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Technology Mediated Interruptions: Attention Analysis and Impact on Task Performance

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ABSTRACT

Information systems that provide easier access to information and enhanced communication channels to help manage these tasks (e.g. through emails, instant messages, and calls via mobile devices) can cause workers to temporarily lose focus on his or her current activity (defined as interruptions) (O'Conaill and Frohlich, 1995). Even though some research has concentrated on explaining the effects of interruptions (Speier, Valacich, & Vessey, 1999; Gillie and Broadbent, 1989; Cellier & Eyrolle, 1992), they fall short of explaining the complex set of relationships that help us understand how and why an individual attends to new tasks, and how this task fragmentation and task-switching process influences performance. The purpose of this dissertation is to explain the effect of TMI and task-switching on performance using the Stimulus Value Role Model (Murstein, 1970) as a theoretical basis and to use working memory to investigate how task-switching and task-fragmentation influence task performance. Controlled laboratory experiments will be conducted to test the hypotheses.

Keywords

Interruption, technology, decision making, Stimulus Value Role, multitasking.

INTRODUCTION

As workplace complexity increases, many knowledge workers have had to become multitaskers who continuously switch tasks and try to manage multiple projects at the same time. Information systems that provide easier access to information and enhanced communication channels to help manage these tasks (e.g. through emails, instant messages, and calls via mobile devices) can cause workers to temporarily lose focus on his or her current activity (defined as interruptions) (O'Conaill and Frohlich, 1995). These interruptions typically require "immediate attention" and are activities that "insist on action" (Covey, 1990, pp.150-152). Such interruptions create technology imposed task fragmentation, and force the knowledge worker into an on-going task switching process, which can impact working memory and make it difficult to return back to the ex-ante conditions.

Rather than considering technology mediated interruptions (TMI) as part of a multitasking, the past research has isolated these interruptions as peripheral part of a decision maker's performance (Miller, 2002). In this regard, an extensive amount of practice driven work has tried to explain the impact of interruptions on task performance (e.g. Adamczyk and Bailey, 2004; McFarlane and Latorella, 2002; Czerwinski, Horvitz, and Wilhite, 2004). In the current research we stress that every interruption is relevant to the decision maker to a certain degree and becomes part of a task switching routine in one's multitasking world.

Apart from considering the effect of interruptions on one's productivity, there is also little theory driven research that explains how task performance is affected by technology mediated interruptions. Even though some research has concentrated on explaining the effects of interruptions (Speier, Valacich, & Vessey, 1999; Gillie and Broadbent, 1989; Cellier & Eyrolle, 1992), they fall short of explaining the complex set of relationships that help us understand how and why an individual attends to new tasks, and how this task fragmentation and task-switching process influences performance.

Overall, the purpose of this dissertation is to explain the effect of TMI and task-switching on performance using the Stimulus Value Role Model (Murstein, 1970) as a theoretical basis. Moreover, this work uses the concept working memory to investigate how task-switching and task-fragmentation influence task performance, proposing the following two research questions:

RQ1: How do individuals evaluate technology mediated interruptions?

RQ2: What is the impact of technology mediated interruptions on multitasking performance?

LITERATURE REVIEW

Interruptions are defined as "incidents or occurrences that impede or delay organizational members as they attempt to make progress on work tasks" (Jett and George, 2003, p. 494). Moreover, they typically result in the recipient discontinuing his or her current activity (O'Conaill and Frohlich, 1995). While interruptions may not be critical to completing the task at hand, they typically require "immediate attention" and are activities that "insist on action" (Covey, 1990, p.150-152).

Interruptions research has received attention from researchers in disciplines such as psychology, marketing, and information systems. One stream of research has revolved around mapping the design space and identifying a broad array of potential influences that address the factors which influence user performance. For example, Speier, Vessey, & Valacich (1999) investigated the effects of different interruption characteristics on performance, such as frequency, duration, complexity, timing, and content, Adamczyk and Bailey (2004) analyzed the impact of different interruption timings, Altman and Trafton (2005) investigated resumption lags for different types of tasks, and McFarlane and Latorella (2005) proposed the taxonomy of human interruptions and their influence on performance. This stream of research illustrates areas of the problem and where specific technologies could be introduced to give people richer support for handling interruption.

A second stream of research has focused more on the influence of interruptions on task performance through analyzing changes in the individual's cognitive processing. For example, interruptions have been shown to deteriorate performance (e.g., Kahneman, Laird, & Fruehling, 1983; Woodhead, 1965; Speier et al., 1999) by reducing a person's ability to sustain mental attention and effort (Baecker, Grudin, Buxton, & Greenberg, 1995), creating difficulties in rationing cognitive resources (Baron, 1986), breaking the flow of tasks (Bederson, 2004) and impairing task processing (March, 1994). These effects have also been shown to reduce task accuracy (Cellier & Eyrolle, 1992; Schuh, 1978) and increase the time required for task completion (Schiffman & Griest-Bousquet, 1992).

Another stream of research in marketing has investigated the impact of distractions on preferences and perceived experience. This research has shown that consumers facing decisions with feasibility-desirability trade-offs change their preferences when exposed to interruptions (Liu, 2008). Furthermore, Nelson, Melvic, and Galvac (2003) showed that when positive experiences are interrupted, these experiences are perceived more attractive, whereas interrupted negative experiences are perceived more negative.

However, there is no significant work to date that has investigated how and why a multitasking decision maker intentionally switches to a new (interruption) task. Moreover, there is no overarching model that explains the consequences of TMI while multitasking. Therefore, we adapt and extend the Stimulus Value Role Model to explain phenomenon.

THEORETICAL BASIS AND HYPOTHESES DEVELOPMENT

This section outlines the model of multitasking which explains the process of task switching and the stages of interruption. Based on literature on working memory and task execution process, we hypothesize the impact of TMI on performance. Next, we list the accounts of multitasking and highlight mechanism that determines attentional draw and task switching to a new TMI based on the Stimulus Value Role Model.

Model of Multitasking

Multitasking is characterized with respect to the time spent on one task prior to switching to the next (Salvucci, Taatgen, and Borst, 2009). Multitasking spans across a continuum. The left extreme of the continuum represents concurrent multitasking activities, such as driving and talking, listening and note taking which require different channels. The right extreme of the continuum represent sequential multitasking activities such as writing and reading email. Based on Trafton et al. (2003), Salvucci et al. (2009) proposed the following model of multitasking with stages of interruptions (please see Figure 1).

According to this model, after performing a task for a short time, the decision maker gets notified by the interruption, subsequently stops execution of the initial task but rehearses on its mental representation for future retrieval. The decision maker then performs the new (interrupting) task but also continues to rehearse the initial task if desired. Once the interruption task is over, the rehearsed information is retrieved.

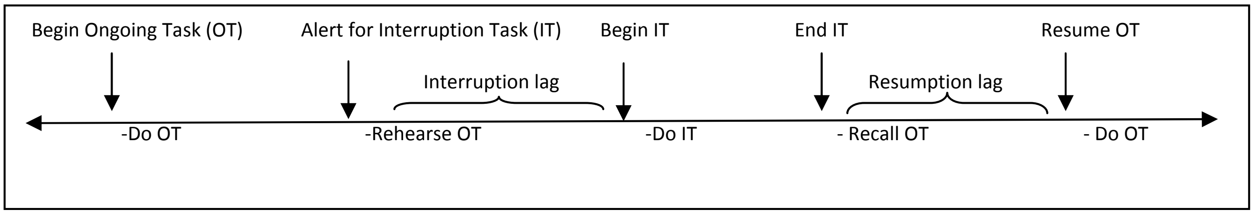

Figure 1. Model of Multitasking (Adopted from Trafton and Altmann, 2001)

Based on this model, the multitasking decision maker has multiple goals to accomplish during this task fragmentation. To accomplish these goals, the task execution process contains “goal shifting” which determines the current and future tasks, and “rule activation” which loads the next task’s rules into short term working memory (Rubenstein, Meyer, and Evans, 2001). For each specific goal, the decision maker identifies the stimulus, selects a response, and produces an action. Each task may differ in duration depending on factors such as complexity of the task and stimulus discriminability. While multitasking, various tasks require multiple problem representations. When there is a switch between tasks, due to limited short term working memory all but the current goal representations and rules are sent to long term memory and retrieved when switched back. However, for this process to occur without errors, the storing of the to-be-recalled problem representations and rules need to be rehearsed before starting the next task (Borst and Taatgen, 2007). When TMI occur, they may block or shorten the time required for this process which leads to unsuccessful or partial restoring.

Accounts of Multitasking

Intermittent interaction between decision maker and computer is the nature of multitasking systems. Therefore, decision makers cannot concentrate on a single task, and needs to switch between multiple tasks and process their postponed tasks. These intermittent interactions lead to interruptions (McFarlene and Latorella, 2002). Overall, decision makers’ performance will depend on how well they integrate these interruptions into their on-going work. For instance, in air traffic control, an alert about the current flight is related to the on-going tasks, but it is also an interruption. In order to understand the performance of a multitasker, this work investigates various aspects that may influence the flow of the multitasking model with interruptions in Figure 1.

Effect of Cognitive Overload

Existing literature has shown that cognitive load is the major determinant of performance. It is defined as the cognitive capacity that is allocated to accommodate task demands (Paas and van Merriënboer, 1994; Sweller, van Merriënboer, and Paas, 1998) in the short term working memory. If the decision maker is overloaded, some of the restoring will get affected, making it harder to activate rules and representations, and identifying the stimulus for selecting a response. Therefore, we propose the following:

P1: Cognitive load significantly influences performance.

Effects of Technology Mediated Interruptions

One important aspect of multitasking is the technology enforced task fragmentation. Depending upon its length, complexity, frequency, importance etc., interruption lag and time spent on the TMI may vary, which in turn influences the rehearsal of the on-going task for future recall. Therefore, this research provides a theoretical explanation for why some of the interruptions may have different impact on the ability to recall information ex-ante to TMI.

In this regard, this dissertation extends the SVR Model—with the insights of relevant IS literature—to the context of technology mediated interruption evaluation. While a decision maker multitasks and switches from one task to another, the SVR model helps understand the triggers that draw attention to TMI. The Stimulus-Value-Role (SVR) model (Murstein, 1970; 1974) explains the process of marital choice by specifying the attributes of the candidate that may potentially influence the partner's decision to further engage in and continue the relationship. Murstein proposes a three stage filtering mechanism to evaluate a potential partner.

The SVR model proposes that the initial *stimulus stage* of a relationship begins with attraction, which is based on non-interaction cues such as physical attributes of the stimuli. Similarly, in technologically advanced environments, external attributes of a TMI (aesthetics, sound, importance and urgency signs, etc.), sender's characteristics (reputation, communication frequency), and association with the interruption can be listed as the main factors that attract attention. Iani and Wickens (2007) showed that salience via auditory and visual cues help draw attention to a TMI.

When moving to the value stage, individuals assess their compatability in beliefs, attitudes, religion with their potential partners to identify their matching interests (Murstein, 1970). Similarly, in online environments, if an interruption passes the stimulus stage, it will then be evaluated at the value filter. This evaluation will be based on the compatibility in the content of TMI such as interest, perceived urgency, importance, and social obligation. Gluck, Blunt, and McGrenere (2007) showed that attentional draw to TMI is higher when it is relevant to the primary task compared to when it is irrelevant.

While some "attachments" are created based on the value filter (Murstein, 1970), a majority of the individuals move to the role stage and apply a filter that evaluates their partners based on the "mutual fit" (whether the relationship is mutually rewarding), and one's own and partner's adequacy in the relationship in the long run. Corollary, in online environments, the receiver decides to form a "relationship" if the task switching requires a role performance. In this regard, the individual will first evaluate the interruption against the task at hand (i.e. comparing the relative importance, complexity, urgency, benefit, cost, etc. of the task). Secondly, the individual will evaluate personal adequacy with the interruption task, as well as adequacy/ability of the source(s) of the interruption to further develop/engage in the interruption task.

Therefore, we argue that different interruption characteristics, such as urgent, complex, important, will have a different impact on the interruption lag as well as time spent on TMI which will change the load on the short term working memory. Hence, the following is proposed:

P2: TMI characteristics will have significant influence on performance through cognitive load.

What the SVR model fails to do is articulate some of the factors that may have an important role in interruption evaluation mechanism and task switching. That is, besides the inherent nature of interruptions that can lead to task switching, there are other factors that can change the evaluation of interruptions. For instance, high interest in the ongoing task (task characteristic), quick email or IM responsiveness as a social norm (environment factor), high involvement in task due technology interactivity (information presentation), or being goal oriented (individual characteristics) are factors that can influence a person's evaluation mechanism and can attenuate or intensify the predicted impact of interruptions. As a result, the permeability (the density of a filter to allow an attribute to pass through) of a filter is likely to get altered.

Effects of Task Characteristics

One factor that influences multitasking performance through its effect on cognitive load and interruption filtering is the on-going task(s') characteristics. For instance, task complexity, interest, importance, urgency, and processing novelty (whether the task is a new or automatic task) are such characteristics.

Given that multitasking requires continuous task switching, task characteristics are one of the major determinants of performance. For instance, cost associated with switching goes up with the complexity of task rules because it takes longer to retrieve complex set of rules after the goal is retrieved (Rubenstein et al., 2001). Moreover, task switching becomes harder when the decision maker switches from a complex set of rules to simple ones because of the difficulty in disengagement in to-be-abandoned tasks set (Allport, Styles, and Hsieh, 1994). In addition, task complexity, importance, and processing novelty require more resources to be allocated for the task which leaves little or no excess capacity (Kahneman, 1975).

Such task characteristics change the permeability (density) of the filters which allow interruptions to pass through. In particular, task characteristics may create a focus and attention shield which directs all cognitive capacity towards the task and acts as a block for the interruption. If the on-going task(s) can form a shield, then the decision maker’s focus will be on the primary task, and the interruption filter will get less permeable.

However, if the decision maker allows the interruption to pass through filters, either because the interruption task is perceived to be more important, valuable, urgent, or current task(s) is (are) overwhelming, trying to process new information in addition to the on-going task(s) is likely to overload the cognitive capacity. In that case, to process the interruption task, the cognitive capacity needs to be freed. As a result, some of the information will exit the working memory if the on-going task is not well rehearsed while sending it to LTM. Therefore, if decision makers face technology imposed task fragmentation, some resources may be taken away from the on-going task(s). Failure to allocate resources to allow rehearsal of an on-going task to assist future recall is likely result in information loss and performance deterioration. Based on the above arguments, we propose the following:

> *P3: Task characteristics will have a significant indirect influence on task performance through cognitive load.*

Effects of Information Presentation Format

Finneran and Zhang (2003) suggest that an activity needs to be divided into two components: the task or main goal of the activity and the artifact that assists the user in accomplishing the task by influencing focus and concentration. Therefore, one such artifact is the way information presented to the decision maker can change one’s ability to acquire and process information (Bettman and Kakkar, 1977). In particular, researchers have investigated various modes of information presentation such as graphical and color-enhanced (Benbasat, Todd, and Dexter, 1986), visual (Chau, Au and Tam, 2000), verbal (Childers, Houston, and Heckler, 1985), tables and graphs (Vessey, 1994), and the vividness and interactivity of the technology (Steuer, 1991).

Rather than a direct effect on the interruption filtering mechanism and performance, these information presentation characteristics are argued to influence primary task characteristics by improving or deteriorating the processing capability of the primary task. If these characteristics enhance the involvement, interest etc. in the primary task, then it will create (enhance) a strong shield to keep concentration on the task and will help activate rules.
Information presentation may therefore alter the susceptibility to changes in the environment and threshold to be interrupted. Therefore, permeability of the interruption filters will be influenced.

> *P4: The impact of task characteristics on task performance through cognitive load will be moderated by the information presentation characteristics.*

Effects of Decision Maker Characteristics

People also have individual differences in their ability to accommodate interruptions while they multitask (Braune & Wickens, 1986; Joslyn & Hunt, 1998; Morrin, Law, & Pellegrino, 1994). Therefore, decision maker characteristics (such as goal orientation, polychronicity, motivation, multitasking efficacy) are a major determinant of decision making in online environments. For instance, monochronic individuals, who possess a high degree of scheduling and promptness in meeting obligations and appointments (Frei, Raicot, and Travagline, 1998), tend to have low permeability in their filter mechanisms and are likely to ignore or postpone incoming interruptions. On the other hand, polychronic individuals who are comfortable with many projects at the same time (Frei et al., 1998), have a tendency to treat interruptions as equivalent to planned activities (Bluedorn et al., 1992). Similarly, goal oriented individuals or those who have started a top-down processing (with set goals to achieve) rather than bottom-up processing (with no set goals, data driven) (Lui, 2008) are expected to show the same attitude towards interruptions. Therefore, the permeability of the filters for such receivers is relatively low compared to monochronic receivers.

In addition, decision maker characteristics play a crucial role on task performance, both directly and through their influence on cognitive load. Experience and efficacy in a topic, issue, etc. has a direct impact on task performance (Mikhail, Walther, Beverly, and Willis, 1997; Bouffard-Bouchard, 1990). In addition, one's locus of control over the on-going task (via being goal oriented, highly motivated, self-regulated) has also an indirect impact on the on-going task performance (Phillips and Gully, 1997; Lee, Sheldon, and Turban, 2003). Such individual characteristics generate a strong block against a new task without completing the current one which reduces the permeability of interruption filters. However, in the absence of such characteristics, the decision maker will have tendency to attend an interruption and alter cognitive load. As argued earlier, failure to rehearse the on-going task(s) is likely to make it difficult to recall information. Hence:

P5: Decision maker characteristics will have a significant direct influence on task performance.

P6: Decision maker characteristics will have a significant indirect influence on task performance through cognitive load.

Social Environment Characteristics

Social environment characteristics are those attributes that are an artifact of the environment one is working in. For instance, social expectations of the organizational culture (Rennecker and Godwin, 2005) and time pressure in regards to responding tasks or TMIs play an important role in one's attentiveness to task at hand or one's perceived appropriate mode of response. Even though technology tools primarily serve to increase productivity, social environment characteristics may inadvertently contribute to creating interruptions and delays in the primary task (Rennecker and Godwin, 2005). As a result, social environment characteristics can create susceptibility to interruptions and increase the permeability of the filters.

Social environment characteristics also influence task performance through their impact on cognitive processing. These characteristics convey an implicit message to decision makers on whether to delay the primary task or disregard the incoming TMIs. In other words, they act to modify the urgency, importance, even relevance of the task or the interruption task by the implicit norms present in the organization. As a result, social environment characteristics will influence the decision maker whether or not to intake more information. If social environment signals high permeability of interruptions through the filters, the decision can get cognitively overloaded and may not be able to reactivate rules from short term working memory. Thus, social environment characteristics have a moderating effect on the influence of primary task on performance through cognitive load. Therefore:

P7: Social environment characteristics will have an indirect influence task performance through cognitive load.

Based on the above descriptions, we propose the following technology mediated interruptions model.

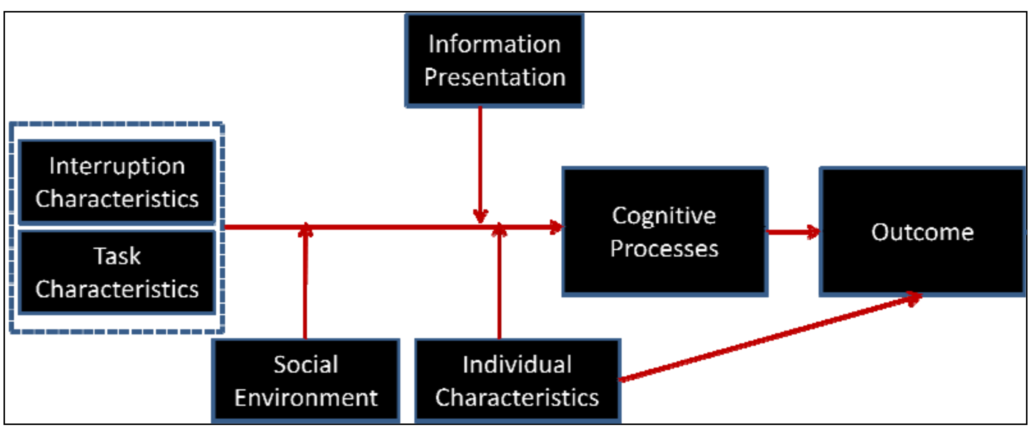

Figure 2. Model of Technology Mediated Interruptions (TMI)

RESEARCH DESIGN

The empirical investigation of the Interruptions Model (see Figure 2) will consist of two studies. In the first, a controlled laboratory experiment will be conducted with undergraduate students. The goal of the first study will be to test the relationship between order of task complexity, interruption frequency, and individual characteristics (multitasking computer self efficacy and interruption management self efficacy) on task performance. For this purpose, we simulate an environment where participants play the role of a project analyst making decisions based on information provided to them, and are exposed to high or low frequency of interruptions. Data analysis will utilize structural equation modeling (SEM).

The second study will be a laboratory experiment as well that utilizes a similar setting as study one where the impact task complexity, visual information presentation, interruption urgency and polychronicity on performance is evaluated. This study simulates an environment where participants are part of a virtual team where they need to analyze their teammates. Depending upon the treatment, participants are exposed to interruptions. Similarly, data analysis will employ structural equation modeling (SEM).

<u>Task and Procedures:</u> Subjects will be briefed on the procedures of the experiment and participate in an initial sample assessment that gathers basic demographic information. Next, subjects will be randomly assigned to one of the treatments. The students will then be given a scenario that was designed to expose them to their role in the situation, and increase realism of the experience. After exposure to the treatment subjects will complete a survey instrument.

<u>Instruments and Measures:</u> The development of the psychometric instruments to measure the constructs in the Interruptions Model attended to the following process; item generation, factor analysis, reliability analysis, and validity analysis. Two separate and independent samples were used in this process. An exploratory data analysis was performed on the first sample, and the second sample was used to confirm the results of the first sample (Byrne 2006). The first sample of 157 undergraduate students was used for exploratory analysis, and a second sample of 257 undergraduate and graduate students were used to confirm the results of the first sample. Results indicate that the instrument meets acceptable parameters for validity and reliability and therefore has shown to be psychometrically sound.

<u>Pilot Studies:</u> One pilot study, beyond those used for the development of the measurement instruments, has been conducted for the two studies. A short summary of the results of these studies are presented in Appendix A. Data analysis was conducted using MPlus 4.0 and SPSS 15.0.

CONCLUSION

In resolving the research questions listed, this proposed dissertation provides a conceptual model that outlines an individual's systematic evaluation of interruptions, and also integrates the effects of interruptions, along with other identified factors, on task performance. This research is, to our knowledge, the first to formally explain the evaluation of interruptions and task switching in high task fragmentation environments. Overall, this proposed dissertation contributes to the literature by providing a theoretical explanation for technology mediated interruption attendance and its influence on task performance.

This research also has practical importance. First, it highlights the need to create worker awareness of the effect of interruptions. Second, this work can provide insights on how knowledge workers and supervisors may best manage interruptions and task-switching in the workplace. Finally, the research also has implications for systems design, providing guidance for designers who want to minimize the effect of interruptions thus minimizing expensive human errors and their costs (McFarlane, 1999) by creating a more effective environment and presentation of information that can help decision makers remain appropriately focuses on necessary tasks.

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