of the interruptions they experienced.

Introduction

The 2005 edition of the New Oxford American Dictionary defines *interrupt* as: "To stop the continuous progress of an activity or process." Previously, interruption research, in both healthcare and non-healthcare fields, has lacked a consistent uniform definition. However, in 2007, Brixey, et al. employed Walker & Avant's method of concept analysis to the term *interruption* to develop a theoretical definition to be used for interruption research in healthcare. The definition used for this research and based on Brixey is: a break in the performance of a task, which results in suspension of that primary task to perform an unplanned task with the assumption that the initial task will be resumed (Brixey, 2007). The following is a simplified version of Brixey's (2007) model of interruption, which is used as a theoretical framework from which to study interruptions:

TASK A | Step i | Interruption Lag | INTERRUPTION | Resumption Lag | Step r |TASK A

Task A represents the initial task that the future recipient of the interruption is engaged in during the pre-interruption phase. An important component of the interruption definition and this model of interruption is that individual must be engaged in an initial task at the time of the interruption. Consider an example of a teacher grading homework assignments. In the middle of her task, a student pops his head into her office to ask, "Are you busy?" Grading homework assignments is the initial task. If the teacher has just finished grading the assignments and put them down when the student arrived, this does not qualify as an interruption as the teacher was between tasks or at a natural break and therefore, the teacher was not engaged in a task to be interrupted.

The student's action, asking the teacher, "Are you busy?" constitutes a "break." A break describes the period when the recipient's attention is captured by the initiator of the interruption while the recipient is engaged in an activity. Step i (the beginning of the "break") is the notification of an impending interruption, in this case, the recipient, the teacher, hears the initiator of the interruption, the student, say, "excuse me." The interruption lag denotes the period of time between Step i, and actually engaging in the interruption, which could simply be the teacher putting down her pencil and turning around in her chair to face the student. In this case, the interruption is a conversation between the teacher and student. Another important feature of interruption, which differentiates it from a *distraction*, is that an individual must suspend the initial task to perform the interruption task. There are times when a break does not constitute an interruption. Chisholm, Collison, Nelson, & Cordell (2000) defined *interruption* as "Any event that briefly required the attention of the physician but did not result in switching to a new task". Ebright, Patterson, Chalko & Render (2003) defined *interruption* as "Every time the participant was distracted from the immediate task or issue on which she was focused." Merriam-Webster Dictionary (2012) defines *distract* as "to divert attention". The interruption definition used for this research specifically states that in addition to diverting attention, an individual must suspend their primary task for the action to be considered an interruption. For example, a distraction would be if the teacher heard the student say, "excuse me" but chose to ignore it and his inquiry and continued on with her grading. However, if the teacher stops her task to address the student (an unplanned task) then this becomes an interruption. The interruption, a conversation between the teacher and student, lasts until the teacher ends the conversation by saying "goodbye." The time period between the end of the conversation and the resumption of the primary task, grading papers, is referred to as the resumption lag. The

resumption lag is the time required to physically and mentally reorient to the initial task. Step R is the point of resumption.

Interruptions are communication events. In their study, Alvarez & Coiera's (2005) "conversation-initiating" interruption was defined, as "A conversation-initiating interruption is a communication event that is not initiated by the observed physician, and occurs using a synchronous communication channel such a face-to-face conversation or the telephone." The prime reason individuals interrupt is to communicate and transfer information.

AGM Activation and Retrieval

Historically, the study of goal or intention recovery after an interruption has fallen into the cognitive realm of prospective memory (PM). Einstein and McDaniel define *prospective memory* as "memory for actions to be performed in the future"(Einstein & McDaniel, 1996, pg. 115) and further, Ellis defines prospective memory in terms of interruption recovery as "realizing delayed intentions" (Ellis, 1996, pg. 1). In this research, *intention* and *goal* was used synonymously to describe the intention to complete a certain task, activity or plan of action. Most recently, the *activation goal memory* (AGM) model (Altmann & Trafton, 2002) has been applied to study the processes of retrieval and reactivation of prior goals or intentions following an interruption (Hodgetts & Jones, 2006; Kleigel & Mackinlay, 2008; Li, Blandford, Cairns & Young, 2008; Monk, Trafton & Boehm-Davis, 2008). The activation goal model is based on the *spreading activation model* of memory and uses the constructs of activation to advance understanding of intention/goal directed behaviors. The spreading activation model is a semantic network consisting of nodes and links. The nodes represent concepts, and the links represent associations between semantically related concepts. Nodes exhibit levels of activation or energy indicating that the concept the node represents is more accessible for use by the cognitive system

(Willingham, 2007). These nodes become active through stimulation when an item is presented to the system from the environment, and once stimulated can pass activation onto neighboring nodes, thus increasing the level of activation of nearby concepts. For example, the concepts *exercise, run* or *gym* might become active through hearing the word *treadmill*. Short-term memory is sometimes described as that part of long-term memory that is currently active (Nairne, 1996). The amount of activation given to connected concepts is assumed to be a function of distance; the closer some concept is in memory to the connected concept or retrieval cue, the more it will be activated and thus, remembered (Ratcliff & McKoon, 1988). Consequently, the spread of activation is used as a significant retrieval component (Dosher & Rosedale, 1989). Input from the environment, such as reminder cues, can heighten activation and assist memory retrieval.

When a person searches their memory, generally they will obtain the most active intention. Interruptions can facilitate prospective memory performance by increasing the activation level of the underlying goal representation and in turn, the sensitivity of the targeted goal (Mantyla & Sgaramella, 1997). For instance, if the nurse previously interrupted the doctor to remind him to check Patient B's x-ray, this reminder may have heightened the activation of this goal and consequently, would be more likely to be chosen than another suspended. Specific input from the environment, such as an interruption that contains a reminder, can counteract decay, as well as interference from other information in memory, heighten activation of the intended goal, and thus, direct action (Altmann & Trafton, 2002).

Kvavilashvili and Ellis (1996) present four stages of prospective memory: encoding, storage, retrieval and performance. With respect to interruptions, the retrieval phase is the most crucial phase because it is at this juncture that an intention is remembered or forgotten. Loftus

and Loftus (1980) reported from a survey of psychologists interested in memory that they believed that "retrieval failures accounted for most cases of forgetting" (Roediger & Guynn, 1996, pg. 198).

In an effort to discover whether forgetting was due to encoding, storage or retrieval difficulties, Tulving and Pearlstone (1966) conducted an experiment in which a group of students were given a list of 48 words with 2 words in each of 24 categories. For example, "bird: robin, blue jay." Participants were asked to remember the words for a test. In two of the conditions, the encoding and storage conditions were held constant. However, at the retrieval phase, one group was given a free recall test and the other group was presented with the category names as recall cues. The students in the free recall group recalled an average of 19 words correctly. The students in the cued recall group remembered an average of 36 words. Their results indicate that when encoding and storage conditions are held constant but the retrieval condition is varied, the information (words) in the free recall condition was stored but not retrievable. Retrieval cues almost doubled the number of words remembered.

Interruptions that contain reminder cues may serve as retrieval cues by activating decayed goals that assist a doctor in resuming a suspended task. Accurate and efficient resumption of goals in a multitask environment, such as an ED, can be improved by the availability of good cues and for associative priming at resumption of the forgotten task. In addition to the presentation of a retrieval cue, an individual must recognize the cue as a stimulus for resuming an intention (Ste-Marie & Jacoby, 1993). To resume a suspended intention after an interruption, the goal needs to become active again through a priming process that boosts the activation level to link the retrieval cue to the forgotten intention. At this point an individual needs to recognize the association between the encoded retrieval context and the forgotten goal before she can

resume her intent and initiate action (Ellis, 1996). Ellis (1996) suggests that recall can often occur as a result of a deliberate act that originates from another person, such as an interruption. For example, it is reasonable to assume that following an interruption by a nurse to ask a doctor a question regarding patient F, the doctor might then remember that he wanted to check patient F's blood tests. This interruption contained an indirect reminder that activated an older goal in the physician's memory. Interruptions that contain direct reminders and/or indirect reminder have the potential to facilitate a physician's prospective memory.

Conversely, interruptions also have the potential to cause memory lapses. Interference during the retention period, such as changing tasks abruptly without explicitly encoding an intention to return to the task, can cause memory performance losses (Nairne, 1996). For example, if a physician is interrupted while viewing a Patient B's x-ray by a nurse asking him to check on a patient, she may not remember what she was doing prior to the interruption or if she does remember she was looking at an x-ray, she may not remember which particular patient's x-ray. In human memory, old goals and items decay gradually and sometimes non-target goals (distracters) can cause interference that makes it difficult to retrieve an intended memory (Altmann & Trafton, 2002). The physician's difficulty remembering may be caused by the several other patient's x-rays she viewed prior to the interruption, and the ones she was anticipating receiving in the future. The patient's x-rays, both the ones viewed in the past and the ones to be viewed in the future, serve as distracters that make it difficult for her to remember which x-ray she was reviewing at the time of the interruption.

Moreover, interruptions that contain reminder cues and interruptions that cause memory lapses can be interwoven. For instance, it is possible for a physician to experience an interruption that contains a reminder to complete a task he started previously and also experience

a memory lapse as a result of that same interruption. Another possible scenario is that an interruption that contains a reminder cue may help a physician to remember a task that he had started but not completed due to a previous interruption. In this case, a reminder cue assisted the physician in "recovering" from a prior interruption but did not assist in recovering from the interruption that contained the reminder cue.

Summary

1. Interruptions may provide outright reminders that help a provider remember to complete a task, e.g., a nurse saying, "Remember, Patient X still needs to have his discharge form printed." Generally in prospective memory tasks, the intention to perform a task has to be remembered by the individual; however, an interruption can serve as a direct reminder to aid in memory retrieval of a suspended intention.
2. Interruptions may provide indirect linking reminders, either by reiteration or semantic relation that stimulate recognition of retrieval cues for prior intentions. Repetition priming suggests that individuals show a memory bias for concepts that are reiterated. In addition, the spreading activation theory suggests that the content of an interruption can stimulate the node representing a concept and can spread heightened activation throughout the network of semantically related concepts. This boost in activation of those concepts can stimulate recognition of the retrieval cue and suspended intention. For example, a nurse tells you that Patient B is requesting more pain medicine and that reminds you that you need to check Patient B's x-ray results. The mention of Patient B would be reiteration of the linking reminder. "Repetition of priming effects indicates that activation of nodes last an hour or more." In addition, the intention superiority effect indicates that memory for intentions, over other types of items, initially has a heightened activation and decays at a slower rate than for

neutral items (Goschke & Kuhl, 1993, pg. 63). With the presentation of a linking reminder, these instances of heightened activation should facilitate intention retrieval from memory.

3. Interruptions can cause interference in memory recall. Interruptions can cause "I forgot" occurrences, in which staff members forget what they were doing or thinking about at the moment of interruption. Changing tasks abruptly without explicitly encoding an intention to return to the task can cause memory performance losses (Nairne, 1996). Older goals and items in memory decay gradually and cause "memory clutter" that makes it difficult to retrieve an intended memory (Altmann & Trafton, 2002).

Purpose Of This Research

Interruption content can contain reminder cues, cause interference that may precipitate forgetting or have no apparent memory effect on the individual who was interrupted. A direct reminder occurs when the interrupter causes the physician to remember a prior goal by telling her that she needs to remember that specific prior goal. An indirect reminder is when the interrupter inadvertently causes the physician to remember a prior goal by presenting a related cue in the content of an interruption that stimulates activation for a physician's prior intention. An "I forgot" occurrence is when the content or the act of interrupting itself causes the physician to forget what he or she was doing or thinking. Another result from an interruption is that no apparent memory event occurs; the physician will experience the interruption and return to his task without specifically remembering or forgetting.

This study used the goal activation model to investigate ED interruptions. It specifically addresses the question: to what extent do interruptions serve as retrieval cues (direct or indirect reminders) to help reactivate a primary intention and reorient an individual to a forgotten task,

and to what extent do they cause memory lapses? There have been no studies in the research literature that investigate these questions.

This project also sought to determine the extent to which ED medical staff believed that the interruptions they experienced were helpful or harmful to themselves and the interrupter with respect to accomplishing their intention to perform a work task, and were justified, that is, did the interrupter have good reason or cause to make the interruption.

Methods

Brief overview

Prior to and following their shift, twelve physicians completed a semi-structured qualitative survey about their experiences with, and perceptions of, interruptions at work. During their shift, these physicians were shadowed and the interruptions they experienced were documented. Physicians provided ratings of the justification and helpful/harmfulness for each individual interruption they experienced. In addition, frequencies of four types of interruptions were tallied: Direct reminders, indirect reminders, memory lapses and no reported memory change.

Participants

Fourteen attending or resident physicians from the University of Rochester Medical Center Emergency Department participated in this study. Two of the 14 physicians were used as pilot subjects; the final sample was 12 physicians. Physicians were identified, and recruited by means of an email sent to 48 URMC emergency medicine physicians who were scheduled for the 3pm -10pm shift, or in the case of resident physicians, 2:30pm-11:30pm shift during January, February and March, 2012. The response rate was 29%. Each night of the week was represented at least once with the exception of Thursdays. Resident physicians do not work in the ED on

Thursdays and therefore, for comparison purposes, Thursdays were omitted.

Materials and Measures

A semi-structured qualitative survey with quantitative spreading activation theory-based questions was administered to the physicians preceding their shift (See appendix A). The physicians were asked general questions about their experiences with, and perceptions of, interruptions at work. For example, they were asked how many times they believe that they are interrupted during an average work hour, and what is the most common reason for them to be interrupted. In addition, they were asked if they have experienced interruptions that reminded them to return to a suspended task or made them forget what they were doing and if so, how often did they believe they experienced these. They also were asked to provide an overall justification and helpful/harmful rating of the interruptions they experience. This interview was audio taped.

Individual interruption rating forms (See appendix B) were used to categorize interruptions and obtain ratings while shadowing the physician. Prior to their shift, the physicians were shown the rating sheets and the shadowing procedure was described:

> [I will be following you for three hours during your ED shift today and documenting the interruptions that you experience during this time. For this study, an interruption is considered a break in the performance of your activity, which results in suspension of your task to perform an unplanned task with the assumption that your initial task will be resumed. I am interested in whether the interruptions you experience directly or indirectly remind you to do something you either forgot or suspended, or cause you to forget what you were doing. A direct reminder, for example, is when a nurse says, "Don't forget to check on Patient B". An indirect reminder is when the person who interrupts you says something that causes you to remember some other task that you had started or meant to complete but for some reason hadn't yet. An "I forgot" occurrence is when you forget what you were doing or thinking after being interrupted. No memory event is when you are interrupted and then resume your task or start a new one with no occurrence of any specific memory event.
>
> In addition, I'd like you to rate whether each interruption was helpful or harmful to you with respect to your ability to achieve your work goals, and helpful or harmful to the interrupter with respect to accomplishing their intention to perform a work task. I will also ask you to rate whether you believe this interruption was justified or not.]

The occurrence of seven types of interruption events were recorded: direct reminders, indirect reminders, forgetting, direct and indirect reminders, direct reminders and forgetting, and indirect reminders and forgetting, and no reported memory event.

After their shift, a subset of the structured qualitative survey was administered to the physicians (See appendix C).

Procedure

The researcher met with each attending or resident physician prior to the observation shift to explain the rationale for the study. Informed consent was obtained. The researcher then administered the pre-shift survey. This interview was audio taped. Following this, the researcher explained the focus of the study, informed them of the shadowing process, and showed them the interruption rating form.

During the shift, each physician was shadowed for 180 minutes. The 3-hour time period was always 7pm to 10pm of a 3pm – 11pm shift, with the exception of 2 senior resident physicians who work 2:30 – 11:30pm shifts. This time period allowed the physician to be at least halfway into a shift and have started some tasks that were suspended. In addition, physicians were more likely to be working on documentation tasks, which exhibit higher rates of interruption than other tasks (Westbrook, et al., 2010). During the three-hour observation period, the researcher shadowed the physician and documented the interruptions. The physicians classified the memory events that occurred during the interruption and provided ratings to the researcher. Ratings were gathered, at the earliest, after the physician reoriented to the primary task so that any memory lapse that occurred as the doctor returned to the primary task would be recorded. Given this study was conducted during evening ED shifts, which tend to be busy, stress to the physician was minimized by asking them to complete the Rating Form at the best time

possible. This study did not compromise patient care/safety. Because of workflow and safety concerns and because the ratings themselves would often introduce another interruption, the ratings were generally obtained every 20-30 minutes. The doctors were encouraged to give ratings more often if they were available. The physician always had the opportunity to postpone completing the Rating Form.

Physicians were also able to indicate that the interruption/event represented a personal matter (e.g. personal phone call or conversation not related to work). Further, it was at the physician's discretion whether any situation/event/information which the investigator witnessed was excluded from this study, as it might represent an invasion of physician or patient privacy. For example, the physician could ask the investigator to step out if they needed to discuss sensitive/legal or private matters (e.g. providing information of a particular accident or abuse case to law enforcement/social work.) None of the physicians requested that the researcher step out at any point during this study.

Within several days following the shadowed shift, the researcher conducted a post-shift survey to reassess the physician's perceptions and gather ratings.

Results

Interruption Frequency and Type

Over 36 hours of data were collected (12 physicians x 3 hours each). A total of 256 separate interruptions were recorded and classified. The mean per hour interruption rate for each physician was 7.11 ($N = 12$, $SD = 2.58$, 95% CI [5.47, 8.75]). Two rating sheets had missing data, therefore for the following analysis those interruptions were omitted ($N = 254$). Originally there were three categories of memory events (direct reminders, indirect reminders and forgetting), however during any single interruption, two or three memory events could occur,

that is, the memory events were not mutually exclusive. For example, the interruption could contain a direct reminder and also make the physician forget what she was thinking at the time she was interrupted. Since the physician was rating each interruption in which potentially more than one memory event could occur, the memory categories were combined to reflect all the possible combinations of memory events. The three categories were paired to make 6 total categories (direct reminders, indirect reminders, forgetting, direct and indirect reminders, direct reminders and forgetting, and indirect reminders and forgetting). During this study, no interruption contained all three memory events, therefore this category was excluded. *None* describes the interruptions in which no memory events occurred.

Descriptive statistics were calculated to identify the frequency of the six categories of memory events (direct reminders, indirect reminders, forgetting, direct and indirect reminders, direct reminders and forgetting, and indirect reminders and forgetting), as well as the proportions of memory events. Sums, percentage of total interruptions, and percentage of memory events (percentage excluding the *none* category) are reported in Table 1. Almost half (47%, $N = 254$, 95% CI [40.86, 53.14]) of all interruptions contained at least one memory event. Out of 254 interruptions, there were 64 direct reminders. One example of a direct reminder during the observation period occurred when a resident physician called and interrupted an attending physician who was in the trauma bay to remind him to come see a patient who he had meant to see before he was called away to the trauma bay. Direct reminders accounted for the largest proportion of total interruptions (25%, $N = 254$, 95% CI [19.67, 30.33]) and the largest proportion of memory events (57%, $N = 118$, 95% CI [48.07, 65.93]). Overall, there were 76 direct reminders (D + DI + DF). 30%, $N = 254$, 95% CI [24.36, 35.64] of all interruptions consisted of a direct reminder (D + DI + DF) for a physician to remember to return to a task they

intended to complete.

Of the 254 interruptions, there were 15 indirect reminders (I) and 19 overall indirect reminders (I + DI + IF). During the shadowing period, a nurse interrupted a physician to "make him aware of a patient" who was getting restless. This indirectly reminded the physician that he needed to check this patient's, as well as another patient's, test results. 8% (N = 254, 95% CI [4.66, 11.34] of all interruptions contained an indirect reminder for a physician to remember to return to a task they intended to complete.

Ten percent (N = 254, 95% CI [6.31, 13.69]) of all interruptions caused physicians to forget what they were doing or thinking at the time of the interruptions. One of the instances of forgetting occurred while a physician was discussing a patient with another doctor. The physician was interrupted by a phone call from Emergency Medical Services (ambulance) to tell her about a patient who was in transport and provide her with a time estimate of arrival. The interruption lasted 2-3 minutes. When the physician hung up, she had forgotten what she had been discussing and it took her several seconds to reorient to her suspended conversation. Out of 254 interruptions, there were 25 instances of forgetting (F) and 37 total memory lapses (F +DF+IF) after being interrupted.

More than half (54%) of all interruptions had no memory event associated with them.

Table 1

Separate Memory Events Counts, Percentage of Total Interruptions and Percentage of Memory Events

Memory Event	Count	Percentage of Total Interruptions	Percentage of Memory Events
Direct Reminders	64	25%	57%
Indirect Reminders	15	6%	12%
Forgetting[a]	25	10%	19%
Direct & Indirect Reminders	2	1%	2%
Direct Reminders & Forgetting[a]	10	4%	8%
Indirect Reminders & Forgetting	2	1%	2%
None	136	54%	
Total	254	101%	100%

Note: Rounding accounted for the extra 1% under the percentage of total interruptions.
[a]The physician who experienced one of the highest interruption rates (29 overall) accounted for 23 of the occurrences of forgetting; 16 of the single forgetting category and 7 direct reminders and forgetting. This data was not omitted from this analysis because it was deemed reasonable that in the overall population of physicians, some physicians would have less experience with, and poorer strategies for, dealing with a multitude of interruptions and would suffer increased forgetting as a result.

Physician's Perceptions of Interruptions

During the shift, each interruption was rated by the physician for harmfulness/helpfulness to the interrupter and themselves, and for justification (good cause to interrupt). Table 2 displays per physician unweighted means and standard deviations for the during-shift helpful/harmfulness and justification ratings for all interruptions. Physicians perceived interruptions to be helpful to the interrupter, $t(11) = 8.87$, $p < .001$ but not to themselves, $t(11) = 1.51$, $p < .16$, and justified, $t(11) = 5.31$, $p < .001$. Only 31 out of 254 (12%) interruptions were considered unjustified, 18 of which were considered harmful to the physician. 24 interruptions out of the 254 were rated neither unjustified nor justified, leaving 199 interruptions that physicians believed to be justified.

Table 2

During-shift Unweighted Average of Mean Physician Justification and Helpful/Harmfulness Ratings.

Rating Question	*M*	*SD*	*95% CI*	
			Lower	Upper
How Justified?	1.53	1.00	1.41	1.65
How Helpful/Harmful to Interrupter?	1.92	.75	1.83	2.01
How Helpful/Harmful to Physician?	.53	1.20	.38	.68

N = 12; Scale was -4 (harmful/unjustified) to +4 (helpful/justified).
Justification ratings ranged from -.8 to 3.16.
Harmful/helpful to the interrupter ratings ranged from .4 to 3.04
Harmful/helpful to the physician ratings ranged from -2.46 to 2.84.
Each physician's ratings were averaged. The mean reported here is the mean of all the physician's separate justification and helpful/harmful rating averages.

Justification and helpful/harmfulness rating for direct reminders, indirect reminders and forgetting. Table 2 shows the means and standard deviations for the during-shift helpful/harmfulness and justification ratings for *all* interruptions. Table 3 displays the mean justification, helpful/harmful to the physician and helpful/harmful to the interrupter ratings for each of the three major memory events: direct reminders, indirect reminders and forgetting, as well as the unweighted mean rating, standard deviations and 95% confidence intervals. The table also shows how many direct reminders, indirect reminders and instances of forgetting that each physician experienced. Each physician's ratings were added together and divided by *n*, the total number of physician's experiencing each memory event resulting in an overall mean rating. For example, 11 physicians experienced direct reminders. Physician number 1 experienced 3 direct reminders. The justification ratings for those three direct reminders were averaged together to get physician 1's average justification rating for direct reminders (e.g. 2.67). This process was repeated for each physician. Following this, each of the physician's individual averaged

justification ratings were added together and divided by *n* (11), the number of physicians experiencing direct reminders, to obtain a mean justification rating of 2.73. Listed directly below the weighted mean ratings are the unweighted mean rating and associated standard deviations and 95% confidence intervals. Interruptions that contained direct reminders, indirect reminders, and caused a physician to forget were considered helpful to the interrupter and justified. While physicians did not consider indirect reminders and forgetting as helpful to themselves, they did perceive direct reminders as slightly beneficial to themselves.

Table 3

Counts and Mean Justification and H/H Ratings for Direct Reminders, Indirect Reminders and Forgetting

Dr.	Direct Reminders, n = 11				Indirect Reminders, n = 7				Forgetting, n = 5			
	D Count	Justified	Helpful/ Harmful to Dr.	Helpful/ Harmful to Interrupter	I Count	Justified	Helpful/ Harmful to Dr.	Helpful/ Harmful to Interrupter	F Count	Justified	Helpful/ Harmful to Dr.	Helpful/ Harmful to Interrupter
1	3	2.67	1.33	2.67	4	2.25	.75	1.75	1	1.00	0	0
2	0				0				0			
3	2	2.50	1.00	2.50	0				0			
4	7	2.29	2.29	1.86	0				0			
5	2	1.50	1.50	2.00	0				16	1.19	-.38	1.19
6	5	2.60	2.20	2.80	0				0			
7	10	3.50	3.30	3.00	1	4.00	4.00	4.00	0			
8	11	1.91	1.27	2.36	1	3.00	3.00	3.00	1	2.00	-2.00	3.00
9	10	3.80	2.00	3.60	3	1.33	1.33	1.33	0			
10	7	3.29	2.43	3.57	1	2.00	2.00	2.00	0			
11	5	2.00	-2.80	2.00	3	2.00	-3.00	2.00	1	2.00	-3.00	2.00
12	2	4.00	3.00	3.50	2	2.50	2.50	3.50	6	1.50	.83	2.17
Mean weighted		2.73	1.59	2.71		2.44	1.51	2.51		1.54	-.91	1.67
Mean Unweighted		2.81	1.75	2.78		2.20	.80	2.20		1.32	-.24	1.48
SD		1.27	2.02	1.06		.86	2.27	1.15		1.78	1.86	1.39
95% CI L / U		2.5, 3.12	1.26, 2.24	2.52, 3.04		1.76, 2.64	-.35, 1.95	1.62, 2.78		.62, 2.02	-.97, .49	.94, 2.02

Table 3 continued.

Note: Combination categories excluded.
Because each physician experienced a different number of events in each memory category, the *n* will be different for each memory event and is displayed with the memory event title in the column heading. For example, 11 physicians experienced direct reminders while only 5 physicians experienced instances of forgetting.
For the unweighted mean rating, each physician's ratings were added together and divided by *n*, the total number of physician's experiencing each memory event resulting in an overall mean rating. For example, 11 physicians experienced direct reminders. Physician number 1 experienced 3 direct reminders. The justification ratings for those three direct reminders were averaged together to get physician 1's average justification rating for direct reminders (e.g. 2.67). This process was repeated for each physician. Following this, each of the physician's individual averaged justification ratings were added together and divided by *n* (11), the number of physicians experiencing direct reminders, to obtain a mean justification rating of 2.73.
SD and 95% CI are associated with the weighted mean rating.
Helpfulness to the interrupter ratings for direct reminders, $t(10) = 13.98$, $p < .001$, indirect reminders, $t(6) = 6.68$, $p < .001$ and forgetting $t(4) = 3.30$, $p < .01$; Justification ratings for direct reminders, $t(10) = 11.12$, $p < .001$, indirect reminders $t(6) = 7.53$, $p < .001$, and forgetting, $t(4) = 7.51$, $p < .01$; Helpfulness to the physician for direct reminders, $t(10) = 3.25$, $p < .10$.

Justification and helpful/harmfulness rating for no memory event (none). Figure 1 illustrates the mean ratings for justification ($M = 2.18$, $SD = 1.62$), helpful/harmfulness to the interrupter ($M = 2.30$, $SD = 1.26$), and helpful/harmfulness to the physicians ($M = 1.07$, $SD = 2.44$) with 95% *CI* for memory events (direct reminders, indirect reminders and forgetting)($n = 118$), as well as the mean ratings for justification ($M = 1.36$, $SD = 2.01$), helpful/harmfulness to the interrupter ($M = 1.78$, $SD = 1.62$), and helpful/harmfulness to the physicians ($M = .12$, $SD = 1.9$) with 95% *CI* for no memory events (n=136). This suggests that overall physician perceived the interruptions that contained memory events as more justified and more helpful for both the interrupter and themselves than interruptions that contained no memory events.

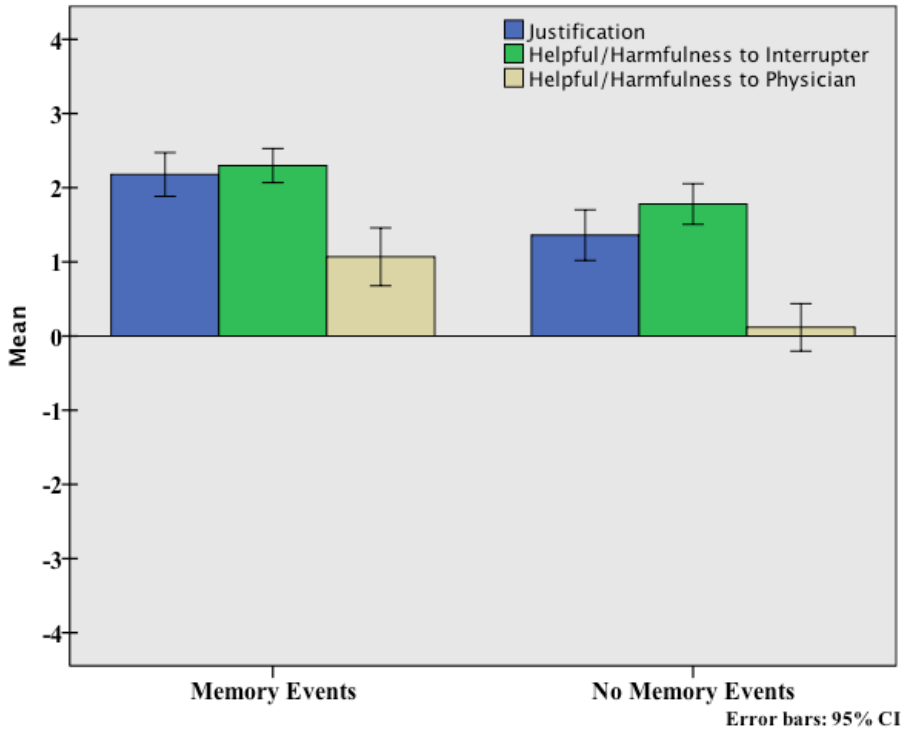

Figure 1. Justification, helpful/harmfulness to interrupter and helpful/harmfulness to physician ratings for memory events and no memory events (None). Error bars are 95% confidence intervals. Scale -4 (harmful) to +4 (helpful).

Justification and helpful/harmfulness rating correlations. In order to assess the relationship between helpful/harmfulness ratings and justification ratings, Pearson correlations were performed for each pair of ratings (helpful/harmfulness to physician with helpful/harmfulness to interrupter, helpful/harmfulness to physician with justification ratings, and helpful/harmfulness to interrupter with justification ratings) per physician. Table 4 reveals a strong significant relationship between helpful/harmfulness ratings for both the physician, $r(21.79) = .5013$, $p < .05$, and the interrupter, $r(21.79) = .4925$, $p < .05$, with justification ratings. If the physician perceived the interruption as justified, he also tended to perceive that interruption as beneficial to himself and the interrupter. No significant correlation was found for helpful/harmfulness for physician ratings with helpful/harmfulness for interrupter suggesting that

if the physicians viewed the interruptions as helpful for themselves, it was unhelpful or neither harmful nor helpful to the interrupter and vice versa.

Table 4

Pearson Correlations of Helpful/Harmful and Justification Ratings

Physician #	Interruption count per physician	r Helpful/Harmful to Physician with Justification	r Helpful/Harmful to Interrupter with Justification	r Helpful/Harmful to Physician with Helpful/Harmful to Interrupter
1	27	.706	.734	.607
2	5	a	-.086	a
3	9	.115	-.296	.014
4	16	.624	.471	.468
5	29	.504	.435	.106
6	25	.489	.757	.368
7	25	.697	.464	.583
8	24	.530	.457	.000
9	30	.260	.154	.339
10	18	.734	.652	.540
11	22	-.084	.302	-.791
12	24	.480	.647	.417
Weighted r mean		.4729	.4602	.2544
z_r		.5510	.5393	.2617
Weighted z mean converted back to r		.5013*	.4925*	.2559

*p < .05 (2-tailed), a = cannot be computed because at least one of the variables is constant
r = .5013, n= 23.79, p (2-tailed) =.0175, t = 2.7, df = 21.79
r = .4925, n= 23.79, p (2-tailed) =.0199, t = 2.64. df = 21.79
r = .2559, n= 23.79, p (2-tailed) =.2504, t = 1.24, df = 21.79
These individual physician rating correlations were converted to Fisher's Z scores then all the physician's Fisher's Z scores were averaged together for a total Z score for each of the three rating correlations. These three weighted averages were then transformed to r.

Shift phase (pre-shift, during-shift, post-shift) comparisons

Because interruptions have a poor reputation possibly due to selective memory, the question of how adept physicians were at judging how helpful and justified interruptions are prior to and after their shift was also explored. Shift phase comparisons were calculated, that is, comparing the physician's total pre-shift mean estimate rating and their total post-shift mean rating with the mean of their actual during-shift ratings. Because the helpful/harmfulness and justification rating data for all three shift phases (pre-shift, during shift, post-shift) will be compared to each other in the following analysis, it is important to note that on the pre-shift and post-shift surveys, each physician gave a single estimated helpful/harmful to themselves, helpful/harmful to the interrupter and justification rating. However, during the shift, each physician gave multiple ratings equal to the number of times they were interrupted during their shift. For example, one physician in this study experienced 22 interruptions over the course of the three hours. Thus the mean of the actual 22 during-shift justification ratings were compared to one pre-shift justification rating and one post-shift justification rating.

Helpful/harmfulness shift phase comparisons. Figure 2 illustrates the mean ratings for helpful/harmfulness to the interrupter with 95% *CI* ($N = 12$) for all three shifts, *(*pre-shift $M = 2.75$, $SD = .62$, during-shift $M = 1.92$, $SD = .75$, post-shift $M = 2.33$, $SD = .78$). Paired sample t-tests were performed between the pre-shift estimate rating and actual shift mean rating, and between the actual shift mean rating and the post-shift rating to judge whether any significant differences exist. Prior to their shift but not after, physicians overestimated the helpfulness of interruptions to the person who interrupted them ($t(11) = 3.35$, $p < .01$).

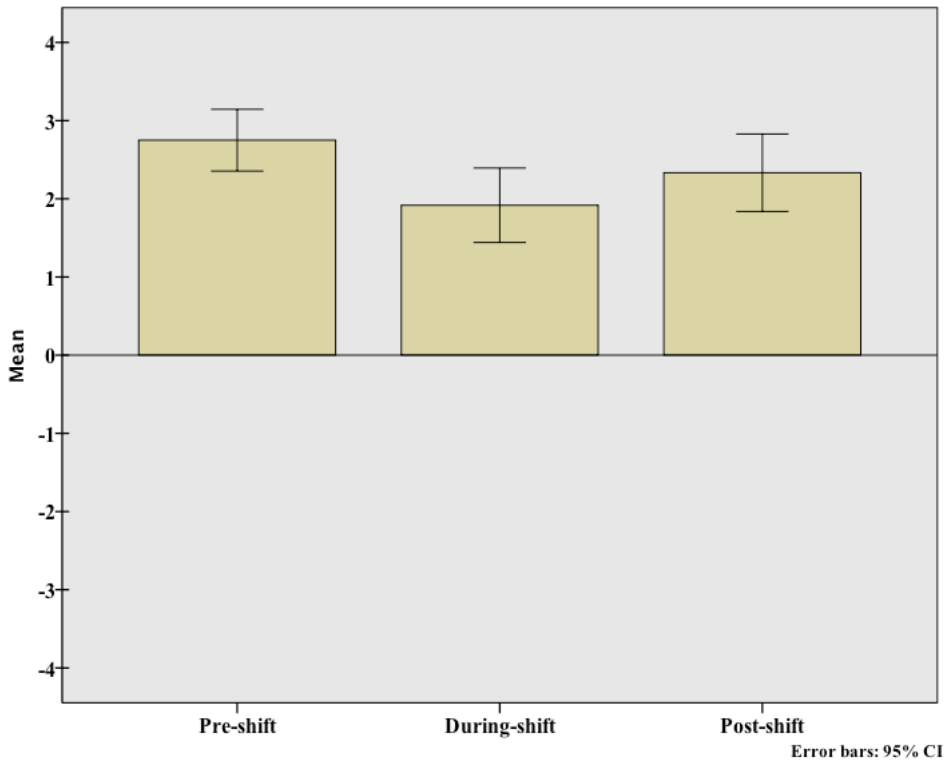

Figure 2. Helpful/harmfulness to interrupter pre-shift, during-shift and post-shift rating comparisons. Error bars are 95% confidence intervals. Scale -4 (harmful) to +4 (helpful).

Figure 3 below shows the mean ratings for helpful/harmfulness to the physician with 95% *CI* (*N* = 12) for all three shift*, (*pre-shift *M* = -1.42, *SD* = 1.73, during-shift *M* = .53, *SD* = 1.21, post-shift *M* = -.42, *SD* = 1.88). Paired sample t-tests revealed that physicians underestimated the helpfulness of interruption to themselves both prior to the shift ($t(11) = -3.49$, $p < .01$, and after the shift ($t(11) = 2.05$, $p < .10$. Moreover, observation of pre-shift 95% CI showed the physicians predicted that interruptions would be harmful to them, but in actuality they were overall neither harmful nor helpful.

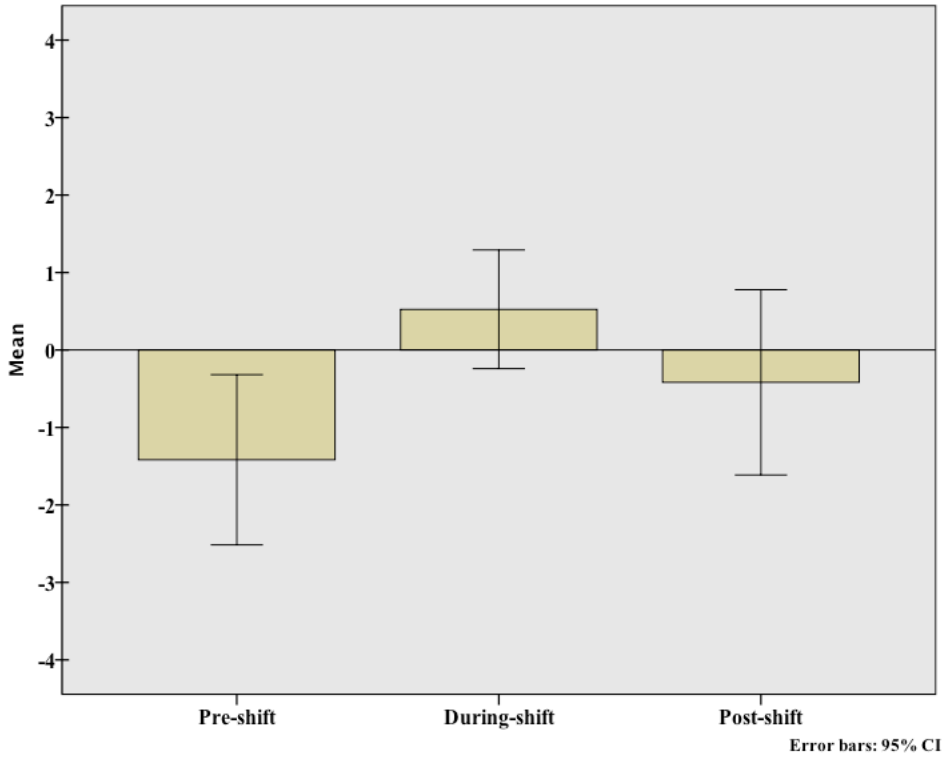

Figure 3. Helpful/harmfulness to physician pre-shift, during-shift and post-shift rating comparisons. Error bars are 95% confidence intervals.

Justification pre-shift, during-shift and post-shift rating comparison. There were no significant differences between the pre-shift, during-shift and post-shift mean justification ratings. The means are listed here and displayed below in Figure 3 (*N* =12, 95% *CI,* pre-shift *M* = *.92, SD = 1.73,* during-shift *M* = 1.53, *SD* = 1.00, post-shift *M* = 1.17*, SD = 1.59).* However, the 95% CIs indicate that, overall, physicians did not predict interruptions would be justified, but during the shift they clearly rated them as justified. In summary, pre-shift perceptions of interruptions overestimated their helpfulness to the interrupter and their harmfulness to the physician, and also underestimated how justified they would be. Post-shift perceptions followed a similar pattern, though not as extreme. The findings lend support to the idea that harmful/unjustified interruptions are selectively recalled.

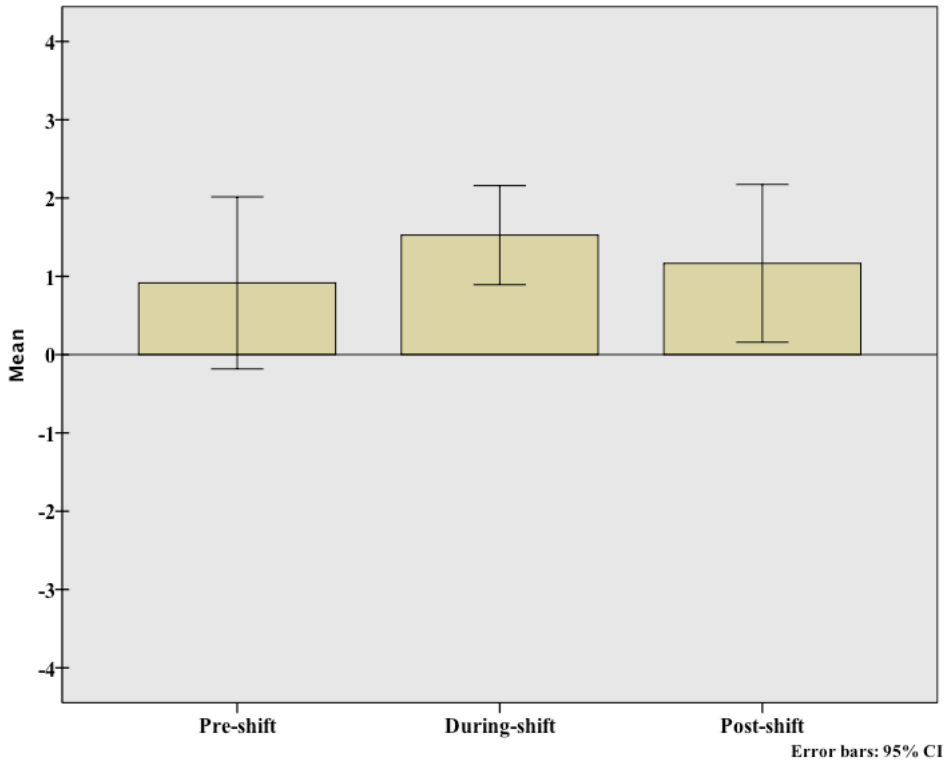

Figure 4. Justification pre-shift, during-shift and post-shift rating comparisons. Error bars are 95% confidence intervals.

Discussion

Summary

This study showed that memory events were a significant component of interruptions (47%). Direct reminders comprised the largest majority (25%), followed by memory lapses (10%) and lastly, indirect reminders (6%). Combination memory events consisted of another 6%. Physicians perceived the interruptions that contained memory events as more justified and more helpful for both the interrupter and themselves than interruptions that contained no memory events.

A common finding throughout this study was that the majority of the interruptions, both

with and without memory events, and surprisingly even including those that caused physician memory loss, were deemed helpful to the interrupter and perceived as justified. If the physician perceived the interruption as justified, he also tended to perceive that interruption as beneficial to himself and the interrupter.

On the pre-shift survey, physicians underestimated the helpfulness of interruptions to themselves, and overestimated the helpfulness of interruptions to the interrupter. Moreover, after their shift, the physicians misremembered the interruptions they experienced during-shift as less helpful than they reported during the shift.

Implications for the Role of Interruptions in Facilitating ED Physician Memory

Dodhia & Dismukes (2003) argue that interruptions intrinsically create prospective memory tasks. If a physician is interrupted while engaged in a task, he or she must remember to return to complete the task at a later time. The goal activation theory postulates that input from the environment can counteract interference and memory decay and reorient an individual to a suspended or forgotten task (Altmann & Trafton, 2002), and since "retrieval failures are believed to account for most cases of forgetting" (Loftus and Loftus, 1980), a direct reminder from medical staff to a physician may assist a physician's prospective memory. In this study, physicians experienced an average of two interruptions per hour that supplied them with a direct reminder to resume the completion of a previously unfinished task. These interruptions aid physicians' memory of a prior intention by presenting them with a salient and directed memory retrieval cue. Given the amount of cognitive load that physicians experience, reminders can be considered beneficial not only in terms of helping medical staff to remember to complete a task at some point in the future, but also to complete the activity at the time of the reminder. For the physician, this also serves a useful purpose in that it lessens the amount of tasks they need to

recall on their own.

An important component of the goal activation theory is that memory retrieval directs behavior back to the suspended task. During this study, there were many times after being interrupted with a direct reminder that the physicians immediately stopped the activity they were engaged in to complete the "reminder" activity. While this study did not track whether a physician completed all the tasks they were reminded of, these reminders did assist the physician in returning to and completing some suspended or forgotten tasks at the time the reminder cue was presented to them.

Past research has found that interruption frequency and duration are not as disruptive as task similarity and processing demands (Cellier & Eyrolle, 1992; Gillie & Broadbent, 1989, Hess & Detweiler, 1994.) The interruption-similarity effect assumes that similarity between an interrupted primary task and the interruption can result in competing memory traces and consequently make memory recall of the primary task difficult (Edwards & Gronlund, 1998). Interruptions that provide direct reminder cues overcome this obstacle by assisting physician due to their specific nature. In this study, not only did the direct reminders to physicians by medical staff heighten activation and target specific uncompleted goals, but they also instigated full primary task retrieval as well as directed task completion. It should be noted that the interruption could also result in the physician changing tasks to complete the "reminder" task and not returning to the initial task she was engaged in at the time of interruption, therefore creating another unfinished task (Westbrook, et al., 2010).

Additionally, the physicians (11 of 12) who experienced direct reminders perceived these interruptions as moderately to very justified ($M = 2.73$), moderately to very helpful to the interrupter ($M = 2.71$), and somewhat to moderately helpful to themselves (M = 1.59). While

direct reminders were perceived as somewhat beneficial to the physician, they were perceived to be more helpful to the interrupter. Because much of ED patient care relies on physician's decisions (e.g., requests for care instructions, signatures on orders, etc), direct reminder interruptions also facilitate the disposition of a patient and benefit the interrupter through the immediate completion of a task required by the interrupter to continue their workflow.

Since the spread of activation is used as a significant retrieval component (Dosher & Rosedale, 1989), even if the physician did not immediately execute the task associated with the direct reminder, these reminders, along with the indirect reminders they experienced, had the potential to heighten the activation of a memory thereby keeping it "fresher" in their mind. While the number of indirect reminders was comparatively low (8% overall), this type of interruption has the potential to heighten the activation of a prior intention. Thus when another memory cue is presented in the environment, the higher activation level may facilitate retrieval of the suspended goal, which in turn, increases the likelihood that the physician will remember to complete the forgotten task. Out of 254 total interruptions experienced during this study, the physicians were presented with 95 memory cues for them to remember and return to a suspended or forgotten task.

Mantyla and Sgaramella (1997) examined the effects of interruption on memory for intentions. Their findings suggest the "interruption of an ongoing activity facilitates subsequent prospective memory performance, possibly by increasing the level of activation of the underlying intention representation that, in turn, increases the individual's sensitivity to identify the target event" (Mantyla & Sgaramella, 1997, Pg. 192). In cases where a memory lapse occurs following an interruption, this suggests that an interruption itself can raise the level of activation for an intention, which may in some cases, diminish its detrimental effect.

Interruptions have been listed as a contributing factor of errors in complex systems. Specifically, interruptions are thought to cause temporary memory lapses or loss of activation errors. This study showed that some physicians do suffer memory lapses as a result of an interruption. However, one of the surprising outcomes of this study was that during their three-hour shifts, less than half of the doctor (5 out of 12) experienced an interruption that initiated a memory lapse. This study did not investigate why memory lapses occurred following some interruptions but not others. Previous research suggests that interruption characteristics such as higher processing demands and task similarity (Edwards & Gronlund, 1998), or incomplete memory encoding (Dodhia & Dismukes, 2009) may contribute to memory loss. In this study, a single resident physician experienced 59% or 16 of the 25 single memory category occurrences of forgetting. This may suggest that a lack of experience or an insufficient strategy to sufficiently cope with the high number of interruptions may account for this physician's higher number of reported memory lapses. It is reasonable to assume that experience and better interruption coping strategies may prevent some instances of memory loss.

Regardless of the fact that these interruptions precipitated a memory lapse, the physicians still deemed them justified, which suggests that the contents of the interruptions were important enough to warrant the action of interruption, and that the occurrence of a memory lapse did not counteract a justified rating.

An important finding of this study was that 59% of memory events were direct reminders (N=11) as compared to 19% of instances of forgetting (N=5). Essentially, physicians experienced more than 2.5 times as many direct reminders (64) than instances of forgetting (25). Moreover, physicians perceived the interruptions that contained memory events (reminders and forgetting), as more justified and more helpful for both the interrupter and themselves than

interruptions that contained no memory events.

Implications for Understanding Interruptions as Part of Communication

Throughout interruption literature, interruptions are categorized as work stressors or causes of error, but rarely conceptualized as communication events. Interruptions themselves serve as communication vehicles. A common finding throughout this study was that interruptions, both with and without memory events, and during all three-shift phases, were perceived as justified and helpful to the interrupter. Moreover, if the physician perceived the interruption as justified, he also tended to perceive that interruption as beneficial to himself or the interrupter. While this study did not investigate how interruptions helped the interrupter, this researcher observed that interruptions offered an effective communication vehicle for the interrupter in the transfer of valuable patient information. Patient updates, delivery of information, requests for care instructions and signatures on orders, etc, were often presented to the physician in the form of interruptions. Specifically, interruptions benefitted the interrupter by the receipt of information necessary to facilitate the disposition of a patient. The interrupter was also aided by having the opportunity to request that the physician complete a task, required by the interrupter, to continue their workflow.

In this study, this researcher observed that the role of interruptions was to replace face-to-face communication that does not exist. In the ED, where a great deal of uncertainty exists surrounding each new patient's care, there is generally little, if any, formalized scheduled face-to-face interaction between staff. In addition, ED communication studies (Eisenberg, et al., 2005; Fairbanks, Bizantz & Sunm, 2007) found that most of the communication exists within professional groups (e.g., between MD - MD or nurse - nurse). In many cases, nurses and doctors work in parallel, relying on a patient's chart for communication and rarely participating in face-

to-face conversation though they are caring for the same patient. As a result, "Nurses must go out of their way to approach the physician with questions or concerns", (Eisenberg, et al., 2005). And, with the implementation of networked electronic patient charting and tracking systems, medical staff are also more likely to be located at their own computers than at a "community" whiteboard or centralized location where they are more likely to engage in face-to-face interaction. This lack of communication protocol and specified centralized information transfer location makes interruptions necessary to receive or disseminate information, especially if the information is time-sensitive. Waiting until a doctor is free of tasks may be unrealistic in such a busy environment and inadvisable if delays of information transfer can put a patient at risk. In a busy environment where there is high workload and difficulty in locating staff members at any given time, this researcher observed that interruptions are also initiated by a chance passing, as when an interruption is initiated by a memory that is retrieved by simply seeing a staff member. For instance, as a nurse passes a doctor while talking to a technician, the nurse, upon seeing the doctor, remembers that he needs to ask this doctor a question about a patient and thus, interrupts him, because it is convenient. Given that there are no specific communication protocol set up for nurses to ask physicians questions, the nurse takes his chance and interrupts the doctor to garner needed information.

Because interruptions can make other communication events vulnerable to potential adverse events, this research does not promote interruptions as the best form of communication. However, it does acknowledge that interruptions are an effective means communication for the transfer of important patient information and recommends that the content of interruptions be further investigated. Improved communication between physician and medical staff may greatly reduce on the amount of interruptions that all medical staff may experience.

The Paradoxical Memory of Future and Past Interruptions

Schneider, Gallery, Schafermeyer, and Zwemer (2003) found that crowding was present in 100% of the 250 emergency departments that they randomly sampled across the U.S. Overcrowding can create unmanageable task loads as medical staff contends with the care of an increasing number of patients. Chisholm et al. (2000) revealed that interruptions are positively correlated with the average number of patients being simultaneously managed. Furthermore, interruptions contribute to medical staff cognitive workload by creating more multitasking behaviors that result from splitting the interruptee's attention between a primary task and an interruption. Both interruptions and multitasking have a detrimental effect on medical staff. Excessive interruptions can increase stress levels and decrease an individual ability to concentrate or make good decisions (Applebaum, Marchionni & Fernandez, 2008; Carayon, 2007; Cohen, 1980). While duration and frequency of interruptions are considered troublesome, the processing demands of an interruption were found to be even more disruptive (Cellier & Eyrolle, 1992; Gillie & Broadbent, 1989, Hess & Detweiler, 1994). Moreover, simply querying physicians about their perceptions of the interruptions they experience can revive the continued experiences of stress and frustration related to being interrupted. The result is that "People are generally very familiar with the subjective idea that interruptions affect their performance", (McFarlane & Latorella, 2002), which suggests that an individual's perceptions about interruptions are affected by their previous experiences. This may explain why physicians predicted, and later remembered, that interruptions were harmful to themselves when during the shift, they perceived them as helpful; this study confirms that doctors underestimate the helpfulness of interruptions to themselves. In general, this may also be a contributing factor to

explain why interruption research focuses on the negative aspects of interruptions and why there is little research into the reasons people interrupt in the first place.

Importance of this Study

No previous research exists of physician's self-report of justification or benefits of interruptions. This research gathered physician's perceptions of justification, helpfulness and harmfulness of the interruptions they experience. It has been implied in previous research that the majority of interruptions are unnecessary and harmful, however the findings of this study provides some evidence that good cause existed for the majority of interruptions and that the doctors believe that the interruptions they experience are justified.

Further this study compared the actual during-shift ratings to doctor's perceptions prior to and after their shift. This study confirms that physician's pre-shift and post-shift perceptions of interruptions do not always match their perceptions of the actual events. This research showed that doctors underestimate the helpfulness of interruptions to themselves. They also believe that there are benefits to interruptions.

This study confirms that memory events comprise a large part of interruptions. This research shows that many interruptions have benefits such as reminder cues that aid a physician's memory and help reorient a physician to a suspended task. Additionally, physicians perceived interruptions that contained memory events (forgetting included) as more helpful to themselves and the interrupter, and more justified than those interruptions that did not contain memory events.

This study also provides evidence that interruptions provide a communication vehicle for the transfer of relevant patient information.

It is unclear whether the results of this study can be generalized to linear (serial) task environments where the individual has a set number of tasks to complete in a certain order such as flying a plane or teaching a class. However, this study can be generalized to other multi-parallel task environments.

Strengths and Limitations of this Study

One of the strengths of this study was that it was conducted during normal medical staff shifts onsite in an ED environment. This allowed for the data to be obtained as the physicians experienced each interruptions or shortly thereafter, in a real work setting. In addition, the physician's perceptions were gathered before, during and after the shifts. As the comparison in this study shows, physician's pre-shift and post-shift perception of the interruptions they experience can differ from the actual shift data suggesting that memory does affect their perceptions of interruptions.

This study did not include a random sampling of shifts. The time observed was always 7-10pm during the night shift. Other variables such as the length of interruption, severity of interruption and severity of task that was interrupted were not studied, but may have affected the results. Obtaining each rating would introduce another interruption, and sometimes the physician's workflow or tasks did not allow for an interruption from the researcher to gather a rating, therefore the rating collection was grouped, generally every 20-30 minutes or sooner if the physician signaled their availability. The more time that elapsed between the interruption and the rating could increase the chance that the physicians forgot whether they experienced a direct or indirect reminder or forgot what they were doing at the time of the interruption. Finally, consequences of interruptions were not examined, so even though a doctor may not have considered an interruption harmful, that does not mean that it did not cause errors.

Future Work

Future research should be directed towards investigating the role and content of interruptions, in addition to their effect. Since the physicians considered the interruptions helpful to the interrupter, it is recommended that interruptions be not only evaluated from the perspective of the interruptee, in this case the physician, but also from the interrupter's perspective specifically, to find out what they gained from interrupting and if and how it helped them in their overall work. Moreover, since 78% of all interruption were perceived to be justified, research could be directed toward investigating what were the content of interruptions that were believed to be justified and what sorts of interruptions were perceived to be unjustified.

Previous research has shown that interruptions can delay task completion (Eyrolle & Cellier, 2000; Monk, Boehm-Davis & Trafton, 2004). In the case of this study, physicians' workflow would be affected and tasks would take longer to accomplish. However, it would be advantageous for the patient if, as a result of an interruption, the interrupter gained required information to progress that patient's disposition. Future research in this field could investigate whether and how interruptions are beneficial to the patient. And, most fundamentally, more research is needed to discover how medical staff communication can be improved so that the need for interruptions is minimized.

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Appendix A

Pre-shift Interruption Survey/Interview

Thank you for your participation in this study regarding interruptions. Please answer all questions to the best of your ability. This survey should take approximately 10 minutes.

For this survey, an interruption is considered: a break in the performance of your work activity, which results in suspension of your task to perform an unplanned task with the assumption that the initial task will be resumed.

1. How many times do you believe you are interrupted during an average work hour?

   _____

2. Generally, who interrupts you?

   _____

   _____

3. What is the most common reason for you to be interrupted?

   _____

   _____

   _____

   _____

   _____

4. Of the interruptions you experience at work, are any of them **direct reminders** from someone else for you to remember to do something (work-related) or complete a task you may have forgotten? For example, "Don't forget you were going to check in on Patient B". (If "No", go to question #8)

   _____

5. How often do you believe that you experience these kinds of reminders?

   _____

   _____

6. Who reminds you?

_____

_____

7. Generally, what tasks are the reminders for?

_____

_____

_____

_____

8. Are there times when you are interrupted and something in or about the interruption reminds you of a different work-related task that you need to do or had forgotten? (This is an **indirect reminder.**) (If "No" go to question #11)

_____

_____

9. How often do you believe that you experience these kinds of reminders?

_____

_____

10. Generally, what is it about the interruption that causes you to remember?

_____

_____

_____

_____

11. Are there times when you are interrupted at work and it causes you to forget what you are doing or what you are thinking? (If "No", go to question 15)

_____

_____

_____

_____

12. How often do you believe that you experience this?

_____

_____

13. Are you generally able to remember what you had forgotten?

_____

_____

14. How long does it usually take you to remember?

_____

15. Please rate the extent to which you believe the interruptions you experience at work are **helpful or harmful to you** with respect to accomplishing **your** intention to perform a work task.

Very Harmful		Moderately Harmful		Neutral		Moderately Helpful		Very Helpful
-4	-3	-2	-1	0	1	2	3	4

16. Please rate the extent to which you believe the interruptions you experience at work are **helpful or harmful to the person interrupting you** with respect to accomplishing **their** intention to perform a work task.

Very Harmful		Moderately Harmful		Neutral		Moderately Helpful		Very Helpful
-4	-3	-2	-1	0	1	2	3	4

17. Please rate the extent to which you believe the interruptions you experience at work are **justified or unjustified**.

Very Unjustified		Moderately Unjustified		Neutral		Moderately Justified		Very Justified
-4	-3	-2	-1	0	1	2	3	4

Appendix B

Individual Interruption Rating Form

Interruption # _____

Interrupter Occupation:

_____
_____
_____
_____

(the above is for the researcher to fill out)

1. This interruption: (Please check all that apply)

☐ was a **Direct Reminder** to complete a work-related task. (The person who interrupted me specifically told me to complete a task.)

☐ was an **Indirect Reminder** to complete a work-related task. (Something in or about the interruption reminded me of something else work-related that I need to do or had forgotten.)

☐ caused me to **Forget** what I was doing or thinking.

☐ **None** of the above**.**

*Please rate the following questions with respect to accomplishing an intention to perform a work task today.

2. Rate the extent to which you believe this interruption was **justified or unjustified.**

Very Unjustified		Moderately Unjustified		Neutral		Moderately Justified		Very Justified
-4	-3	-2	-1	0	1	2	3	4

3. Rate the extent to which this interruption was **helpful or harmful to you.**

Very Harmful		Moderately Harmful		Neutral		Moderately Helpful		Very Helpful
-4	-3	-2	-1	0	1	2	3	4

4. Rate the extent to which this interruption was **helpful or harmful for the individuals who interrupted you.**

Very Harmful		Moderately Harmful		Neutral		Moderately Helpful		Very Helpful
-4	-3	-2	-1	0	1	2	3	4

Appendix C

Post-shift Interruption Survey/Interview

For this survey, an interruption is considered: a break in the performance of your work activity, which results in suspension of your task to perform an unplanned task with the assumption that the initial task will be resumed.

1. How many times do you believe you are interrupted during an average work hour?

2. How often per hour do you believe that you experience a direct reminder to do something (work-related) or complete a task that was suspended or you may have forgotten?

3. How often per hour do you believe that you experience indirect reminder, that is when you are interrupted and something in or about the interruption reminds you of a different work-related task that you need to do or had forgotten?

4. How often per hour do you believe that you are interrupted at work and it causes you to forget what you are doing or what you are thinking?

5. Please rate the extent to which you believe the interruptions you experience at work (overall) are **helpful or harmful to you** with respect to accomplishing **your** intention to perform a work task.

Very Harmful		Moderately Harmful		Neutral		Moderately Helpful		Very Helpful
-4	-3	-2	-1	0	1	2	3	4

6. Please rate the extent to which you believe the interruptions you experience at work (overall) are **helpful or harmful to the person interrupting you** with respect to accomplishing **their** intention to perform a work task.

Very Harmful		Moderately Harmful		Neutral		Moderately Helpful		Very Helpful
-4	-3	-2	-1	0	1	2	3	4

7. Please rate the extent to which you believe the interruptions you experience at work (overall) are **justified or unjustified**.

Very Unjustified		Moderately Unjustified		Neutral		Moderately Justified		Very Justified
-4	-3	-2	-1	0	1	2	3	4

Appendix D

University of Rochester Research Subjects Review Board

Letter of Approval

RSRB: RSRB00034220 **Principal Investigator**: Madelyn Garcia

Study Title: The Effect of Interruptions on Prospective Memory in the Emergency Department

Initial Approval: November 5, 2010

Study Approval Expires: November 4, 2011

Length of Review: 1 year

Risk Level: - Minimal Risk - Adults only

Review Level: Expedited

Expedited Category(ies):

- 6 - collection of data from voice, video, digital, image recordings

Additional Remarks: - The investigator will provide the subject with written information about the consent - HIPAA: Does not apply

- Protocol dated 6/23/2010. Consent last modified 10/28/2010.

This approval is contingent upon the investigation being conducted in compliance with the approved study protocol including all requirements and/or determinations of the RSRB. Unless a Waiver of Consent is specified above, consent must be obtained and documented in the manner approved by the RSRB. Please note all remarks and/or attachments. Only consent forms bearing a current 'RSRB Approved' Watermark may be used. Only the most recently approved version of any consent or recruitment document may be used when obtaining consent. **Consent forms/recruitment letters must be printed on department letterhead.**

As the Principal Investigator, you are responsible for the following activities:

1. Timely submission of continuing review progress reports apply to RSRB

at least 8 weeks before expiration. Federal Regulations require that the RSRB conduct continuing review of research. You will receive an email notification when the expiration date is approaching.

2. Requesting any proposed changes in the above research activity. All subject recruitment materials must be approved prior to use. Changes may not be initiated without RSRB approval except when necessary to eliminate apparent immediate hazards to the subject(s) and then a report must be submitted along with the amendment request
3. Maintaining all approved study documents in your study file
4. Maintaining signed consent forms for at least three years after the research is completed or for a longer term if required by FDA regulations
5. Reporting any unexpected serious problems involving risks to subjects or others (including unexpected deaths, hospitalizations or serious injuries) in accordance with the RSRB Adverse Event guidelines
6. Submitting a final progress report to the RSRB upon completion of this study

John Loughner, RSRB Chair

November 5, 2010

The Department of Health and Human Services has approved a Federalwide Assurance (FWA) with the University of Rochester (FWA9386), which is in effect through May 28, 2013.

601 Elmwood Avenue, Box 315
Rochester, New York 14642
(585) 275-2398

R·I·T

Rochester Institute of Technology

RIT Institutional Review Board for the
Protection of Human Subjects in Research
141 Lomb Memorial Drive
Rochester, New York 14623-5604
Phone: 585-475-7673
Fax: 585-475-7990
Email: hmfsrs@rit.edu

Form C
IRB Decision Form

TO: Kate Walders; Nicholas DiFonzo

FROM: RIT Institutional Review Board

DATE: **December 5, 2010**

RE: **Decision of the RIT Institutional Review Board**

Project Title – The Effect of Interruptions on Prospective Memory in the Emergency Department

The Institutional Review Board (IRB) has taken the following action on your project named above.

☒ Approved, no greater than minimal risk

Now that your project is approved, you may proceed as you described in the Form A. **Note that this approval is only for a maximum of 12 months; you may conduct research on human subjects only between the date of this letter and 12/5/2011.**

You are required to submit to the IRB any:

- **Proposed** modifications and wait for approval before implementing them,
- Unanticipated risks, and
- Actual injury to human subjects.

Return the Form F, at the end of your human research project or 12 months from the above date. If your project will extend more than 12 months, your project must receive continuing review by the IRB.

Heather Foti, MPH
Associate Director
Office of Human Subjects Research

Revised 10-18-06

Appendix E

RECRUITMENT EMAIL

RE: Seeking EM attending or resident physicians for a research study

We would like to encourage you to participate in a study of interruptions in emergency physician's workflow. This study involves a 20 minute interview which can take place at corporate woods or SMH, then (up to several days later) you will be shadowed for 3 hours by a researcher during one of your ED shifts. The purpose will be to document your interruptions. The researcher will ask you 4 brief rating questions about each interruption, at a time that doesn't further interrupt your workflow. At the end of the three hours, it is likely that you will be asked to briefly answer a few clarification questions.

We expect to start in January. Patients and other staff will not be approached for any information. The researcher will be sensitive to minimizing the impact on your work during the observed shift.

If you are interested, please contact either Kate Walders (RIT Graduate Student) or Madelyn Garcia at the following email addresses:

Kate Walders, M.S.
kcw@rochester.rr.com
or

Madelyn Garcia, MD, MPH
Assistant Professor of Emergency Medicine
madelyn_garcia@urmc.rochester.edu

Sincerely,

Kate Walders
Madelyn Garcia
Terry Fairbanks

Consent Form

Title of Study:
Principal Investigator:
University of Rochester Department:
Co-Investigator:

Introduction:
This consent form describes a research study and what you may expect if you decide to participate. Please read this consent form carefully and ask the person who presents it any further questions you may have before you decide whether or not you want to take part. The study researchers are Kate Walders, M.S. from the Rochester Institute of Technology, Department of Engineering Psychology and Madelyn Garcia, MD, MPH from the University of Rochester, Department of Emergency Medicine.

You are being asked to take part in this study because you are an attending or resident physician in the Emergency Department.

Purpose(s) of Study:
Research is designed to benefit the healthcare field by gaining new domain knowledge. The purpose of this study is to learn more about how interruptions positively and negatively affect physicians in the Emergency Department (ED).

Description of Study Procedures
If you agree to take part, the following procedures will occur:

- Prior to your ED shift, the researcher will interview you for about 20 minutes regarding interruptions that you experience during work. We would like to audio-tape this interview. It can be conducted in your office or in a quiet location before your ED shift. After the interview, someone will transcribe the audiotape into a computer file at which time all names will be removed. Once the audiotape is transcribed, it will then be destroyed. At the end of this form, you will be asked to indicate whether or not you agree to have this interview audio-taped.

- During your ED shift, the researcher will shadow you for three hours and will document each interruption you experience. Following each interruption, you will be asked to complete (verbally or written) a rating sheet with 4 ratings that should take no more than a minute. Your name will not appear on these sheets.

- At the end of the three hours (or, if time does not allow, at the end of your shift), the researcher will ask you to answer a few questions, clarify some of your ratings and clear up any missing data. Expected time for this is 10 minutes.

Number of Subjects:
14 attending or resident ED physicians will take part in this study.

Risks of Participation:

- Given this study will be conducted during evening ED shifts, which tend to be busy, the investigator will try to minimize additional stress to the subject by asking them to complete the Rating Form at the best time possible. This study will never compromise patient care/safety. The subject will always have the opportunity to postpone completing the Rating Form.

- Regarding invasion of subject privacy, the subject will always be able to indicate to the investigator that the interruption/event represents a personal matter (e.g. personal phone call or conversation not related to work).

- It will be at the subject's discretion whether any situation/event/information which the investigator is witnessing should be excluded from this study, as it might represent an invasion of subject or patient privacy. For example, the subject can ask the investigator to step out if they need to discuss sensitive/legal or private matters (e.g. providing information of a particular accident or abuse case to law enforcement/social work).

- The pre-shift interview will be audio-taped. The interview is between you and the researcher and does not involve patients or any other hospital staff. After the interview, someone will transcribe the audiotape into a computer file at which time all names will be removed. Once the audiotape is transcribed and assigned a number, it will then be destroyed. The audio recording can be turned off at any time or you can withdraw from the study if you are uncomfortable.

Payments
You will not be paid for taking part in this study.

Costs
There are no costs to you to participate.

Benefits
You will not benefit personally from being in this research study.

Confidentiality of Records
While we make every effort to maintain confidentiality, it cannot be absolutely guaranteed. Although every effort will be made to keep research records private, there may be times when federal or state law requires the disclosure of such records, including personal information. This is very unlikely, but if disclosure is ever required, the University of Rochester will take steps allowable by law to protect the privacy of personal information. In some cases, your information in this research study could be reviewed by representatives of the University, research sponsors, or government agencies for purposes such as quality control or safety.

Contact Persons

For more information concerning this research or if you feel that your participation has resulted in any emotional or physical discomfort please contact: Kate Walders or Madelyn Garcia. If you have any questions about your rights as a research subject, or any concerns or complaints you may contact the Human Subjects Protection Specialist at the University of Rochester Research Subjects Review Board, Box 315, 601 Elmwood Avenue, Rochester, NY 14642-8315, Telephone (585) 276-0005, for long-distance you may call toll-free, (877) 449-4441. You may also call these numbers if you cannot reach the research staff or wish to talk to someone else.

Voluntary Participation

Taking part in this research study is your choice. You are free not to participate or to withdraw at any time, for whatever reason. No matter what decision you make, there will be no penalty or loss of benefit to which you are entitled. In the event that you do withdraw from this study, the information you have already provided will be kept in a confidential manner.

Taking part in this research is not a part of your University duties, and refusing will not affect your job. You will not be offered or receive any special job-related consideration if you take part in this research.

****

Signature/Dates

Please check the line that best matches your choice:

_____ OK to record you during the pre-shift interview.

_____ Not OK to record you during the pre-shift interview.

Subject Consent

I have read (or have had read to me) the contents of this consent form and have been encouraged to ask questions. I have received answers to my questions. I agree to participate in this study. I have received (or will receive) a signed copy of this form for my records and future reference.

Study Subject: _____ Print Name

Study Subject: _____ Signature _____Date

Person Obtaining Consent

I have read this form to the subject and/or the subject has read this form. I will provide the subject with a copy of this consent form. An explanation of the research was given and questions from the subject were solicited and answered to the subject's satisfaction. In my judgment, the subject has demonstrated comprehension of the information. I have given the subject adequate opportunity to read the consent before signing.

_____ Print Name and Title

_____ Signature _____Date