Examiner the Impacts of Information Technology Interruptions on Individual and Group Performance: Does Interruption Type Matter?

Shamel Addas
Information Systems Area
Desautels Faculty of Management
McGill University, Montreal

December 2012

A thesis submitted to McGill University in partial fulfillment of the requirements of the degree of PhD

©Shamel Addas 2012
TABLE OF CONTENTS

Contents
ACKNOWLEDGEMENTS........................................................................................................................................6
CONTRIBUTION OF AUTHORS.........................................................................................................................8
THESIS ABSTRACT .............................................................................................................................................8
RÉSUMÉ THÈSE ..................................................................................................................................................9
CHAPTER I. A THREE-ESSAY DISSERTATION ON THE INDIVIDUAL AND GROUP-LEVEL IMPACTS OF IT INTERRUPTIONS: A Summary.................................................................................................................................11
INTRODUCTION AND MOTIVATION FOR THE DISSERTATION ..........................................................................11
OVERVIEW OF ESSAY 1 – THE MANY FACES OF IT INTERRUPTIONS: A TAXONOMY AND PRELIMINARY INVESTIGATION OF THEIR PERFORMANCE EFFECTS ...........................................................................................21
  Theoretical Development ................................................................................................................................21
  Methodology ......................................................................................................................................................22
  Key Findings ...................................................................................................................................................22
OVERVIEW OF ESSAY 2 – EMAIL INTERRUPTIONS AND TASK PERFORMANCE: A TALE OF TWO INTERRUPTION TYPES ..................................................................................................................................25
  Theoretical Development ...............................................................................................................................25
  Methodology ..................................................................................................................................................26
  Key Findings ................................................................................................................................................27
OVERVIEW OF ESSAY 3 – IT INTERRUPTIONS AND COORDINATION EFFECTIVENESS IN SOFTWARE DEVELOPMENT GROUPS: A CONCEPTUAL, MULTILEVEL MODEL ......................................................................................29
  Theoretical Development ................................................................................................................................29
  Key Findings ..................................................................................................................................................30
REFERENCES ....................................................................................................................................................32
CHAPTER II (ESSAY #1). THE MANY FACES OF INFORMATION TECHNOLOGY INTERRUPTIONS: A TAXONOMY AND PRELIMINARY INVESTIGATION OF THEIR PERFORMANCE EFFECTS ..............................................38
  ABSTRACT.......................................................................................................................................................38
  INTRODUCTION AND MOTIVATION ..................................................................................................................38
  CONCEPTUALIZATION AND TAXONOMY OF IT INTERRUPTIONS ......................................................................42
    Conceptualization of IT Interruptions .............................................................................................................42
    Taxonomy of IT Interruptions .........................................................................................................................44
ACKNOWLEDGEMENTS

I would like to acknowledge the role of several people who helped me complete this dissertation. First, I am indebted to my supervisor, Alain Pinsonneault, from whom I learned a great deal. Alain never ceased to amaze me with his ability to provide critical feedback that has always been right on track. While I did not always see it at first, my dissertation improved significantly after each iteration because of Alain’s help. I benefited tremendously from Alain’s expertise, guidance, and support.

I would also like to recognize the role of the faculty members of my committee, Liette Lapointe, Suzanne Rivard, and Omar El Sawy. Liette provided me with good advice on qualitative research design, an area I had very little experience in. Suzanne’s feedback during my proposal defense about how to narrow down the scope of the dissertation provided just the right nudge to push me in the right direction. Omar played the role of therapist during this rugged journey. He always kept in touch to see how I was progressing, pushed me to finish, and provided elegant advice about how to handle the different stages. I appreciate all those emails I received with the title “Khalast?” (translation: “Did you finish?”).

My thanks also go out to several people within the Joint PhD Program. Mary Dean Lee helped me improve my qualitative research design skills with her great course and welcoming support outside of the classroom. Ulrike de Brentani welcomed me in her office despite her busy schedule and even though we never had any prior or subsequent contact. She offered me valuable advice on survey design and even shared her own survey. I would also like to thank all the faculty members at McGill and the Joint Program for being a part of this learning experience. And to my fellow PhD students Mazen, Wissam, Elisa, Yasser, Moataz, Kyung, Salman, Jing,
Saeed, Momin, Hani, and other students at McGill and the Joint Program: Thank you for making this a pleasant, friendly, and collegiate environment.

I am also grateful to the many “external” people who helped me collect data for my qualitative and quantitative studies. This includes all the anonymous informants and respondents who participated in my research. In particular, I would like to thank the third-party data collection company that helped with the survey, and which provided superb service and professional support.

I also feel very lucky to have joined IESEG during my final stages of the PhD. My new colleagues at IESEG welcomed me and supported me at a time when I had “the PhD blues” and lots of worries about the job market. And a special thanks to Stefan Creemers for his magic touch in helping to code my survey.

Finally, and most important, I would like to thank my family for their unrelenting love and support. To my beautiful wife Joyce: I know that I did not succeed in getting you to read more than a couple of pages of my thesis without you getting bored. This bugged me a bit at first. However, I soon realized that I was chasing the wrong dependent variable. What was much more important to achieve was to get your unconditional support and motivation to help me through this difficult journey. And this I definitely succeeded in getting from you! I really believe that I could not have gone through this without you.

To my daughter Yasmina: You were born right before my proposal defense and since that day, you continue to brighten my life every day. When you were born, I made a vow not to let the PhD eat up our time together. I succeeded most of the time. For the times I did not, my consolation for spending time away from you is that I was doing something that I hope will make you proud one day.
To my son we are expecting in July 2013: we cannot wait for you to arrive and complete our family. Your arrival is perfectly timed with the ending of my PhD journey. You were in my thoughts as I was wrapping up the last pieces of this PhD.

To my parents: As always, you were present in the background providing me with a steady boost of support and prayers that I badly needed to be able to go through this. To my brother: Thanks for the sound and pragmatic advice you provided to me whenever I needed it. You also helped reduce much of the uncertainty I initially had about joining the PhD program.

CONTRIBUTION OF AUTHORS

For all three essays of the dissertation, Shamel Addas acted as the first author and Alain Pinsonneault acted as the second author. The main contribution of the first author was to write the manuscripts in their entirety. Several draft versions were generated from the three essays. Alain Pinsonneault reviewed all draft versions of the manuscripts and provided pertinent feedback to the first author about how to improve the content and structure of the papers.

THESIS ABSTRACT

Despite the widespread occurrences of information technology (IT) interruptions in the workplace – defined as perceived, external events that are induced by or mediated by IT, with a range of content that captures cognitive attention and breaks the continuity of primary task activities – this phenomenon has received scant attention in the extant research. This dissertation aims at explicating the nature of IT interruptions and examining their impacts on the performance of individuals and groups. The dissertation comprises three essays, each addressing one of the following questions: (1) What are the different types of IT interruptions, and how does each type affect individual performance? (2) What are the cognitive and behavioral performance impacts of email interruptions? What are the moderating and mediating effects that shape these relationships? (3) What are the group-level effects of IT interruptions? The main premise is that variations in individual and group performance are associated with the type of IT interruption faced by individuals as they conduct their work. Whereas much of the prior literature has conceptualized IT interruptions as a monolithic, mostly negative phenomenon, this dissertation develops a taxonomy
of different interruption types and shows how the distinct types exhibit performance effects that range from positive to negative. The first essay develops a taxonomy of IT interruptions with help from a multidisciplinary review of the work interruptions literature. This essay also develops propositions that link each interruption type with performance measures for individuals working in project environments. A qualitative inquiry comprising 21 in-depth, semi-structured interviews with team members from eight new product development organizations is conducted. The results provide preliminary support for the taxonomy and propositions in addition to uncovering a third type – “hybrid IT interruptions” – with its distinct performance effects. The second essay deepens our understanding about the impacts of IT interruptions on individual performance by proposing a model that focuses on the mediating and moderating factors. Drawing upon theories of cognitive psychology (cue utilization theory and mindfulness theory), it is posited that subjective workload and mindfulness fully mediate the effects of email intrusions and email interventions on performance, respectively. The model is tested with 365 sales professionals working in the business-to-business industry. Results support the full mediation model and show that there are compensating mechanisms that help reduce the negative effects on performance. The third essay is a conceptual paper that examines the impacts of IT-triggered interruptions at the group level. Drawing on coordination theory, it is proposed that IT interruptions are initially experienced at the individual level, but create multilevel effects as a result of interdependencies among group members’ tasks. On one hand, intrusions debilitate group coordination effectiveness and these effects can be mitigated by exercising task organization coordination. On the other hand, interventions enhance coordination effectiveness by leveraging group problem-solving coordination mechanisms. Overall, this dissertation enhances our understanding of IT interruption and the effects of different types of interruptions on individual and group-level outcomes.

RÉSUMÉ THÈSE

Malgré la fréquence et l’ampleur des interruptions des technologies de l'information (TI) au travail – définies comme des événements causés ou transmis par les TI qui captent l'attention cognitive et rompent la continuité d'une tâche primaire – ce phénomène a fait jusqu'ici l'objet de peu d'attention dans les travaux actuels de recherche. La thèse explique la nature des interruptions des TI et examine leurs effets sur la performance des personnes et des groupes. La thèse est composée de trois articles, chacun étant consacré à l'une des questions suivantes : (1) Quels sont les différents types d’interruptions des TI et comment chaque type influence-t-il la performance individuelle ? (2) Quels sont les effets cognitifs et comportementaux d’interruptions par courriel ? Quels sont les effets de médiation et de modération de certains facteurs cognitifs sur la performance individuelle ? (3) Comment les interruptions influencent-elles la performance d’un groupe ? Selon l'hypothèse de base, les fluctuations de la performance individuelle et collective sont associées au type d'interruptions des TI auxquelles font face les individus dans le contexte de leur travail. Alors que la plupart des recherches ont conceptualisé les interruptions des TI comme un phénomène monolithique et négatif, la thèse élabore une taxonomie des différents types d'interruptions et montre comment ces types produisent des effets sur la performance qui peuvent être positifs ou négatifs. Le premier article élabore une taxonomie des interruptions des TI à l'aide d'un examen pluridisciplinaire des études sur les interruptions de travail. Cet article comprend également des propositions servant à établir un lien entre chaque type d'interruptions et la performance des individus travaillant dans des équipes de projets. Nous avons mené une enquête qualitative se composant de 21 entrevues semi-structurées auprès de membres d'équipes dans huit organisations.
de développement de nouveaux produits. Cette étude offre un support préliminaire à la taxonomie et aux propositions. De plus, nous avons dégagé un troisième type (les « interruptions technologiques hybrides ») qui exerce des effets particuliers sur la performance. Le deuxième article approfondit notre compréhension au sujet des impacts des interruptions des TI sur la performance individuelle en proposant un modèle qui met l'accent sur les facteurs de médiation et de modération qui façonnent ces relations. En nous appuyant sur les théories de la psychologie cognitive, nous postulons que la charge de travail subjective et l’attention (« mindfulness ») produisent une médiation entre les différents types d'interruptions par courriel et la performance. Une enquête empirique auprès de 365 professionnels commerciaux travaillants dans le secteur des ventes a été conduite. Les résultats soutiennent le modèle de médiation et montrent que certains mécanismes de compensation aident à réduire les effets négatifs sur la performance. Le troisième article consiste en une analyse conceptuelle où sont examinés les impacts des interruptions des TI à un niveau collectif. En s’appuyant sur la théorie de la coordination, on postule que les interruptions des TI sont ressenties au départ à l’échelle individuelle, mais qu’elles entraînent des effets à un niveau collectif en raison des interdépendances qui existent entre les tâches des membres du groupe. D’un côté, les intrusions affaiblissent l’efficacité de la coordination du groupe, mais ces effets peuvent être atténués par la coordination de l’organisation des tâches. D’un autre côté, les interventions renforcent l’efficacité de la coordination en accentuant l’effet des mécanismes de coordination des efforts de résolution de problèmes du groupe. Globalement, cette thèse permet de mieux comprendre les interruptions des TI et les effets de différents types d’interruptions de la technologie sur les performances individuelles et sur celles des groupes.
CHAPTER I. A THREE-ESSAY DISSERTATION ON THE INDIVIDUAL AND GROUP-LEVEL IMPACTS OF IT INTERRUPTIONS: A SUMMARY

INTRODUCTION AND MOTIVATION FOR THE DISSERTATION

Information technology (IT) interruptions can be described as perceived, IT-based external events with a range of content that captures cognitive attention and breaks the continuity of an individual’s primary task activities (Addas & Pinsonneault 2010). For many years, such interruptions have captured the attention of both scholars and practitioners. Indeed, while IT is increasingly used to facilitate interactions among individuals and collectives, a byproduct of such technology usage is the interruption of task activities (McFarlane 2002; Speier et al. 1997). Extant research points out that the average cluster of uninterrupted work time is roughly 11 minutes (Mark et al. 2005), and that 10 minutes of each hour are consumed by interruptive activities (O'Conaill & Frohlich 1995). Interestingly, more than half of the interruptions experienced are irrelevant to primary task activities and in almost half of the time the interrupted activities are not resumed (Mark et al. 2005; O'Conaill & Frohlich 1995). IT is a main contributor to such interruptions, with over 70% of instant messaging users reporting interrupting their coworkers (Garrett & Danziger 2008), and knowledge workers reporting over 70 interruptions from email on average each day that take over a minute each from which to recover (Jackson et al. 2003). Together, these findings indicate that IT interruptions are a very important phenomenon to study.

Extant research on IT-mediated interruptions is abundant and covers several areas such as interruptibility, interruption coordination strategies, preparatory practices for interruptions, and interruption effects. First, we know from interruptibility research that some moments are better
than others for interruptions from the interruption target’s perspective such as at subtask boundaries when cognitive loads have been released (Adamczyk & Bailey 2004; Bailey et al. 2001). Indeed, studies comparing interruptions at subtask boundaries to random interruptions found that the former result in reduced levels of annoyance (Adamczyk & Bailey 2004; Iqbal & Bailey 2005), frustration (Adamczyk & Bailey 2004; Bailey et al. 2001), anxiety (Bailey et al. 2001) and time pressure (Adamczyk & Bailey 2004), in addition to enhancing memory recovery (Edwards & Gronlund 1998) and respect (Iqbal & Bailey 2005). From the interruption source’s perspective, research on awareness display systems shows that such systems better regulate interruptions and improve joint performance outcomes (Dabbish et al. 2007; Dabbish & Kraut 2004; Dabbish & Kraut 2008; France et al. 2005; Ho & Intille 2005).

Second, research on interruption coordination examines strategies employed by individuals to decide about whether and when to respond to the interruptions. A taxonomy developed in one seminal study in this area identifies four interruption responses: immediate, negotiated, scheduled, and mediated (McFarlane 2002). Researchers building on this framework found negotiated interruptions to trigger the least deleterious effects on performance (Gievska et al. 2005; Gievska & Sibert 2004; McFarlane 2002). Such negotiated interruptions are further distinguished with respect to different levels of control exhibited such as oblivious dismissal, unintentional dismissal, intentional dismissal, preemptive integration, and intentional integration (Latorella 1999).

Third, IT-mediated interruptions research drawing on cognitive psychology recognizes that there is a window of opportunity during which individuals can exercise cognitive practices that help with task resumption and mitigate the negative effects of the interruptions. More specifically, during the time lag between the interruption alert (e.g., pop-up signaling email
arrival) and the interruption proper (e.g., interrupting primary activity to read, respond to, or act upon the email), individuals may exercise two practices to better prime their memories: goal rehearsal (rehearsing details of the primary tasks) and associative priming (linking them to cues in the environment) (Altmann & Trafton 2002). Such task activation practices improve memory recovery from the interruption and enhance task resumption performance (Cades et al. 2007; Iqbal & Horvitz 2007; Monk et al. 2004b; Ratwani et al. 2007; Trafton et al. 2005).

Finally, a large stream of interruptions research focuses on the effects of interruptions on individual task performance. Most of this research associates interruptions with detrimental consequences such as negative emotional responses (Bailey et al. 2001; Zijlstra et al. 1999), cognitive overload (van den Berg et al. 1996), longer task completion times (Cutrell et al. 2001; Speier et al. 1997), higher error rates (Bailey & Konstan 2006; Kapitsa & Blinnikova 2003), and decreased productivity (Perlow 1999). The aggregate cost of such interruptions in the US economy alone has been estimated at $588 billion annually (Spira & Feintuch 2005). Nevertheless, another – albeit much smaller – body of evidence in this area has identified positive performance effects from IT interruptions such as enhanced task accuracy (Ang et al. 1993), improved idea generation performance (Jung et al. 2010), and better investment decisions (Earley et al. 1990).

Despite these important contributions in various areas related to IT interruptions, much remains unknown about this phenomenon. Specifically, there are knowledge gaps with respect to (1) the actual nature of IT interruptions; (2) the effects of IT interruptions on performance. First, the construct of interruptions has been conceptualized loosely in the extant research. Indeed, much of the literature on interruptions does not provide a definition of this concept (see Appendix 1 in Essay #1). This is problematic because without clear definitions, interruptions in
one study may have evoked events that are entirely different from interruptions examined in another study. Another consequence of this lack of a systematic conceptualization is that IT interruptions are not distinguished from other work interruptions and are implicitly present in much of the extant research (e.g., Adamczyk & Bailey 2004; Altmann & Trafton 2007; Bailey et al. 2001; Cutrell et al. 2001; McDaniel et al. 2004; McFarlane 2002). This is unfortunate because particular properties of the technology can influence the way interruptions are experienced and managed. For example, individuals may behave differently with respect to email interruptions and face-to-face interruptions as a result of email’s asynchrony, which provides some control over whether and when to respond (Barley et al. 2011; Iqbal & Horvitz 2007). Moreover, interruptions have been conceptualized mostly as indistinguishable events that break the continuity of a primary task, without a clearly specified content (e.g., Adamczyk & Bailey 2004; Altmann & Trafton 2007; Bailey et al. 2001; Basoglu et al. 2009; Cades et al. 2007; McFarlane 2002). However, some researchers suggest that explicitly examining the content of the interruption may be important for differentiating its effects on performance (Jett & George 2003; Speier et al. 2003).

Second, the vast majority of research investigating the impacts of interruptions has been conducted in laboratory settings. Such research designs have achieved a fine-grained handle on the phenomenon and produced results with high internal validity. For example, experimental studies identified specific temporal characteristics of the interruption – such as frequency, duration, and timing – that directly or indirectly influence cognitive load and task performance (Gievska et al. 2005; Monk et al. 2008; Cutrell et al. 2001). However, the experimental approach is less suitable for explaining interruptions that occur in real-life situations. Specifically, the extant research has involved interruptions of brief durations and has focused on singular,
isolated, artificial activities that have no real consequences to the individual outside of the laboratory environment (e.g., Adamczyk & Bailey 2004; Cutrell et al. 2001; Cutrell et al. 2000; Czerwinski et al. 2000; Dabbish & Kraut 2004; McFarlane 2002; Speier et al. 1997). More research is needed to examine interruptive events that occur in their organizational settings and that have bearing on individuals’ real work environment.

Third, the results of empirical research on the effects of IT interruptions on cognitive and behavioral task outcomes are equivocal. The overwhelming majority of such research focuses on the negative impacts (e.g., Adamczyk & Bailey 2004; Bailey et al. 2001; Basoglu et al. 2009; Burmistrov & Leonova 1996; Cades et al. 2007; Dodhia & Robert 2009; Einstein et al. 2003; Eyrolle & Cellier 2000; Gievska et al. 2005; Gillie & Broadbent 1989; Hodgetts & Jones 2006b; Iqbal & Horvitz 2007; McDaniel et al. 2004; McFarlane 2002; Monk et al. 2008; Oulasvirta & Saariluoma 2004; Ratwani et al. 2007), and some operationalize interruptions using terms with negative connotations such as disruptions (Carton & Aiello 2009; Weisband et al. 2007) and stressors (Speier et al. 2003). While a small number of studies have identified positive consequences of interruptions (e.g., Ang et al. 1993; Jung et al. 2010; Robertson et al. 2004), there have been no attempts – to the author’s knowledge – to explicitly examine factors that differentiate the positive and negative effects (e.g., interruption types; mediating factors). Hence, little explanation is provided for the mixed results.

Finally, the impacts of interruptions are studied mostly at the individual level and research at the group level is virtually non-existent. However, this is somewhat removed from reality because contemporary work contexts rarely involve interruptions to individuals that work on their tasks in an isolated fashion. Instead, interruptions frequently occur as part of interactions between individuals working on interdependent tasks in group and/or project contexts.
In short, more work is needed to better understand the phenomenon of IT interruptions and its impacts on cognitive and behavioral outcomes. This dissertation addresses these gaps. The approach we follow is that by better specifying the concept of IT interruptions, we can gain a deeper understanding of the impacts of IT interruptions at the individual and group levels. It is thus argued in this dissertation that the equivocal empirical findings are due in part to the lack of a clear conceptualization of IT interruptions that allows us to map the distinct performance effects of various interruption types. Also, it is important to consider the role of the IT because IT interruptions can be different from other interruptions (e.g., IT may induce or mediate the interruption; specific properties of IT such as asynchrony can change the way individuals experience and manage the interruptions). The following research questions are posed in the dissertation:

1. What are the different types of IT interruptions, and how does each type affect individual performance?

2. What are the cognitive and behavioral performance impacts of email interruptions? What are the moderating and mediating effects that shape these relationships?

3. What are the group-level effects of IT interruptions?

These questions are addressed in this dissertation, which develops a framework of IT interruptions that organizes interruptive events along two dimensions: (1) the direction of attention allocation based on the interruption’s content relevancy to primary task activities; (2) the specific content of the interruption. The main premise is that different IT interruption types exhibit distinct effects on performance at the individual and group levels. Building on the
literature on work interruptions (e.g., Jett & George 2003), two main types of IT interruptions are identified: IT intrusions and IT interventions. On one hand, intrusions divert attention from the primary task activities and exhibit negative cognitive and behavioral effects on performance. On the other hand, interventions refocus attention on the primary task activities and improve its performance by providing task-critical information that motivates corrective action. Furthermore, IT intrusions can be distinguished with respect to four interruption subtypes: informational, communicational, actionable, and system intrusions. Similarly, three subtypes of IT interventions can be identified: informational, communicational, and actionable interventions. A third type of IT interruptions, which is a hybrid of intrusions and interventions, is also identified in this dissertation based on an inductive analysis of individuals working in project environments. Such hybrid interruptions are posited to exhibit positive and negative effects on performance.

Our framework of IT interruptions is partly validated through qualitative field studies of individuals in project teams involved in product development activities (Essay #1) as well as a large-scale empirical survey of 365 sales professionals (Essay #2). This hybrid research design is suitable for testing our phenomenon of interest since the theory developed can best be described as intermediate (Edmondson & McManus 2007). More specifically, this research draws on insights from separate, mature research areas, but presents them in a new way to develop a framework of IT interruptions. It also generates some hypotheses deductively and others inductively. Hence, a blend of qualitative and quantitative methods strengthens confidence in the conclusions generated from this research.

This dissertation is organized as follows. The first essay in this dissertation develops a framework of IT interruptions based on the multidisciplinary interruptions literature. To deepen our understanding about IT interruptions, the essay relates each of the various interruption types
and subtypes to individual performance in a project environment. It thus addresses the first research question. The second essay further explores the impacts of IT interruptions on individual performance by focusing on one technology that is especially representative of interruptions (email) and examining the mediating and moderating factors. It thereby addresses the second research question. The third and final essay develops a conceptual model of the multilevel impacts of IT interruptions, which addresses the third research question. The organizing framework for the dissertation is shown in Figure 1. A summary of the three essays is shown in Table 1. The remaining sections of the dissertation describe the theoretical development, method, and key findings of the various essays. The completed drafts of each essay are then presented. The dissertation concludes by highlighting the main contributions of this research and providing suggestions for future research.
Figure 1: Organizing Framework for Dissertation

Table 1: Summary of Multi-Essay Dissertation

<table>
<thead>
<tr>
<th>Research question</th>
<th>Essay #1</th>
<th>Essay #2</th>
<th>Essay #3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>What are the different types of IT interruptions and how does each type affect individual performance?</td>
<td>What are the cognitive and behavioral performance impacts of email interruptions? What are the moderating and mediating effects that shape these relationships?</td>
<td>What are the group-level effects of IT interruptions?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Theory</th>
<th>Essay #1</th>
<th>Essay #2</th>
<th>Essay #3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jett &amp; George’s (2003) work interruption types</td>
<td>Jett &amp; George’s (2003) work interruption types</td>
<td>Jett &amp; George’s (2003) work interruption types</td>
</tr>
<tr>
<td></td>
<td>Cue utilization theory and</td>
<td>Cue utilization theory and</td>
<td>Coordination theory</td>
</tr>
<tr>
<td>Method</td>
<td>Qualitative inquiry: semi-structured interviews with 21 individuals from the NPD units of eight organizations</td>
<td>Cross-sectional survey of 365 sales professionals from various industries</td>
<td>Conceptual study focusing on teams in the software development context</td>
</tr>
<tr>
<td>--------</td>
<td>----------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Key findings | • IT intrusions and interventions and their subtypes supported by the data  
• A new type of hybrid interruption emerges  
• Diverse effects of the IT interruption types on performance | • Subjective workload fully mediates between IT intrusion intensity and individual performance  
• Mindfulness fully mediates between IT intervention intensity and individual performance  
• Perceived control and multitasking self-efficacy compensate for the negative effects | • The effects of IT intrusions ripple through to debilitate group coordination effectiveness (this is mitigated through task organization coordination) while IT interventions enhance group coordination effectiveness via group problem-solving coordination |
OVERVIEW OF ESSAY 1 – THE MANY FACES OF IT INTERRUPTIONS: A TAXONOMY AND PRELIMINARY INVESTIGATION OF THEIR PERFORMANCE EFFECTS

Theoretical Development

The first essay seeks to develop and preliminarily validate a conceptualization of IT interruptions that can be used as a basis for further theoretical development and empirical investigation. Based on a literature review of the HCI, Psychology, Management, IS, and Medical Informatics fields, IT interruptions are defined as perceived, IT-based external events with a range of content that captures cognitive attention and breaks the continuity of an individual’s primary task activities. Building upon the concept of work interruptions (Jett & George 2003), two types of IT interruptions are developed: IT intrusions (external events that are unrelated to – and that divert attention from – an individual’s primary task activities) and IT interventions (external events that direct attention to a discrepancy between expected and actual task performance). This conceptualization is further expanded by developing subcategories of interruption content. For IT intrusions, the following subtypes are identified from the review: informational intrusions (e.g., status updates; pop-up notifications), communicational intrusions (e.g., information requests; online discussions), actionable intrusions (e.g., switching to personal tasks), and system intrusions (e.g., IT breakdowns). For IT interventions, the following subtypes are identified: informational, communicational, and actionable interventions.

To deepen our understanding about IT interruptions, the first essay also relates some of the different interruption types and subtypes to the performance of individual project team members. More specifically, drawing on cue utilization theory (Easterbrook 1959; Kahneman 1973) and the notion of mindfulness (Langer 1989; Louis & Sutton 1991), initial propositions are
developed and tested that suggest distinct performance effects by some of the disparate IT interruption types and subtypes.\(^1\) Some propositions (the ones on IT intrusions and interventions) are developed deductively, while others (the ones on hybrid interruptions) are developed inductively through evidence from a qualitative inquiry.

**Methodology**

The taxonomy of IT interruptions and the proposed performance effects are partially validated via a qualitative inquiry of individual team members working in new product development (NPD) environments. Semi-structured interviews are conducted with 21 individuals from the NPD units of eight organizations. The data analysis follows an analytic induction approach (Patton 2002) where the framework and propositions are first tested deductively with qualitative evidence. Then, new insights from the data yield an additional category of technology interruptions (hybrid interruptions) and new propositions are developed that relate this interruption type to performance.

**Key Findings**

Concerning the taxonomy of IT interruptions, all IT interruption subtypes are supported by the data. With respect to the effects of various IT interruption subtypes on performance, the results are consistent with our theoretical propositions. System intrusions are perceived as detrimental to performance efficiency by consuming additional project time. This *structural* effect occurs primarily through three interrelated patterns: (1) increasing task completion time;

\(^1\) While we develop a taxonomy of seven IT interruption subtypes (in addition to three hybrid subtypes that are developed inductively), propositions are presented for only some *extreme* subtypes from the taxonomy as a way to provide a preliminary test for the framework.
(2) task/project delays; (3) task blocking. Additionally, the data reveal that actionable intrusions also debilitate performance efficiency by incurring temporal switching costs (switching attention between the primary task activities and the unrelated intrusions). This cognitive effect may accumulate over the individual’s project work over time, over chains of activities, over interruptions phases, and across tasks. Also, actionable intrusions are found to be detrimental to quality and learning.

Actionable IT interventions also behave as expected by debilitating efficiency in terms of project time while enhancing quality and learning. Two patterns are observed for the detrimental effects: increased task completion time, and task/project delays. Quality is improved by interrupting individuals’ ways of working and triggering a more mindful information processing mode. In particular, three primary mechanisms associated with such mindfulness are salient: (1) an informational mechanism; (2) a motivational mechanism; (3) a reflective mechanism. Finally, actionable interventions enhance learning primarily when NPD project members used bug tracking tools as a knowledge repository and/or as a troubleshooting guide.

The data also reveal a new type of hybrid interruption that – while having different content from the primary task – is related to the focal project or to other development projects individuals are involved in, and hence, falls within their overall project portfolio. The performance effects of this hybrid category of interruptions entail tradeoffs between efficiency and learning. The learning component is a result of the discrepancy, which opens up a window of opportunity during which individuals learn how to resolve the problem. Additionally, learning is enhanced because of cross-learning effects. Hybrid interruptions also exhibit both beneficial and detrimental effects on quality. On one hand, they allow project members to gain access to new insights and knowledge that can be integrated into their primary tasks and across projects in a
way that enhances an individual’s contribution to the quality of product deliverables. However, having to split one’s attention between the primary task and other tasks within the project portfolio can lead to attentional residues that elicit cognitive overload and negatively affect performance efficiency and effectiveness.

Overall, the findings from the first essay contribute to the literature by developing a new framework of IT interruptions that improves our understanding about this phenomenon and its potential consequences on performance. This essay also demonstrates the value of differentiating among the different types and subtypes of IT interruptions. Finally, the framework can help practitioners tailor managerial policies and interventions depending on the specific interruption types they need to deal with.
OVERVIEW OF ESSAY 2 – EMAIL INTERRUPTIONS AND TASK PERFORMANCE: A TALE OF TWO INTERRUPTION TYPES

Theoretical Development

The second essay further investigates the performance effects of the IT interruptions from the taxonomy that is developed and preliminarily validated through the first essay. The second essay focuses on one type of technology (email) and a subset of the taxonomy from the first essay (the two interruption types of intrusions and interventions without going to the level of the subtypes). This approach provides a clear focus and allows us to contextualize the phenomenon by identifying specific factors related to email interruptions that shape the relationship between email interruptions and the cognitive and behavioral performance outcomes.

Drawing upon two complementary psychological theories of attention allocation, the second essay develops and tests an empirical model that examines the direct and indirect effects of email interruptions on task performance in a sales context. Specifically, it is suggested that different types of email interruptions have distinct effects on performance by leveraging different attention-allocation mechanisms that enhance or inhibit performance. The attention-allocation mechanisms that enhance or inhibit performance are derived from cue utilization theory and mindfulness theory, respectively. The inhibiting effect of email intrusions (interruptions that are unrelated to primary task activities) is due to shrinkage in the range of cue utilization as a result of the increased – and often competing – attentional demands triggered by the intrusions (Easterbrook 1959). This increases cognitive switching costs and debilitates performance efficiency and effectiveness (Easterbrook 1959; Kahneman 1973; Speier et al. 1997).

Additionally, we draw upon mindfulness theory to suggest that email interventions (interruptions that are directly related to primary task activities) introduce novelty and discrepancy in the task
environment, which motivates *mindful* states of cognitive processing (Langer 1989; Louis & Sutton 1991). This stimulates individuals to redirect attention to the problem source, recognize the need for change, and subsequently improve performance.

In addition to these disparate attention allocation mechanisms, which we argue mediate between email interruptions and task performance, two important moderating factors emanating from the asynchronous nature of email are identified. First, perceived control is introduced as an important mitigating factor because of the tradeoffs between email’s asynchrony, which affords control, and the social factors surrounding email use that limit such control (e.g., the compulsion to respond). Second, email’s asynchrony also provides more opportunity and flexibility for coordinating the interruption response via task interleaving (Barley et al. 2011), especially when compared to more synchronous media (Aral et al. 2006). Hence, multitasking self-efficacy is included as a second moderating factor that mitigates the negative impacts of email intrusions.

**Methodology**

The research model is tested via a cross-sectional field study design using a web-based survey technique. This design provides greater confidence in the validity and generalizability of the taxonomy developed in the first essay. The measurement instrument is developed using a rigorous process (MacKenzie et al. 2011). Content validity is assessed via two rounds of card-sorting analysis with academic expert panels (Moore & Benbasat 1991), in addition to the pre-testing of the final instrument with sales experts in the field. Screening questions are included in the survey to enhance response quality and reduce sampling error. The target population is North American business-to-business (B2B) salespersons selling products/services with a relatively quick turnaround. A reputable data collection company specializing in B2B research was
recruited to collect the data. The final data set includes 365 respondents. The data are analyzed using the partial least square (PLS) technique.

**Key Findings**

The empirical results show that email intrusion intensity has an indirect effect on individual task performance. Consistent with cue utilization theory, the negative effect is fully mediated by subjective workload. Similarly, email interventions are found to enhance individual task performance indirectly via mindfulness.

In line with the hypotheses, perceived control is found to moderate the relationship between email intrusions intensity and individual task performance. However, no such moderation effect is found on subjective workload. Instead, perceived control directly reduces subjective workload. Similarly, multitasking self-efficacy is found to exhibit a direct negative effect on subjective workload rather than the hypothesized moderation effect. The existence of these direct effects may be explained by the specific nature of the interaction being non-multiplicative, or due to the perception of control acting as a psychological mechanism that independently reduces workload (Aiello & Svec 1993; Glass & Singer 1972).

Surprisingly, perceived control has a direct negative effect on mindfulness. This can be explained by the fact that individuals with high perceived control are likely to develop a feeling of certainty over their outcomes, which impels them to switch to a mindless information processing mode (Brown & Langer 1990; Langer 1992). Another explanation may be that the less control over their social circumstances, the more mindful individuals become because they perceive email as a socially-delivered, explicit request for attention.
Overall, strong support is found for the main hypotheses positing differential effects of the two interruption types. These findings contribute to the extant literature on IT-mediated interruptions by identifying the disparate performance effects of email interruptions. Additionally, the findings help explain some of the mixed effects of interruptions because they show that the positive and negative effects occur as a result of differences in interruption types. Finally, by drawing on two complementary theories on attentional allocation, this essay shows the mediating mechanisms by which email interruptions enhance or impede individual performance, in addition to some compensating mechanisms.
OVERVIEW OF ESSAY 3 – IT INTERRUPTIONS AND COORDINATION EFFECTIVENESS IN SOFTWARE DEVELOPMENT GROUPS: A CONCEPTUAL, MULTILEVEL MODEL

Theoretical Development

The third essay addresses a large gap in the interruptions literature, which focuses mostly on interruptions faced by individuals working on isolated tasks. The main premise in the paper is that interruptions are experienced individually but their effects spill over to the group level via interdependencies among group members’ tasks. This idea is explored in the context of software development groups. The third essay draws on coordination theory as a theoretical framework to propose a multilevel model of IT-based interruptions. This theory is appropriate because it allows us to understand how individually experienced interruptions rise to higher levels due to interdependencies between team members’ tasks. Additionally, by identifying specific coordinating mechanisms, the theory allows us to explain how such dependencies can be effectively managed to reduce the adverse effects of some interruptions.

It is suggested that IT interruptions can have both positive and negative effects on coordination effectiveness of software development groups, and that the relative impacts are contingent on the type of interruption. On one hand, individually-experienced interventions may enhance the group’s coordination effectiveness by creating opportunities for using group problem-solving coordination (Okhuysen & Eisenhardt 2002; Zellmer-Bruhn 2003). On the other hand, intrusions debilitate group coordination effectiveness by creating coordination problems that impact various dependencies among the group’s activities. These problems, which constrain how the task is performed, emerge to the group level and require performing additional activities (coordination mechanisms) to mitigate the negative effects of the intrusions on coordination.
effectiveness (Crowston 1997; Ren et al. 2008). Hence, the third essay proposes that different interruption types exhibit differential effects on the coordination effectiveness of software groups by creating different coordination problems and interacting with different coordination mechanisms.

Key Findings

Theoretical arguments are presented that relate each type of interruption to group-level coordination effectiveness. First, intrusions debilitate the software group’s coordination effectiveness by creating coordination problems as a result of sharing dependencies and flow dependencies (Crowston 1997; Malone & Crowston 1994). For example, intrusions create time pressures at the individual level that propagate to the group level as a result of sharing dependencies (Chong et al. 2011; Karau & Kelly 1992). Coordination effectiveness is also reduced by cognitive workload, which is generated by intrusions at the individual level but propagates to the group level via sharing dependencies (Bowers et al. 1997; Funke et al. 2012; Gopher et al. 1984). Furthermore, the effects of intrusions are proposed to be influenced by another form of dependencies – flow dependencies – through time delays that ripple through the group’s lifecycle activities (Brooks 1979; Reichelt & Lyneis 1999). Flow dependencies are also argued to lead intrusions to debilitate group coordination effectiveness as a result of work product errors that cause more errors downstream (Powell 2001; Wohlin & Korner 1990).

Second, the paper suggests that the negative effects of intrusions on the software group’s coordination effectiveness can be mitigated by exercising task organization coordination (Thompson 1967; van De Ven et al. 1976). This structural coordination mechanism helps manage the coordination problems created by intrusions while reducing the need for intense
communication. Two specific coordination mechanisms – based on manipulating resources or tasks – can be used by software development groups to effectively cope with intrusions: (1) role switching (manipulating people resources); (2) temporal task management (manipulating tasks and time resources).

Third, interventions are argued to trigger a mindful information processing mode in which software team members – because of interdependencies among their activities – call upon other members to share knowledge about the problem, its scope, and ways to resolve it (Okhuysen & Eisenhardt 2002; Zellmer-Bruhn 2003). In turn, this group problem-solving coordination mechanism is likely to enhance group coordination effectiveness. This is because it provides a large capacity of information processing and a platform for coordinating the expertise of group members to effectively resolve the discovered problems (Nidumolu 1995; Okhuysen & Eisenhardt 2002). It is further proposed that the effects of IT interventions on group problem-solving coordination are moderated by characteristics of the interventions (perceived quality and intervention level).

The main contribution of the third essay is that it represents an initial step toward building and testing theory on the multilevel effects of IT-triggered interruptions. Most of the prior research has involved individuals (Beeftink et al. 2008; France et al. 2005; Gong 2006; Madjar & Shalley 2008; Speier et al. 1997; Zijlstra et al. 1999) or dyads (Dabbish & Kraut 2004; McFarlane 2002; Rennecker & Godwin 2005). Also, most of the prior research has examined individuals working on isolated tasks.
**REFERENCES**


CHAPTER II (ESSAY #1). THE MANY FACES OF INFORMATION TECHNOLOGY INTERRUPTIONS: A TAXONOMY AND PRELIMINARY INVESTIGATION OF THEIR PERFORMANCE EFFECTS

ABSTRACT

Despite the growing emergence of interruptions that are mediated or induced by information technology, very little is known about the nature of such interruptions and their consequences on performance. This paper develops a taxonomy of information technology interruptions and presents propositions that relate some of the distinct interruption types to individual performance in project environments. A qualitative inquiry of 21 individuals working in the product development units of eight organizations is used to partially validate the taxonomy and propositions, and to develop new insights based on an inductive analysis. Three main types of information technology interruptions are identified (intrusions, interventions, and hybrid interruptions), along with various underlying subtypes (informational, communicational, actionable, and system). While the effects of the specific subtypes we examined from the three categories are all found to be detrimental to the efficiency component of performance, the quality and learning components are found to be enhanced by actionable interventions and reduced by actionable intrusions. Hybrid actionable interruptions are beneficial to learning but have mixed effects on quality. The paper contributes to extant research by laying the groundwork for a conceptualization of information technology interruptions in the context of individuals working on interdependent tasks that are nested in related projects. Also, it shows how distinct types of information technology interruptions exhibit differential effects on performance outcomes.

INTRODUCTION AND MOTIVATION

Over the past years, the work of individuals has been transformed by several technological developments such as continuous information technology (IT) connectivity, ubiquitous access, and the fusion of IT into most work processes. Whereas this changing computing environment enables continuous interactions across spatial and temporal boundaries, a byproduct of such a transformation is the increasing emergence of technology-based work interruptions (hereafter, IT interruptions), which reflect IT-induced and IT-mediated events that capture attention and break the continuity of a primary task.
Work interruptions have important implications. For example, the average cluster of uninterrupted work is just over 11 minutes (Mark et al. 2005), and managers spend ten minutes of each hour engaged in interruptive activities (O'Conaill & Frohlich 1995). More than half of those interruptions are unrelated to the primary task (Mark et al. 2005), and in 41% of the time interrupted tasks are not even resumed (O'Conaill & Frohlich 1995). IT interruptions – as a subset of work interruptions – have gained particular importance in recent years by making interruptions more salient and adding new avenues for interruptions. For example, 72% of instant messaging (IM) users interrupt coworkers and 44% interrupt clients every day, several times a day, compared with 62% and 34% of non-users, respectively (Garrett & Danziger 2008). Also, individuals receive over 247 billion emails per day, of which 75% is Spam (Wood 2012), with the average individual receiving over 100 emails each workday (Jackson et al. 2003). 70% of emails received are addressed within six seconds, and individuals take over a minute on average to recover from each email interruption (Jackson et al. 2003).

Despite the clear importance of IT interruptions, there is a lack of understanding about this phenomenon. Much of the extant literature does not explicitly define IT interruptions (or general work interruptions) and treats this phenomenon as an undifferentiated monolithic entity that is manipulated in controlled laboratory environments (e.g., Adamczyk & Bailey 2004; Ang et al. 1993; Beeftink et al. 2008; Cutrell et al. 2000). While such a fine-grained handle on interruptions has yielded insights in areas such as interruptibility (Dabbish et al. 2007; Ho & Intille 2005; Hopp et al. 2005) and interruption-mitigating mechanisms (Cades et al. 2007; Dabbish & Kraut 2008; Edwards & Gronlund 1998; France et al. 2005), it does not provide an optimal means to understand the actual nature of the interruption phenomenon. Indeed, the
contention that there is “no systematic body of research on what physical or psychological characteristics make an interrupt” (Moray 1993, p. 120) seems to still hold.

In this paper, we argue that one such important interruption characteristic relates to the content of the interruption. Specifically, conceptualizing interruptions based on the content and its relation to primary task activities allows us to better distinguish interruption types and understand their effects on the work of individuals. Indeed, several researchers pointed out the importance of taking the content of the interruption into account (Chong & Siino 2006; Gluck et al. 2007; Jett & George 2003; Speier et al. 1997; Speier et al. 2003). Also, empirical results – while not explicitly conceptualizing interruption content – indicate that IT-mediated interruptions with non-relevant content elicit negative emotional reactions (e.g., Bailey et al. 2001; Gievska et al. 2005), lead to losses in efficiency of both resuming and completing the interrupted tasks (e.g., Arroyo & Selker 2003; Bailey et al. 2000; Monk et al. 2004b), and debilitate performance effectiveness as a result of increased errors (e.g., Kapitsa & Blinnikova 2003; McFarlane 2002; Speier et al. 1997) and a reduced ability to remember interrupted task details (McDaniel et al. 2004; Oulasvirta & Saariluoma 2004). One study that explicitly looked at content found that interruptions that are irrelevant to the primary task, but which have similar content, increase task completion time (Gillie & Broadbent 1989). Conversely, some studies found IT-mediated interruptions that provide useful information to generally enhance task performance (Ang et al. 1993; Robertson et al. 2004). One study compared interruptions with relevant and irrelevant contents and found the former to lead to shorter resumption lags and task completion time (Cutrell et al. 2000; Czerwinski et al. 2000).²

² These results are obtained from a literature review, which is presented in Essay #2.
Hence, there seems to be some evidence indicating that a systematic conceptualization of IT interruptions based on content allows us to distinguish different interruption types and better understand their consequences on the work of individuals. The following questions are posed in this paper: *What are the different types of IT interruptions? How does each type affect individual performance?* We conceptualize IT interruptions and develop a taxonomy that classifies IT interruption types according to their range of content and the way they direct attention relative to the primary task. Drawing upon insights from two complementary theories on attentional allocation – cue utilization theory and mindfulness theory – we develop and test propositions that predict the performance impacts of different IT interruption types in project environments.

This research makes four contributions. First, our taxonomy of IT interruptions extends prior conceptualizations and serves as a foundation for further theoretical and empirical research on this increasingly important phenomenon. By being able to clearly conceptualize and distinguish among different types of interruptions, future research can be developed on topics such as the contextual conditions that give rise to each type of interruption, how to control (i.e., mitigate or reinforce) the effects of each type, and the impacts on different interruption types at the individual and collective levels. Second, the propositions help explain the inconsistent findings in the literature by relating interruption type to variation in performance. A third contribution of this study is the uncovering of a new type of hybrid IT interruption with its unique effects on performance. Finally, the paper contributes by extending the traditional focus on IT interruptions in the context of brief, singular and artificially manipulated tasks (e.g., Adamczyk & Bailey 2004; Cutrell et al. 2000; McFarlane 2002), to a broader context where individuals are working on real, interdependent tasks nested in larger projects. This helps us explain a wider range of the phenomenon.
The paper begins with a conceptualization of IT interruptions based on a taxonomy of IT interruption types and subtypes. It then presents the theory-based propositions. This is followed by the methodology section, which preliminarily validates the taxonomy and propositions through a qualitative inquiry of individuals working in the new product development (NPD) units of eight organizations. Then, the results are presented, and new propositions are formulated based on an inductive analysis of the data. The paper concludes with a brief discussion of the implications of this research.

CONCEPTUALIZATION AND TAXONOMY OF IT INTERRUPTIONS

In this section, we conceptualize the notion of IT interruptions. Since few studies exist that explicitly conceptualize IT interruptions, we develop our conceptualization with help from the multidisciplinary work interruptions literature where IT interruptions were implicitly present. Building upon the conceptualization and incorporating specific dimensions to account for the content of the interruption, we develop a taxonomy of IT interruption types and subtypes.

Conceptualization of IT Interruptions

Our conceptualization of IT interruptions is guided by prior conceptualizations that are summarized in Appendix 1. As shown in Appendix 1, most studies do not formally define IT interruptions. For the remaining studies, several common elements are found across the definitions. First, most studies defined interruptions as external. Externally generated

---

3 The review covered the past 30 years of literature (1980-2009), was backward-looking and forward-looking, and used relevant keywords to search multiple data sources: ABI/Proquest, ISI Web of Science, Google Scholar, and an independently administered database on interruptions with over 680 articles (http://interruptions.net/literature.htm, accessed February 7, 2010). The search process resulted in a sample of 87 articles that were included as the basis of this investigation.
interruptions take place between actors (individuals or groups) and their external IT environment. Hence, IT interruptions do not include internally generated interruptions such as breaks (e.g., Fortin & Tremblay 2006) and distractions (e.g., Monk et al. 2004a: driver distractions). Those interruptions (e.g., mental breaks; daydreams; intrusive thoughts) are excluded because they are often self-initiated, mostly self-contained, and involve little physical interaction with the IT environment.

Second, IT interruptions are defined as *events*, which is distinct from related concepts such as actions and tasks. Whereas an action is a subset of an event that requires an actor to initiate it (Zacks & Tversky 2001), some IT interruptions are events that are not initiated by any particular actors (e.g., IT system failures). Also, they are distinct from tasks in that some work interruptions may contain no specific tasks to perform (e.g., a pop-up window that displays the latest stock news).

Third, IT interruptions *break the continuity of a primary task’s activities*. Primary task activities are ongoing activities that individuals perform as their primary responsibility (Iqbal & Horvitz 2007). IT interruptions occur in the midst of performing such tasks and break their continuity. Thus, they would not count as interruptions if they occurred after the primary tasks have been completed.

Finally, with few exceptions (McCrickard et al. 2003; Oulasvirta & Saariluoma 2004; van den Berg et al. 1996), prior definitions of IT interruptions do not take the content of the interruptions into account. As we noted earlier, interruptions with different types of content can lead to different performance outcomes that range from negative (e.g., Bailey et al. 2001; Cutrell et al. 2001; Speier et al. 1997) to positive (e.g., Ang et al. 1993; Jung et al. 2010). Therefore, it is important to explicitly account for the content of the interruption when defining interruptions.
Building upon the above elements, this paper defines IT interruptions as *perceived, IT-based external events with a range of content that captures cognitive attention and breaks the continuity of an individual’s primary task activities*. Conceptualizing IT interruptions as *perceived* allows the interruption to be defined from the point of view of the interruption target that experiences it rather than an experimenter manipulating it. Further, IT interruptions are *IT-based* by virtue of being a subset of work interruptions where technology is implicated either by inducing interruptions (e.g., system failures; see Johansson & Arronsson 1984; France et al. 2005) or mediating the interruptive events (e.g., email information requests; see Jackson et al. 2003). Hence, IT interruptions can be instigated by human activity or by the system’s behavior. Our definition also considers the content of the interruptive event, and how it directs cognitive attention. Finally, our conception of IT interruptions is consistent with prior research that considers interruptions as a chain of events that may or may not include an interruption stimulus (e.g., pop-up signaling email arrival) and the interruptions content (e.g., email message). Those events elicit a chain of reactions including detection, processing, and integration of the interruption content (Iqbal & Horvitz 2007; McFarlane 2002; Okhuysen & Eisenhardt 2002).

**Taxonomy of IT Interruptions**

We develop a taxonomy of IT interruptions to better understand the nature of IT interruption types and subtypes. Two content-related dimensions are used to classify IT interruptions in the taxonomy: (1) the direction of attention allocation based on content relevancy to primary task activities; (2) the specific nature of the interruption content. The first dimension is based on the framework of work interruptions developed by Jett & George (2003), and adapted...
in this paper to fit the notion of IT interruptions. Two broad types of IT interruptions are identified based on Jett & George’s framework: IT intrusions and IT interventions.⁴

We define IT intrusions as perceived, external events that are induced by or delivered via IT, comprising a content domain that is unrelated to an individual’s primary task activity. These events break the continuity of – and divert attention from – such primary task activity.⁵ As shown in the third column of Appendix 1, a vast proportion of the studies focused exclusively – whether explicitly or implicitly – on intrusions. This illustrates the point we made earlier about most studies conceptualizing interruptions as a monolithic, mostly negative phenomenon.

IT interventions are defined as perceived, IT-based external events that occur during the execution of a primary task, reveal a discrepancy between performance expectations and actual task performance, and direct attention toward the source of the discrepancy. This definition builds on Jett & George’s (2003) discrepancy interruptions, and the literatures on feedback (Ilgen et al. 1979) and control (Campion & Lord 1982). IT Interventions are considered interruptions because they disrupt an individual’s ongoing behavior and motivate a behavioral change as a result of the perceived discrepancy in task performance (Jett & George 2003). Hence, whereas IT intrusions divert attention from the primary task, IT interventions are designed to refocus attention on the primary task.

We introduce a second dimension for classifying IT interruptions, which is based on the specific nature of the interruption content. This dimension contains four sub-dimensions: informational interruptions; communicational interruptions; actionable interruptions; system

---

⁴ Jett & George included two other types in their original framework (breaks and distractions). Those were excluded here because they do not fit with our definition of IT interruptions, especially with respect to fully capturing attention and being IT-based and externally generated.

⁵ This definition builds on Jett & George’s (2003) conception of intrusions, but differs in at least two ways: (1) it focuses on IT-based events; (2) it is broader because it allows for chains of events to be subsumed under the conception of a single intrusion (e.g., the interruption alert and the interruption proper).
interruptions. The first three sub-dimensions represent interruptions generated by human activity and mediated by technology tools (e.g., email) (Bellotti et al. 2005; Dabbish et al. 2005; Kettinger & Grover 1997; Kimble et al. 1998). First, informational interruptions refer to one-way dissemination of information that is delivered to recipients via IT, and which interrupts their ongoing task activities. Such interruptions do not trigger the execution of behavioral task action, and they do not necessarily require a response from the interruptee. Second, communicational interruptions refer to IT-mediated interruptions involving two-way communications and exchanges. Such interruptions require the interruptee to respond, but they do not typically trigger the execution of behavioral task action. Third, actionable interruptions refer to IT-mediated interruptions that involve executing behavioral task action, and are thus more cognitively demanding. While these three content sub-dimensions reflect interruptions produced by human activity and mediated by the technology, the fourth sub-dimension represents interruptions with no specific content that are directly generated by the system’s activity (e.g., IT breakdowns).

The reason for including interruption content as a second dimension with its four underlying sub-dimensions is that different IT interruptions with different contents may exhibit qualitatively different behaviors. For example, evidence from the computer-mediated communication (CMC) literature shows that emails with different types of communicational content have different antecedents (Kettinger & Grover 1997) and exert different influences (Dabbish et al. 2005; Kimble et al. 1998; Markus 1994). To illustrate this point, Kimble et al.’s (1998) case study of a large international organization found that informational overload was experienced only from a particular type of email communicational content (informational email broadcasts that are unnecessary for performing the primary tasks). Others similarly found that different types of email communicational content have varying impacts on perceived message
importance and user response actions (Dabbish et al. 2005) as well as on perceived media appropriateness (Markus 1994).

The combination of the two dimensions results in a 2 x 4 taxonomy of IT interruptions containing seven IT interruption subtypes. The combination of the two dimensions results in a 2 x 4 taxonomy of IT interruptions containing seven IT interruption subtypes. Table 1 summarizes the different IT interruption subtypes in the taxonomy with a description and example of each. Below we elaborate on each component of the taxonomy, and in the following section we propose how some of the different interruption types and subtypes influence an individual’s performance. The literature summarized in Appendix 1 is used to illustrate each IT interruption subtype discussed below.

**Informational Intrusions**

This category reflects one-way informational elements that are disseminated via IT tools (e.g., email; instant messaging; pop-up displays). These informational elements may involve general work contexts, personal/social contexts, or other contexts that generally fall outside of the domain of an individual’s primary task activity. They intrude on individuals while they are working on such activities, and divert attention from them. Examples of informational intrusions in the literature include a wide range of events that are disseminated as general reminders (Ho & Intille 2005), announcements (Bellotti et al. 2005; Sproull & Kiesler 1986), status updates (Dabbish & Kraut 2004), notifications (Bailey et al. 2000; Bailey et al. 2001; Cutrell et al. 2000; Czerwinski et al. 2000), and FYI email (Mackay 1988). McCrickard et al. (2003) examined the efficacy of different notification systems displayed during web browsing tasks to inform users

---

Note that the 2 x 4 taxonomy contains seven categories and is thus missing one theoretical category. This is because we did not find a conceptually coherent category for system interventions. While the literature identifies interventions that are directly generated by the system (Ang et al. 1993; Earley et al. 1988), these interruptions do not represent a separate category because they typically represent feedback on task performance and thus overlap with informational interventions.
about stocks, weather, and sports scores. They found no significant differences for the intrusiveness of different notification systems, and that fading animation displays were best for reacting to the interruptions.

**Communicational Intrusions**

This category comprises communicational exchanges that are mediated by IT. Like informational intrusions, they involve contexts that are unrelated to – and that divert attention from – an individual’s primary task activity. Unlike informational intrusions, they comprise bi-directional exchanges that require the interruptee to put together a response or engage in ongoing communications. Examples of this category in the literature include conducting online discussions (Bellotti et al. 2005; Ducheneaut & Bellotti 2001), and responding to requests for documentations and information (Ducheneaut & Bellotti 2001; van Solingen et al. 1998), opinions (Kettinger & Grover 1997), and questions or queries (Kapitsa & Blinnikova 2003; Zijlstra et al. 1999).


<table>
<thead>
<tr>
<th><strong>Interruption Type</strong></th>
<th><strong>Interruption Content</strong></th>
<th><strong>Informational</strong></th>
<th><strong>Communicational</strong></th>
<th><strong>Actionable</strong></th>
<th><strong>System</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intrusion</strong></td>
<td>IT-mediated interruptions involving one-way dissemination of information that is related to an individual’s secondary (non-primary) task activity E.g., pop-up display notifying an individual of unrelated information (e.g., sports scores; stock quotes; weather reports) while she performs a browsing task (McCrickard et al. 2003)</td>
<td>IT-mediated interruptions involving two-way communications and exchanges that are related to an individual’s secondary (non-primary) task activity E.g., electronic message that interrupts an individual performing a text editing task with a request for contact information from a directory (Kapitsa &amp; Blinnikova 2003)</td>
<td>IT-mediated interruptions involving executing behavioral task actions that are related to an individual’s secondary (non-primary) task activity E.g., switching from the execution of a text editing task to a task that requires summarizing short video clips (Adamczyk &amp; Bailey 2004)</td>
<td>IT-induced interruptions involving system property issues or lack of availability of system resources, which disrupt an individual’s current flow of work in his or her primary task activity E.g., computer or diagnostic malfunction that interrupts the work of a physician (France et al. 2005)</td>
<td></td>
</tr>
<tr>
<td><strong>Intervention</strong></td>
<td>IT-mediated interruptions involving one-way dissemination of information that is directly related to an individual’s primary task activity E.g., computer-mediated feedback delivered to an individual who is participating in a mockup recruitment session (Ang et al. 1993)</td>
<td>IT-mediated interruptions involving two-way communications and exchanges that are directly related to an individual’s primary task activity E.g., email requesting to share information and question others in a group problem-solving task (Okhuysen &amp; Eisenhardt 2002)</td>
<td>IT-mediated interruptions involving executing behavioral task actions that are directly related to an individual’s primary task activity E.g., instant messaging alert instructing an individual about how to organize websites in a web search task (Cutrell et al. 2000)</td>
<td>N/a</td>
<td></td>
</tr>
</tbody>
</table>
Actionable Intrusions

This IT intrusions subtype describes events where individuals suspend their primary task activity and switch attention to executing secondary, unrelated task actions (e.g., general work-related actions or personal/social actions). IT has made it much easier to engage in such task switching. For example, computer applications are designed in such a way as to facilitate multitasking. Also, multiple communication media are available at work, which makes it easier to engage in multiple interactions at the same time (Cameron & Webster 2011). Dabbish et al. (2005, p. 696) argued that a third of all email messages contain requests for action that “cause people to shift gears and to add new tasks to their current stack.” As shown in the fourth column of Appendix 1, actionable intrusions are the most represented form of interruptions in the prior literature (e.g., Adamczyk & Bailey 2004; Bailey & Konstan 2006; Cutrell et al. 2001). IT can be used to deliver the intrusion (e.g., Adamczyk & Bailey 2004; Latorella 1998; Scott et al. 2006), or both the intrusion and the alert that precedes it, if there is one (e.g., Altmann & Trafton 2007; Bailey et al. 2000; Ho et al. 2001). Also, these intrusions can be delivered via a wide range of IT tools such as pop-up displays (Adamczyk & Bailey 2004), instant messaging systems (e.g., Cutrell et al. 2001; Iqbal & Horvitz 2007; Ratwani et al. 2007), and PC applications (e.g., Einstein et al. 2003; McDaniel et al. 2004; Speier et al. 1997), among others.

System Intrusions

Whereas the intrusions described previously are IT-mediated, this interruption subtype is actually induced by IT rather than by human activity. System intrusions are relevant in contexts where the primary work is computer-based, a condition describing most organizational work today (McFarlane 2002). They generally involve: (1) system property issues; (2) lack of
availability of system resources. System property issues arise when the system’s features are novel or discrepant from expectations, which interrupts the current flow of work and diverts cognitive attention away from the primary task toward the system’s interface (Griffith 1999; Louis & Sutton 1991). Examples include systems that are slow, unreliable, difficult to use, loaded with features, demand constant attention, provide too much information, or do not fit with the task. For instance, Dabbish & Kraut (2004; 2008) investigated the amount of information provided by awareness display systems as a form of intrusion. They found that too little information on the helper’s state harms the helper while too much information harms the asker’s performance.

At a higher level of disruption, system resources may become unavailable to individuals as a result of system glitches, breakdowns, or upgrades. For example, Google Mail (Gmail) service interruptions repeatedly occur (Treynor 2009). This may have grave task performance consequences for business users that rely on Gmail for conducting real-time business transactions (e.g., lead management). Similarly, a field study found that computer or diagnostic malfunctions seriously disrupt the work of physicians (France et al. 2005). Appendix 1 (fourth column) indicates where system intrusions appear in prior studies.

**Informational Interventions**

Informational interventions reflect one-way informational elements that are disseminated via IT tools (e.g., email; instant messaging; pop-up displays), and that are directly related to an individual’s primary task activity. The information in those interruptive events reveals specific feedback about discrepancies in the task being performed and/or the way an individual is handling a particular task, which may help in resolving such discrepancies (Kluger & DeNisi
1996). It identifies the discrepancy source without constraining actors’ response choices (Ilgen et al. 1979). As an example, Ang et al. (1993) examined computer-mediated feedback delivered to 72 individuals while participating in mockup recruitment sessions and found that such interventions enable them to better realign their focus on the recruitment tasks. Specifically, the interventions mitigated the negative effects of social cues that are perceived in the case of human-delivered feedback.

**Communicational Interventions**

Communicational interventions are IT-mediated events that stimulate two-way interactions, communications, and discussions among individuals who are working on their primary tasks. They are directly related to an individual’s primary tasks and designed to reduce discrepancies in the performance of such tasks. For example, Okhuysen & Eisenhardt (2002) administered interventions to team members engaged in a problem-solving task. These interventions required members to share information and question others about the task. Indeed, the “questioning others” intervention created windows of opportunity in which individuals focused their attention, discussed task issues, and closed discrepancies that emerged between their task behaviors and the behaviors implied by the intervention. Conversely, the “information sharing” intervention did not have significant effects, mainly because it resulted in self-focus, rather than stimulating true two-way discussions. Similarly, Woolley (1998) examined 90 student groups participating in a Lego-building contest. Two types of interventions were administered: (1) instructions to freely discuss the strategy of group members’ tasks; (2) instructions to discuss interpersonal aspects. The results showed that the communicational
interventions centered on identifying discrepancies with the task strategy are the most effective, especially when administered at the task midpoint.

**Actionable Interventions**

This intervention subtype reflects IT-mediated directives triggering the execution of behavioral action that is directly related to the primary tasks of individuals. For example, an individual working on her primary task activity may receive an email from her manager or coworker providing instructions or requesting actions to be taken relative to her task. A series of experiments by Cutrell and colleagues (Cutrell et al. 2000; Czerwinski et al. 2000) examined instant messaging alerts that instructed individuals about how to organize websites in their web search task. Consequently, such actionable interventions were found to be more efficient than informational intrusions that disseminated irrelevant content. Okhuysen & Eisenhardt (2002) administered instructions to group members to manage their time properly. This created a discrepancy-seeking mode, which stimulated group members to improve the way they used time in their task. In turn, this improved their focus on more effective task execution and enhanced their knowledge integration behaviors. Finally, Weisband et al. (2007) studied electronically-mediated interventions (some of which were action-oriented) delivered to doctors in a simulated operating room environment and found that passive notifications that could be negotiated are best for scheduling task surgeries.

**Summary**

In this section, we developed a two-dimensional taxonomy of IT interruptions. The direction of attention implied by the interruption relative to the primary task comprises one
dimension, while the other dimension reflects the specific content of the interruption. Table 1 summarizes the IT interruption subtypes and shows an example of each from the literature.

It is to be noted that there may be fluidity among the interruption subtypes because – consistent with our conceptualization – IT interruptions are not necessarily one-off events but may constitute chains of events. For example, an individual may receive an informational intervention providing feedback on his or her performance. This initial informational intervention may develop into a communicational intervention when such feedback is discussed in threads of back and forth emails. Alternately, it may become an actionable intervention if it is transformed into action to ameliorate the performance discrepancy. For example, Weisband et al. (2007) investigated IT interventions as electronic notifications of events that in some cases required action (e.g., notifications about operating room carts requiring maintenance, which necessitates rescheduling decisions).

TESTING THE TAXONOMY: PROPOSITIONS EXPLORING THE PERFORMANCE EFFECTS OF THREE IT INTERRUPTION SUBTYPES

To further develop the taxonomy and discover differences among IT interruption subtypes, we conducted an exploratory study to achieve the following:

1. Determine the existence of the different IT interruption subtypes and explore whether there are new ones that emerge.

2. Provide a preliminary exploration of the consequences of three IT interruption subtypes that are expected to have the most important impacts.
To accomplish the goals of the exploratory study, we first develop propositions that link three of the IT interruption subtypes to individual performance. Because there is little prior theoretical work to explicitly support the entire IT interruption taxonomy, we selected three IT interruption subtypes that are expected to have the most important effects: actionable intrusions; actionable interventions; system intrusions.

According to psychological theories of attention allocation and especially capacity theory (Kahneman 1973), the performance effects of interruptions are most salient when they stimulate heightened arousal, which is directly linked to the level of attention mobilization (Kahneman 1973; Weick 1990). Actionable interruptions are the most cognitively demanding when compared to informational and communicational interruptions because they require behavioral action to be taken. According to capacity theory, increased cognitive demands cause an increase in the level of arousal, attention, and effort, which directly influences task performance (Kahneman 1973). Indeed, it was found that while being exposed to informational content triggers arousal, such arousal increases dramatically when subjects are asked to act upon the informational content (Kahneman 1973; Tursky et al. 1970). Therefore, actionable intrusions and interventions are likely to be more impactful on performance than their informational and communicational counterparts.

The prominence of actionable intrusions stems from their triggering of actions related to secondary activities that strongly interfere with primary activities and compete for cognitive attention. As for actionable interventions, interruptions research suggests that interventions are most intense – and most beneficial – when they stimulate action and trigger behavioral reactions to address the discrepancy (Jett & George 2003). This view about actionable interventions is shared more generally in the feedback literature, which posits that feedback is most effective
when it leads to behavioral changes and corrective actions to resolve the task discrepancies (Ilgen et al. 1979; Kluger & DeNisi 1996; London & Smither 2002). In summary, while informational and communicational interruptions may only partially offset attention, actionable interruptions increase arousal and mobilize attention away from the ongoing primary task activities toward secondary activities (actionable intrusions) or toward corrective primary task actions (actionable interventions). Selecting these two interruption subtypes allows us to contrast their disparate effects.

The third subtype selected – system intrusions – is also expected to exhibit salient effects. According to Weick (1990), system intrusions (both system property issues and resource scarcity) impose “sizable cognitive demands” (p. 14) and increase arousal to the extent that they block attention from the main work required. This can have adverse effects especially on efficiency measures of task performance. With system property issues (e.g., new system implementation), arousal is increased as a result of attention being directed to the technology’s features instead of the primary task activities. With system resource availability issues (e.g., system breakdown), arousal is increased because attention is blocked from the main task and individuals search for alternative responses to resume the interrupted activity. In general, system intrusions trigger more arousal than informational and communicational intrusions that may block attention partially while absorbing the informational content or putting together a response. In addition to the above arguments, system intrusions are deemed important to investigate in our proposition development effort because this is the only interruption subtype in the taxonomy that is generated by the system’s – rather than human – activity.

Our propositions that relate each type of IT interruption to individual performance are developed and tested in the context of individuals working in project environments. In such
project environments, individuals are responsible for one or more tasks that are nested within projects in each individual’s project portfolio. Project environments provide a fertile context to study IT interruptions. First, they allow us to study tasks within a context that has clear boundaries. Whereas the tasks and interruptions examined in most prior research were artificially manipulated in laboratory environments (e.g., Adamczyk & Bailey 2004; Bailey & Konstan 2006; Cutrell et al. 2001; McFarlane 2002), our project environment allows us to better understand the actual context in which the interruptions occur. Second, the project environment complements the approach used in prior experimental research, which focused on singular, isolated tasks. Because tasks within a project environment are interrelated and hierarchically nested, this allows us to explain a wider range of the IT interruptions phenomenon. Third, project environments provide visibility to our phenomenon of interest since they involve significant cross-functional interactions and interruptions that are enabled by IT. Finally, a project environment can be easily tied to the performance of individuals because it has defined goals and a defined beginning and end.

Individual project performance is conceptualized as the sum of the individual’s performance behaviors over the life of the project (Motowildo et al. 1997). It is assessed using a holistic view, which includes the following dimensions: efficiency; quality; learning (Hackman 2002; O’Leary et al. 2011). Efficiency is further composed of two sub-dimensions: a structural dimension that reflects the additional project time consumed by the interruption; a cognitive dimension which represents temporal switching costs. The latter reflects efficiency losses from having to switch back and forth between demanding interruptions and primary tasks and go through a process of cognitive suppression / activation of cues associated with those tasks.
Our propositions are shaped by two theoretical perspectives on attention allocation: cue utilization theory\(^7\) (Easterbrook 1959) and the notion of mindfulness (Langer 1989; Louis & Sutton 1991). Cue utilization theory is based on the notion that attention is a limited resource that is allocated to a given task as the task’s demands increase. Task demands are increased by intrusions that heighten arousal and divert attention from the primary task (Gong 2006; Speier et al. 1997; Weick 1990). Increased task demands from such intrusions may then exceed an individual’s available attentional capacity – a notion known as capacity interference (Kahneman 1973; Speier et al. 1997). To cope with such demands on attentional capacity, the individual being interrupted dismisses cues associated with performing his or her primary tasks. This process of attentional contraction begins with dismissing peripheral cues but then leads to dismissing central cues in addition to impairing the ability to select the relevant cues. Consequently, performance efficiency and effectiveness suffer (Easterbrook 1959; Kahneman 1973). Attentional capacity limits can also trigger temporal switching costs as individuals switch back and forth between demanding interruptions and primary tasks. This requires re-ordering of task priorities and suppressing/activating cues associated with those tasks. Such detrimental effects can be further exacerbated by cognitive interference (Kahneman 1973; Wickens et al. 2005) when the primary task and interruption draw on similar resources in a way that confuses attentional allocation (e.g., if both activities are visual in nature, or if both use similar IT tools).

\(^7\) Another theory that was considered for use in explaining the effects of IT intrusions is integrative complexity theory. Essentially, the theory posits that there is an inverted-\(U\) relationship between the complexity of input information and the level of information processing output (Driver & Streufert 1969). Beyond the optimal point, processing output decreases, leading to information overload and deterioration in information processing quantity and quality (Driver & Streufert 1969; Paul & Nazareth 2010). Despite the relevance of that theory, we opted for cue utilization theory as a theoretical lens since it adopts an attention allocation perspective. That perspective is more in line with our conceptualization of IT interruptions as events that direct cognitive attention relative to primary task activities.
Conversely, the notion of mindfulness posits that in an effort to conserve limited attentional resources, individuals performing a particular task typically resort to automatic (mindless) information processing schemas, especially when the task is well-learned (Jett & George 2003; Louis & Sutton 1991). However, some interruptions and other events that bring novelty and/or reveal a discrepancy between actual and perceived performance motivate a cognitive switch toward a more “mindful” state (Langer 1989; Louis & Sutton 1991; Zellmer-Bruhn 2003). This mindful state entails paying more attention to the task, actively attending to new information, being open to different points of view, heedfully relating actions to those of others, and orienting oneself to the present (Langer 1989). Hence, interventions can actually expand attentional capacity and redirect attention toward the primary task by focusing on the source of discrepancy.

**System Intrusions, Actionable Intrusions, and Individual Project Performance**

**System Intrusions, Actionable Intrusions, and Efficiency**

With respect to the structural dimension of efficiency, actionable IT intrusions consume additional project time and allocate it toward addressing intrusions that are unrelated to an individual’s project portfolio. Consequently, project tasks are postponed (McFarlane 2002; O’Conaill & Frohlich 1995) and the project’s continuity can be disrupted, especially if interrupted tasks reside on the critical paths for given projects. Similarly, system intrusions consume project time while the system is down or while the system features are not fully functional. Users typically cannot control those intrusions to occur at more opportune moments or during natural task boundary points. France et al. (2005) found that computer malfunctions interrupted physicians in the emergency department and contributed to their inefficiency.
With respect to the cognitive dimension of efficiency, actionable IT intrusions also incur temporal switching costs when individuals switch attention back and forth between demanding interruptions and primary task activities and go through a process of cognitive suppression / activation of cues associated with those activities. First, it takes time and effort to cognitively engage in a new task with new demands while suppressing the information from the previous task. Two studies of individuals involved in problem-solving tasks found that switching to new, computer-based tasks significantly increases the time to complete those intrusive tasks (Bailey et al. 2000; Bailey et al. 2001). Similar results were found for task switches involving text editing tasks (van den Berg et al. 1996) and game contests (McFarlane 2002). Second, it is also cumbersome to retrieve previously stored cues and resume the interrupted project work (Altmann & Trafton 2007; Oulasvirta & Saariluoma 2004). Indeed, numerous studies found increased resumption lags from task switching (Cutrell et al. 2001; Hodgetts & Jones 2006b; Monk et al. 2008; Ratwani et al. 2007; van den Berg et al. 1996). One study found that the average recovery time from a single email intrusion is 64 seconds (Jackson et al. 2003). Third, completing the primary task in the project is likely to take longer upon resumption due to cognitive and emotional loads that remain unreleased. An experiment by Bailey & Konstan (2006) quantified those effects at 3-27% more time to complete the primary task, and many others supported such effects (e.g., Burmistrov & Leonova 2003; Cutrell et al. 2001; Eyrolle & Cellier 2000; Nagata 2003; Speier et al. 1997). Fifth, research in psychology on task switching also found significantly longer total task completion times (Kapitsa & Blinnikova 2003; van den Berg et al. 1996). We thus propose:

*Proposition 1: System intrusions are detrimental to the efficiency of project members as a result of diversion of attention from primary project activities, which consumes additional project time.*
Proposition 2: Actionable IT intrusions are detrimental to the efficiency of project members as a result of two mechanisms: (a) diversion of attention from primary project activities, which consumes additional project time, and (b) fragmentation of attention between primary project tasks and non-project activities, which incurs cognitive switching costs.

System Intrusions, Actionable Intrusions, and Quality

Beyond their effects on efficiency, system intrusions are also expected to debilitate the quality of project task performance. For example, system feature issues (e.g., slow, complex, or unresponsive systems) may interfere with effective completion of tasks as a result of fragmenting attention away from the primary activity. Research by Dabbish and colleagues on awareness systems displaying the work contexts of their coworkers supports this effect. Specifically, information seekers were found to be interrupted by the interfaces of such systems when too much information was provided, which harmed effective performance (Dabbish & Kraut 2004; Dabbish & Kraut 2008). One study provided contradicting results where system response time had an adverse effect on stress but a positive effect on performance (Thum et al. 1995). However, the system response times that were manipulated were too short – lasting less than six seconds – to meaningfully infer performance effects for our context.

Actionable intrusions are also expected to hamper task performance quality. While individuals have a natural disposition to constantly scan the environment for new stimuli and engage in several tasks at a time, cue utilization theory posits that effective multitasking ability is severely restricted by shrinkage in the range of cue utilization (Easterbrook 1959) and capacity and cognitive interferences on cognitive attention (Kahneman 1973; Loukopoulos et al. 2001; McFarlane 2002). This is especially problematic in project environments that are fraught with
tensions between the expectation of multitasking and the need for concentration and reflection to effectively perform knowledge-intensive project work. Hence, frequent switching between project task contexts and external contexts unrelated to the project portfolio is likely to fragment attention, increase errors, and generally hamper the quality of project task performance. Indeed, extant research found that frequent occurrence of actionable IT intrusions for individuals performing complex facility location and aggregate planning tasks are detrimental to decision accuracy for both the primary and interruptive tasks (Speier et al. 1997). Similar results were echoed in other contexts (Bailey & Konstan 2006; Kapitsa & Blinnikova 2003; McFarlane 2002; Speier et al. 2003). Based on the above evidence, we propose:

Proposition 3: Because system intrusions divert attention from primary project activities, their frequent occurrence is detrimental to the quality of work of project members.

Proposition 4: Because actionable IT intrusions divert attention from primary project activities, their frequent occurrence is detrimental to the quality of work of project members.

System Intrusions, Actionable Intrusions, and Learning

In addition to the effects on efficiency and quality, system intrusions and actionable IT intrusions are also likely to hamper project members’ learning about the project by reducing the time available to integrate new information, and through cognitive and capacity interferences that affect memory retrieval and thus learning. For example, Sitzman et al. (2010) conducted a longitudinal study of 530 trainees using a web-based instruction system as part of an online training program. The study found that system intrusions (technical difficulties such as error
messages and the lack of access to training material due to network issues) inhibit self-regulation and learning, leading trainees to forget some key declarative and procedural aspects of their training material. Similarly, this effect is expected to be most salient for actionable intrusions.

With each such intrusion, individuals have to unload parts of their working memories to successfully deal with the interruptive events and then resume the interrupted task. Hence, with increasing frequency of such interruptions, the information retrieval process - and thus learning - are adversely affected (Gong 2006). Indeed, extant interruptions research found that actionable intrusions hamper the retrieval of task cues both from prospective memory (Einstein et al. 2003; McDaniel et al. 2004) and retrospective memory (Gong 2006; Oulasvirta & Saariluoma 2004), especially when the two tasks have similar content (Edwards & Gronlund 1998). We thus propose:

*Proposition 5*: Because system intrusions divert attention from primary project activities, their frequent occurrence is detrimental to the learning of project members.

*Proposition 6*: Because actionable IT intrusions divert attention from primary project activities, their frequent occurrence is detrimental to the learning of project members.

**Actionable Interventions and Individual Project Performance**

**Actionable Interventions and Efficiency**

Since actionable IT interventions are by definition events that refocus attention on the primary task, they do not entail switching costs between primary and secondary tasks. However, apart from the cognitive dimension of efficiency, such events may still consume additional...
project time as project members faced with a performance discrepancy channel their attention toward making sense of the discrepancy, redoing the work or coming up with ways to improve performance and close the gap. Indeed, evidence was found that actionable interventions in simulated decision-making tasks have a detrimental effect on information processing efficiency, especially for more pessimistic individuals (Szalma et al. 2006).

Proposition 7: Because they disrupt the work of project members and prompt them to act upon the content of the intervention (e.g., redo the work; design and implement corrective action strategies), actionable IT interventions are detrimental to the efficiency of project members by consuming additional project time.

Actionable Interventions, Quality, and Learning

Actionable IT interventions are expected to enhance performance quality and learning. First, consistent with the notion of mindfulness, such interventions focus attention on the source of the task performance discrepancies and motivate individuals to expend additional efforts to learn about and effectively close those gaps (Campion & Lord 1982; Ilgen et al. 1979; Kluger & DeNisi 1996; Okhuysen & Eisenhardt 2002; Zellmer-Bruhn 2003). Second, they provide information that is directly pertinent to recognizing areas of improvement, and successfully completing the primary task (Jett & George 2003; Woolley 1998). Third, they trigger a more mindful cognitive state that helps individuals to close task performance discrepancies by being more oriented to the present and by integrating new information and stimuli from multiple sources (Langer 1989). Individuals then begin to actively and reflectively process the task information in new and meaningful ways rather than rely on pre-existing, abstract knowledge.
representations (Ilgen et al. 1979; Jett & George 2003; Langer 1989). The technology component distinguishes IT-induced and IT-mediated interventions from other forms. Since IT-based interventions focus attention more on the task-at-hand rather than on other situational factors (e.g., interpreting the intentions of a feedback-giver), such events are typically better perceived and may lead to higher self-efficacy and performance (Ang et al. 1993; Earley 1988; Kluger & DeNisi 1996).

The relationship between actionable IT interventions and performance effectiveness can be justified via prior empirical research. For example, an experimental study of 85 subjects found that computer-generated interruptions that provide the subjects with feedback on their stock investment decisions enhance the value of their stock portfolio, the quality of their task strategy, and the appropriateness of their information search (Earley et al. 1990). While the authors investigated both informational interventions (notifications about stock portfolio performance) and actionable interventions (more directive and strategy-shaping feedback about the investment process), they found the results to be stronger in the latter case. Further evidence comes from a study of 38 software developers experiencing actionable interventions in the form of electronic software bug notifications (Robertson et al. 2004). More specifically, the study found that lower intensity (negotiated) actionable interventions enhance task performance prediction accuracy and learning effectiveness. These beneficial results occurred because developers could act further on the interventions by actively seeking explanations of the discrepancies through the “tool tips” option provided by the system. They were also more engaged in editing formulas in order to understand how to best fix the bugs. Finally, Waller (1999) showed that flight crews experiencing non-routine events commit fewer performance errors when they respond to such
events through timely implementation of actionable interventions (information collection and transfers; task prioritization; task distribution). Hence:

Proposition 8: Because they reorient the attention of project members to areas of discrepancy in the performance of their primary tasks, actionable IT interventions are beneficial to the quality of work of project members.

Proposition 9: Because they reorient the attention of project members to areas of discrepancy in the performance of their primary tasks, actionable IT interventions are beneficial to the learning of project members.

METHODOLOGY

Qualitative Design and Site Selection

A qualitative approach was deemed appropriate for collecting individual-level data about IT interruptions in a project environment. First, there is virtually no research that is explicitly focused on IT interruptions, which calls for a method that is able to provide rich insights into this nascent area (Benbasat et al. 1987). Second, the qualitative inquiry allows us to examine the phenomenon of IT interruptions within a natural context in a project environment. Third, consistent with our definition of IT interruptions as perceived events, such an approach enables us to directly capture the experiences of actors. Finally, the qualitative approach helps us to validate the IT interruptions taxonomy (e.g., add, modify, or delete categories) and performance propositions without forcing any specific response categories on the informants.
The objectives of the qualitative inquiry were to (1) validate the IT interruptions taxonomy; (2) explore the individual performance effects of the selected interruption subtypes in the taxonomy; (3) complement the deductive analysis with an inductive one that reveals any additional IT interruptions categories and/or other effects on performance.

The qualitative inquiry focused on studying IT interruption types and subtypes by sampling individuals working within project teams. These individuals are unlikely to have experienced even numbers and types of technology interruptions. Hence, the unit of analysis is the interruption subtype and – since interruptions are experienced mostly individually – the unit of observation was the individual project member working in a project environment.

As a specific context for such projects, we selected our research sites among new product development (NPD) units. First, this is appropriate because in NPD, performance is often contingent on developing products in a timely manner. Since interruptions are temporal events, this allows us to observe how they impact individual performance in NPD in a context where time plays a key role. Second, it is likely for interruptions to manifest intensely in the NPD environment, which is non-continuous in nature and where individuals typically operate under significant pressures. Finally, individuals in cross-functional units use IT extensively in NPD for communication, collaboration, and decision making (Nambisan 2003), which is likely to provide fertile ground for the emergence of IT interruptions. Within this context, the NPD project is conceptualized as a process of developing digital or physical products or product components comprising roughly the following set of interdependent tasks: idea generation; concept development; product/process design; testing and validation; market launch (Cooper 2001). At any given time, an NPD unit is involved in one or more NPD projects under its umbrella. Tasks are distributed among individuals in cross-functional teams in a way that forms a network of
interdependencies where, at a given point in time, an individual may be involved in one or more tasks belonging to one or more projects in their project portfolios.

We targeted individuals in NPD units via a heterogeneity sampling approach, which serves to replicate and extend emerging theory (Eisenhardt 1989; Gersick 1988; Patton 2002). This strategy was aimed at facilitating our development and validation of the IT interruptions taxonomy as well as supporting the effects on individual performance. As noted by Harris & Sutton, “Similarities observed across a diverse sample offer firmer grounding for […] propositions than constant elements observed in a homogenous sample” (1986, p. 6). To achieve this, we looked for common patterns across the heterogeneous sample. Also, we allowed for potentially contradicting cases in order to see whether there were other IT interruptions that did not fit within our taxonomy, or whether there was contradictory evidence pertaining to the effects of IT interruptions. If such contradictory evidence was found, it would have to be explained with respect to our theoretical framework, while the absence of such contradictory evidence would serve to strengthen our conclusions.

We varied the selection of research sites and studied participants by five specific attributes that allowed us to learn more about IT interruptions and their effects. First, to capture a broad array of IT interruption categories, we selected individuals organized in teams with varying levels of task interdependence. For example, we expected to observe IT interventions primarily in teams with high task interdependence. The logic behind this comes from organizational information processing theory, which posits that increasing task interdependence among individuals or organizational units is matched by corresponding increases in communication frequency and other information processing mechanisms that are designed to

---

8 As the results will show, the resulting patterns were mostly consistent across this heterogeneous sample, indicating that informants with diverse attributes have common perceptions and experiences about IT interruptions.
facilitate task execution among the interdependent entities (Galbraith 1977; Gattiker & Goodhue 2005). Indeed, the positive relationship between task interdependence and communication-based feedback mechanisms among organizational units has been confirmed in NPD (Souder & Moenaert 1992) and other settings (van De Ven et al. 1976). Additionally, one is less likely to see system intrusions as a significant issue in teams with high task interdependence since interdependent team members can engage in mechanisms that mitigate the salience of events such as role switching (Ren et al. 2008) and task distribution (Waller 1999). With respect to the other IT intrusion subtypes, we had no a priori rationale to assume that their saliency would vary as a result of task interdependence.

Second, we selected participants with a diverse set of NPD-related roles (e.g., NPD managers; product/process designers; marketing professionals; manufacturing engineers) in order to elicit information from highly knowledgeable informants, to limit biases, and to view the evidence from multiple perspectives (Eisenhardt 1989). We paid special attention to including participants close to the customer interface (e.g., marketing professionals; marketing analysts) as well as those that were part of the internal development process (e.g., developers; designers). The rationale for this was that the former category would be more suitable for observing IT interventions (e.g., feedback from customers about existing or desired product features; bug fixes) while the latter category would be more directly related to intrusions that impede the product development process.

Third, to allow for different technology interruptions to be revealed, we targeted NPD units involved in a wide range of physical and digital products that relied on different technologies.
Fourth, since we conjectured that the frequency of interruptions influence individuals’ perceptions about the effects of interruptions, we studied individuals within teams that were both small and large, with a team size of ten as a cut-off point (see Hackman 2002). We expected inefficiencies due to team size to allow more IT interruptions to emerge in larger teams (Martins et al. 2004).

Finally, we selected individuals with varying levels of project experience (with the cut-off point being one year) to rule out whether experience mitigates individuals’ perceptions of the adverse influence of IT intrusions (see Cades et al. 2007; Edwards & Gronlund 1998; Hess & Detweiler 1994; Oulasvirta & Saariluoma 2006; Trafton et al. 2003).

Beyond those heterogeneous attributes, we allowed some of our selection criteria to remain constant across the cases. First, individuals had to be involved in a current or recent (going back one year) NPD project. Second, NPD activities needed to occur within a team context. Finally, individuals needed to use IT for communication, collaboration, decision making, and so forth.

Following Mason (1996), we constructed a list that documented our quota targets. This list specified the range and number of the different sampling units to be included, based on the heterogeneity sampling strategy described above. The list is shown in Table 2 below.

<table>
<thead>
<tr>
<th>Table 2: Quota Target List</th>
</tr>
</thead>
<tbody>
<tr>
<td>The sample is to include:</td>
</tr>
<tr>
<td>• Individuals from at least 2 small teams</td>
</tr>
<tr>
<td>• Individuals from at least 2 large teams</td>
</tr>
<tr>
<td>• Individuals from at least 2 teams with low task interdependence</td>
</tr>
<tr>
<td>• Individuals from at least 2 teams with high task interdependence</td>
</tr>
<tr>
<td>• Individuals from at least 2 teams that develop physical products</td>
</tr>
<tr>
<td>• Individuals from at least 2 teams that develop digital products</td>
</tr>
<tr>
<td>• At least 4 individuals with a low level project experience</td>
</tr>
<tr>
<td>• At least 4 individuals with a high level project experience</td>
</tr>
<tr>
<td>• At least 4 NPD managers</td>
</tr>
</tbody>
</table>
This approach resulted in the selection of 21 individuals from the NPD units of eight organizations as a basis of this investigation. The interviewee list is shown in Appendix 2, which illustrates the heterogeneity criteria in columns and the individual cases in rows. The eight organizations included in this discussion are referred to as Alpha, Beta, Gamma, Delta, Epsilon, Zeta, Eta, and Theta. Alpha is a small, Canadian-based company that develops engineering software solutions supporting product designers in the process of NPD. The individuals we interviewed were part of a team that develops a drafting solution. Beta is a large, global engine maker, with the particular individuals we interviewed being part of a team involved in developing gas turbine engines for industrial power generation and oil and gas mechanical drive applications. That team has over 200 members that are distributed across three countries. Gamma is a small developer of Web Analytics software with a large, international customer base. Individuals in Gamma were selected from teams of various sizes and occupied various roles such as development, marketing, and marketing research. Delta includes a small, Canadian-based team of engineers that develop test solutions for a broad range of high-speed semiconductor device interfaces. Epsilon is a global manufacturer of denim jeans, with the focus in this study on an individual within a small team of three designers. Zeta is a Canadian company that specializes in international film productions and interactive digital media. Eta is the international arm of a global, multinational corporation that makes a broad range of computing solutions, where we interviewed three software development engineers. Finally, Theta is a subsidiary of a large, European bank that develops financial solutions.
Data Collection

Preparatory Stages for Data Collection

Initial set-up. The set-up phase consists of collecting background information about the research sites from their published websites. In some cases, information was also retrieved from online business databases and the business press. Also, since several of the sites were recruited through personal connections, such information was also collected directly from those contact people or the person who referred the author to the site. The main information sought at this phase concerned the main products developed at the company, information about the development team (if available), and information about how well the company was doing.

Kick-off of the project with contact person. To initiate the data collection phase, logistical issues were arranged mostly with the key contact person. This included sending the participation letter, setting up a meeting with the contact person to explain the objectives of the study and obtain background information, signing the consent forms, and developing a data collection strategy. The participation letters that were sent to the key people explained the goals of the research project, the participation requirements, ethical procedures, and the benefits from participating in this project (see Appendix 3 for a sample participation letter). Also, the following issues were settled with the key contact: (1) key people to be interviewed; (2) timing and duration of interviews; (3) location of interviews; (4) preparatory procedures prior to interviews, if any; (5) the documents to be collected, if any (e.g., organizational structures; NPD process model).

Prior to collecting data from the research sites, two qualitative methodology experts were consulted on the interview questions. These consultations resulted in revising and/or changing the flow of some questions. Additionally, the interview questions were pilot-tested with two
NPD professionals and this resulted in further refining of the questions and the overall data collection strategy. The interview guide – which contains a rough outline of the questions asked to informants – is shown in Appendix 4.

**Data Collection Procedures**

**Ethical procedures.** Several ethical procedures were followed prior to and during data collection in order to protect the rights of the research participants. First, informants were assured that participation was entirely voluntary and participants could skip any interview questions and/or withdraw at any time during the research. Second, the data were masked to protect the identity of individuals, teams, and companies. Third, the data were stored on a personal computer and access was granted only to the principal researcher, the supervisor, and a research assistant. Finally, the data were used for scientific purposes only while protecting the confidentiality of critical information collected during the study. Official approval was secured from the University’s Research Ethics Board prior to data collection. Appendix 5 shows a copy of the consent form given to research participants.

**Data collection methods.** Data were collected via multiple methods and informants, in order to achieve triangulation and bias reduction. The primary data collection method was in-depth, semi-structured interviews with NPD managers and project members. The interviews guided the flow of the conversation without forcing informants to select from pre-established answers. Due to the nature of the phenomenon, interviews were deemed less intrusive than direct observation (cf. Dix et al. 1998). Also, direct observation is less practical due to costs, the long-term nature of the NPD project, the geographical dispersion of project members, and the difficulty of observing individual instances of technology interruptions that are rather ephemeral.
in nature. However, to provide some triangulation (as well as contextual information about the sites), pertinent documentations were also reviewed such as project documents, company newsletters, and company websites/blogs.

Retrospective bias and impressions management were reduced by selecting highly knowledgeable informants for the interview (NPD managers and cross-functional project members) in addition to the use of reminders for informants to report only on current or recent NPD activities (Eisenhardt & Graebner 2007). To further curb retrospective bias, we complemented the interview data with logs that were completed by some informants and that reported on the real-time technology interruptions they experienced over a period of two days. Leading questions were avoided in the interviews (e.g., we avoided questions like “Do you think that IT interruptions are generally negative?”). Also, questions were expressed in a way to allow informants to use their own words, rather than forcing pre-specified response categories (e.g., we avoided questions like “How do technology interruptions affect learning?”).

Follow-up phone and/or email communication were used to clarify ambiguous information or inquire about new information and emerging patterns. Data collection stopped at the point where the categories of IT interruptions and their purported effects were saturated, keeping in mind to meet the sampling quota targets identified previously. In all, 21 NPD managers and project members were interviewed from eight organizations and the interviews lasted one hour each. For consistency, all interviews were conducted by the first author.

**Data Analysis**

To analyze the data, each recorded interview was transcribed, coded, and summarized in a contact summary sheet. Following Eisenhardt (1989), two types of analyses were conducted:
(1) individual case write-ups that yield unique patterns at each site (within-case analysis); (2) comparing patterns across sites for similarities and differences (cross-case analysis). The logic behind the within-case analysis is that “initially each case must be understood as an idiosyncratic manifestation of the phenomenon of interest” (Patton 2002, p. 450).

For the cross-case analysis, chains of evidence were established (see Appendix 6) that reconciled the data with the theoretical dimensions defined a priori (e.g., technology interruption types; performance consequence). An analytic induction approach (Patton 2002) was also used to complement the deductive analysis with an inductive one where, based on emergent understandings from the qualitative evidence, additional hybrid technology interruptions were identified and propositions relating those interruptions to performance were developed.

RESULTS

In this section, we present excerpts of the interview data to support both the IT interruptions taxonomy and the propositions relating the three IT interruption subtypes to individual project performance. Furthermore, a new type of hybrid IT interruption emerged directly from the data. Evidence for this new type of interruption and its effects on performance is also presented below.

Evidence of IT Interruption Subtypes in the Taxonomy

Analysis of the data indicated that both IT intrusions and IT interventions were experienced by NPD project members. We also found evidence of the existence of all IT interruption subtypes. The main quotations from key informants that provide support for the various categories in the IT interruptions taxonomy are summarized in Appendices 7 and 8.
IT Intrusions

Informational Intrusions. Informational intrusions were mostly manifested with NPD project members being copied on emails that were irrelevant to their work in the development projects. Some individuals perceived such interruptions as attempts to keep them in the loop (e.g., Assistant Product Designer, Epsilon; see also quote Q1, Appendix 7)\(^9\) while others perceived them as documentations disseminated by interrupters to deflect responsibility; a “cover your own back” phenomenon (VP development & distribution, Zeta), or a way to “avoid facing the issues” (NPD manager, Beta; see also Q2). Other times, project members got interrupted with notifications from others who faced problems with their work (Q3).

Communicational Intrusions. We also found evidence of communicational intrusions such as information requests that impinged on project work. Such requests were typically initiated by individuals from other departments, and often by superiors (Q4, Q5).

Actionable Intrusions. The data revealed that to the extent that the information required in information requests was not ready-at-hand and had to be searched and prepared, such information requests can actually be classified as actionable intrusions (Q6). We also found that actionable intrusions were addressed via IT tools that were not restricted to the email medium (Q6, Q7, and Q8).

System Intrusions. System intrusions were caused by both system properties interfering with product development tasks, and system crashes that could block the whole development process. For example, some NPD project members experienced interruptions as a result of the features of the systems they used in product development being too slow or not working as

\(^9\) The quotes in Appendices 7, 8, and 9 are numbered for ease of referencing.
planned (Q9). Most system intrusions, however, came in the form of lack of availability of technology resources due to system crashes (Q10, Q11).

**IT Interventions**

The data indicated that the other main type of IT interruptions – namely IT interventions – was also present among NPD project members. Such interruptions were mostly in the form of IT-mediated feedback (see Appendix 8).

**Informational Interventions.** NPD project members often received information in the form of feedback while working on their primary tasks. Consistent with our heterogeneity sampling criterion of task interdependence, we found that such interventions were intensely witnessed in teams with high task interdependence such as the teams we interviewed in Gamma and Epsilon. This feedback was about product issues either at the pre-launch stage or at the post-launch stage if the product was in continuous development. It was largely delivered by email (Q1, Appendix 8). Beyond email, Twitter notifications - or “Tweets” - from clients were also considered by NPD project members as informational interventions that provide real-time feedback and insights about product features, issues, limitations, and things customers like or dislike about a product under development (Q2).

**Communicational Interventions.** IT-mediated interventions also entailed multidirectional exchanges among product developers or other individuals from the internal departments as well as interactions with customers that interrupted the main project work but also refocused attention on discrepancies in performing such work (see Appendix 8). For example, project members from Alpha and Gamma described how developers collaborated on their tasks via a shared workspace that disrupted the way the work was performed (Q3, Q4). The
distribution and marketing manager from Zeta similarly referred to email discussions with customers that stimulated changes in task performance (Q5).

**Actionable Interventions.** NPD project members also experienced IT-mediated interventions that triggered the execution of actions related to their primary tasks. As elaborated by a development engineer in Eta, emails were sometimes responsible for such behavioral changes (Q6). Also, actionable interventions came frequently from clients who requested changes in product features (Q7, Q8).

**Effects of Three IT Interruption Subtypes on Individual Project Performance**

Here we present evidence from the qualitative inquiry to test the propositions linking the three IT interruption subtypes to individual project performance. The main quotations that support the propositions are summarized in Table 3 (system intrusions and actionable IT intrusions) and Table 4 (actionable IT interventions).

**Effects of System Intrusions and Actionable Intrusions on Individual Project Performance**

Consistent with our propositions, NPD project members perceived overall negative effects of system intrusions and actionable intrusions on their individual project performance, as assessed by efficiency, quality, and learning. A critical point we wish to reemphasize here is the notion that to better understand the efficiency costs of intrusions, it is important to consider not only project time (structural effect), but also temporal switching costs (cognitive effect). A product strategist from Gamma explained this in terms of differences between the duration effects of interruptions (project time) and the frequency of interruptions that leads to fragmenting focus and makes it difficult to return to the interrupted task (switching costs):
It’s the frequency of these things; it is not just about the length. I prefer to have two [interruptions] a week that take me two hours each than 20 that take five minutes each [...] [The problem is] taking the focus away and having to get back into the groove. It’s about ‘What was I thinking? Where was I?’ To sort of rebuild the story I had in my mind.

**Efficiency (Project Time).** System intrusions were found to be especially detrimental to efficiency by consuming additional project time (see Table 3). The data further revealed that this occurred primarily through three interrelated patterns: (1) increasing task completion time; (2) task/project delays; (3) task blocking. In the first pattern, we observed that individuals had to spend more time than planned in completing their primary project tasks. For example, the distribution and marketing manager from Zeta described system freezes she experienced when she created posters for film projects in Photoshop:

> [If] it is a big picture it can take up to 10 minutes and then every time I save, it will be another 5 minutes...

In some cases, significant increases in task completion time also led to the second pattern we observed, namely task/project delays. For example, the CTO of Delta identified productivity issues that led to project slippage when developers migrating from C++ to a Python system had to continue supporting the old development tasks (Q1, Table 3). In other cases, task/project delays occurred independently of the first pattern as a result of intrusions that compelled NPD project members to prioritize between tasks and to reschedule project tasks in order to accommodate the intrusions (Q2). Regarding the third pattern, we found that some project tasks could become completely blocked through the onset of system intrusions (Q3, Q4).

**Efficiency (Switching Costs).** With regard to the cognitive dimension of efficiency, data from the qualitative inquiry revealed that temporal switching costs were incurred from actionable
IT intrusions. While we found that system intrusions could also contribute to such switching costs, this mainly occurred in the relatively uncommon case of system intrusions lasting for long durations. For example, a software developer from Alpha incurred switching costs when he returned to his project tasks after spending half a day trying to resolve system issues and then having to figure out where he left off. By contrast, even brief actionable intrusions could trigger switching costs, owing to the interference generated by cognitively demanding secondary tasks that compete for individuals’ attention. NPD project members reported that the problem was one of being taken away from project tasks that required deep focus, having to suppress cues associated with the tasks left behind to perform the interruptive tasks, and then having to reactivate cues associated with the task to be resumed (Q5, Q6, and Q7). Individuals described the effects of such interruptions with terms such as “losing the flow” (director of post-production, Zeta), “ramp-up time” (senior software developer, Delta), and the difficulty to “be back into the mood” (head of strategic planning and product development, Theta). Such switching costs were especially salient with complex primary tasks (software developer 2, Alpha), complex interruptive tasks (CTO, Delta), and creative tasks that require continuous flow (director of post-production, Zeta).

In summary, the data show that both the structural and cognitive dimensions of efficiency were adversely affected by IT intrusions. A question that remained was how the effects of such events that occurred at the task level accumulated to a more aggregate level that influenced the individual’s project work as a whole. We found four mechanisms through which system and actionable intrusions affect an individual’s overall project efficiency: (1) accumulation over time; (2) accumulation over chains of activities; (3) accumulation over interruption phases; (4) ripple effects across tasks. First, detrimental effects on efficiency accumulated with the
increasing frequency of the intrusions. As a NPD manager (Alpha) remarked, “Two minutes from one email, two minutes from another, so it adds up.” Similarly, a software developer from Eta complained that non-project-related instant messaging messages “are really interrupting, because they accumulate; two seconds here, two minutes here, one minute there.” Second, the effects of the intrusions also accumulated over chains of activities set off by the initial interruption. For example, a NPD manager at Alpha said this about intrusions in the form of email: "It keeps on bouncing back and forth and the email becomes way, way, way too long. It just becomes a chain of email activity." This is consistent with prior research by Okhuysen and colleagues (Okhuysen 2001; Okhuysen & Eisenhardt 2002) who conceptualize interruptions as clusters of subsequent activities that follow an initial attention switch. Third, consistent with our definition of IT interruptions as events that may involve various phases such as detecting, processing, and integrating the interruptions content (Iqbal & Horvitz 2007; McFarlane 2002; Okhuysen & Eisenhardt 2002), we found informants who referred to the effects of interruptions covering those various phases (e.g., some mentioned that just reading emails affected their productivity before even reacting to the email messages). Finally, there were some ripple effects of the intrusions that were caused by task interdependency. As noted by the head of strategic planning and NPD at Theta, "It [system intrusions] ends up creating backlogs in other aspects of the product that are dependent on this being finished." Based on the above analysis and the evidence summarized in Table 3, Propositions 1 and 2 are supported.

**Quality and Learning.** Similar to what we found with temporal switching costs, the data indicate that actionable intrusions are responsible for decrements in the quality and learning
dimensions of individual project performance. System intrusions were not as cognitively demanding, did not typically insist on action, and did not “lead into other steps” that competed for attention (Product strategist, Gamma). One informant indicated that “system issues like network failures and these sorts of interruptions have a time impact for sure, but they don’t really affect the quality of work” (Software development engineer 3, Eta). When system intrusions were detrimental to quality, it was primarily due to the nature of the tools themselves not being available or not working properly (e.g., defect in a quality control tool, which in turn allows defective products to pass) rather than their interruptive nature that interferes with the functioning of a primary task.

Conversely, we found that actionable intrusions were detrimental to quality and learning, although several facilitating conditions needed to be in place for such detrimental effects to crystallize. Those conditions were that intrusions needed to reflect task switches that were unanticipated, demanding, and insistent on action. Also, they needed to interrupt complex project tasks that require deep focus (Q8, Q9) and occur at points in the task where no closure had been reached (Q10). With such mechanisms in place, actionable intrusions caused individuals to become overwhelmed having to juggle their attention back and forth between the primary project tasks and the intrusions, and having to suppress and reactivate the cues that were associated with those tasks. This led to various performance problems such as cognitive load (Q11), errors (Q8, Q11), wrong decisions (Q11), lower ability to find solutions (Q9), decrease in creative output (Q10), decreased levels of understanding (Q9), and forgetfulness (Q11). This evidence – combined with the evidence in Table 3 – supports Propositions 4 and 6 (informants did not

---

10 NPD workers often mentioned quality and learning outcomes together, which is why we present the results associated with them together.
envision system intrusions to affect quality and learning, so Propositions 3 and 5 are not supported by the data).
| System Intrusions | Q1 [Referring to system migration from C++ to Python]: It took two months of start-up issues where you assign some tasks to the developers and they started doing them but they were distracted by either having to support the old code or by having to learn the new code, so what happened is the project slipped by I would say by 8 weeks because of that. (CTO, Delta) | ✓ |
| Q2 Well from my point of view whenever such a thing [breakdown of network server] happens my first thought is that because I am responsible for the schedule and the momentum of the project so if I do not deliver on a certain date that means it gets rescheduled to some other date and that means my project is being postponed. (NPD manager, Beta) | ✓ |
| Q3 Software and network failures are not very frequent, but when it happens it can become a blocker and take a lot of time to resolve. This time is project time. I can't work on a project if I don't have access to the resources. (Software development engineer 3, Eta) | ✓ |

| Actionable Intrusions | Q4 [Referring to a meeting with the CEO where she was demonstrating product features]: Then the system is crashed and you cannot do anything so you find yourself completely handicapped and we have just to wait until the system goes back online. (Head of strategic planning and product development, Theta) | ✓ |
| Q5 [Some tasks] really require all your attention. You have to be inside the problem [...] you cannot do it by slices and have to do it as a whole [...] For example, last week I was working on a complex issue, using analytic geometry on the drafting system in order to change multiple system parameters that are all linked together. I was interrupted by other non-related email tasks and this made me forget the mental state in which I was. I was not deep into the problem anymore. I was taken out of it and had to spend more time to return to the same point. (Software developer 2, Alpha) | ✓ |
| Q6 Yeah, that can be something major too because you are working on something in the middle and then you have to switch to other stuff [referring to computerized tasks that are not related to the project work of test automation] and when you come back you probably have to restart from the beginning so that is double. (Quality assurance specialist, Alpha) | ✓ |
| Q7 When we are developing a new banking product a lot of the tasks require deep focus. So when you get distracted by your computer to do other stuff, then you have to start the process all over again mentally in order to reach the stage where you were previously. It often takes about half an hour after a long interruption just to recover mentally and be back into the mood and in the environment where you left off. (Head of strategic planning and product development, Theta) | ✓ |
| Q8 [On email prompting switching to tasks unrelated to vibration testing]: Vibration testing is a complex process. You have to simulate the vibration environment, measure the pressure waves, the input signals, do the modal analysis. If I keep being pulled to doing other tasks required by our other departments, this raises the likelihood that errors will be committed in my work (Vibrations specialist, Beta) | ✓ |
| Q9 Part of our work entails mathematical problem-solving tasks. When I am doing complex mathematical tasks, such as analytical geometry, being constantly interrupted with other tasks that have nothing to do with what you are doing can really affect how you understand and tackle these problems. For some problems that can be solved in one day if I really concentrate, I can spend one month and not find a solution. (Software developer 2, Alpha) | ✓ |
| Q10 [Referring to effects of emails that prompt switching to tasks unrelated to developing new movies]: Yeah, I think it is definitely flow especially because it is a very creative process and you know with music and everything coming in I sort of look at it as one piece. When you are interrupted with other tasks you sort of break the piece into separate pieces which I do not think sometimes works as well for certain movies. I think it sometimes impacts creatively how we can work and what we get out. (Director of post-production, Zeta) | ✓ |
| Q11 When I am struggling to meet the deadlines and then my email keeps telling me 'No, do this instead,' I can become overwhelmed, forget stuff, and make wrong decisions. It's not worth it, especially since many of those things that interrupt us are not even part of the development projects. (Distribution and marketing manager, Zeta) | ✓ |

Table 3: Data Supporting Propositions on System Intrusions and Actionable Intrusions

<table>
<thead>
<tr>
<th>Supporting Evidence</th>
<th>Proposition Support</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P1</td>
</tr>
</tbody>
</table>

- P1: Evidence supports P
- P2: Evidence does not support P
- P3: Evidence supports P
- P4: Evidence does not support P
- P5: Evidence supports P
- P6: Evidence does not support P
Effects of Actionable Interventions on Individual Project Performance

Consistent with the propositions for actionable IT interventions, evidence from the interviews suggests that such interruptions are detrimental to efficiency in terms of project time, but that they enhance quality and learning (see Table 4).

Efficiency (Project Time). Actionable interventions did not have effects on the cognitive dimension of efficiency since they did not lead individuals to switch their attention to non-project activities. However – as we elaborated earlier – such interventions aim at improving the performance of the main project tasks, and in the process of doing so they may consume additional project time as individuals dedicate time and effort to closing the performance discrepancy. We found evidence in the qualitative data that supports Proposition 7 relating to the detrimental effect of actionable interventions on the structural dimension of efficiency, namely project time. This seemed to depend on the magnitude of the discrepancy. For small discrepancies such as changing the color of a product (Q1, Table 4) or the location of an icon (Q7), no significant effects on efficiency were reported. Conversely, larger discrepancies take more time to resolve (Q1, Q2). Two patterns were observed for the detrimental effects of IT interventions on efficiency: increased task completion time and task/project delays. Those patterns were manifest throughout two processes performed by NPD project members: (1) making sense of the discrepancy revealed by the intervention; (2) responding to the intervention in order to close the discrepancy. First, efficiency was adversely affected as individuals had to reflect and consciously think about what brought about a particular discrepancy. For example, a product manager at Gamma reported:

*While the web analytics tool was still under development, we got some customer feedback on our Twitter site that told us the product was not capturing analytical data about their website visitors in the right way. We had no idea what was*
causing this and it took a while to troubleshoot. I had to freeze development for a while until this issue was fixed before releasing the next product iteration.

Second, efficiency was also affected while individuals had to come up with a solution that closes the task performance discrepancy. This often involved several iterations with clients and/or other stakeholders and it sometimes involved changes in planning or implementation strategy (Q1).

Quality. Consistent with our theorization, we found that actionable IT interventions enable NPD project members to improve the quality of their work, and this was translated to the final product that was being launched. Quality improved by interrupting individuals’ ways of working and triggering a more mindful information processing mode. In particular, three primary mechanisms associated with such mindfulness were salient: (1) an informational mechanism; (2) a motivational mechanism; (3) a reflective mechanism. In the informational role, the interventions furnished individuals with critical information that revealed a discrepancy in some aspect of their task performance typically relating to product issues or features, and reoriented them toward the gap (Q3). Second, actionable interventions were also beneficial to quality through a motivational mechanism that stimulated individuals to close the discrepancy (Q4). Third, they also triggered a more reflective information processing mode in which individuals became sensitized to new possibilities and integrated them into a better product solution (Q5). Based on the above and the results in Table 4, we conclude that Proposition 8 is supported.

Learning. NPD project members indicated that actionable IT interventions are beneficial to learning (Q7). We also found some evidence of how the technology component in such interventions was in particular conducive to learning. This effect was salient when NPD project members used specific IT tools to manage interventions such as bug reporting tools. First, we
found that individuals used the feedback system as a knowledge repository, which helped cue their memories and effectively reuse knowledge from past interactions with the issue and from past projects. As such, once individuals were interrupted with bug fixing requests for products they were developing, they could search the system’s database for information that would help them to better learn about the bug and ways to fix it. A product manager from Gamma stated:

*The interaction with [name of tool] is very effective; it is like a super-notebook. It is an interruption I guess but it is very positive because if it is not recorded you will probably forget the details. The list never gets lost and the tracking is very accurate. So we can go in there, search for an issue, find out the history, and through the process of fixing this issue we can actually relate it to the source code that was changed during the process. It is very powerful.*

Second, we found that individuals also used the feedback system as a troubleshooting guide. As such, interruptions with product bugs are presented to individuals in visually and/or textually stimulating ways through the system so that they can better learn how to trace the problem, limit its range, and address it in a step-by-step manner.

*In the system there is a description of when and how it happens; like the customer was doing this operation with that file and the file is normally attached in the system and I can open it in my system and look what is going on there. So we have like breakpoints; control points where we can execute the program step-by-step, and I can qualify whether I am I right or not. So I find that the problem happened exactly in this place.* (Software developer 2, Alpha)

Based on the above and results summarized in Table 4, Proposition 9 is supported.
### Table 4: Data Supporting Propositions on Actionable Interventions

<table>
<thead>
<tr>
<th>Actionable Interventions</th>
<th>Supporting Evidence</th>
<th>Proposition Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 [Referring to customer feedback on product features that are being launched]: The merchandisers would actually e-mail us [...] and if it is something they want to have in this pant in this color where they need me to initiate one more color, it is not a big deal. It is already my task-at-hand to which I need to add something so I just work on it. But then if it is something major then we would have to stop and redesign. Redesigning is a major task because that involves other people. It involves bringing the contractor and communicating the change with the technical designer. Then I have to update an Excel sheet with the specifications. So if the feedback involves a total overhaul of something, it is like a ripple effect where you have to involve more and more people. And they have to come back to you because you want to change this but to change that, this would delay things (Assistant product designer, Epsilon)</td>
<td>P7</td>
<td></td>
</tr>
<tr>
<td>Q2 [Referring to “Tweets” and blog comments from clients who are using a beta product undergoing development]: Well from the customers’ perspective I guess if they are complaining from something relating to the product it is negative in the sense that it takes time and work to address their concerns, but it is positive in the sense that they are telling me about something to be fixed, which will help me improve the product. (Product manager 1, Gamma)</td>
<td>P7, P8</td>
<td></td>
</tr>
<tr>
<td>Q3 Yeah, a new thing that we are also doing now is that when we work on a new project, we get emails from our internal departments providing feedback that can help us improve our product offering. In fact, it is usually good feedback because they filter information from the clients and they come up with something that is essential to the product or which we should focus on. (Product manager 2, Gamma)</td>
<td>P7</td>
<td></td>
</tr>
<tr>
<td>Q4 The emails that contain feedback about the tasks I am doing can help me in a lot of ways. They can help me see things that are open in the project, help me create the big picture, re-prioritize what I am doing, and be more attentive to the important issues. When the feedback is negative I may be disappointed for a while but I am also motivated to get it working. It helps me see the problems and fix them. (Software development engineer 3, Eta)</td>
<td>P7</td>
<td></td>
</tr>
<tr>
<td>Q5 [Referring to customer email feedback on product features that are being launched]: Most of the requests for change are positive because customers open your eyes to things that take your product to the next level and align it with the market [...] So these emails are interruptive but also positive in the sense that they help you give people what they want and make people happy. And of course your own performance is tied to that. (Assistant product designer, Epsilon)</td>
<td>P7</td>
<td></td>
</tr>
<tr>
<td>Q6 [Referring to email interruptions about bug fixes for products under beta release]: The good part of this is that you get to find these bugs early before release so you can fix them. This improves the quality of your work and preserves the image of the company as a whole in front of the end-users. (Software development engineer 2, Eta)</td>
<td>P7</td>
<td></td>
</tr>
<tr>
<td>Q7 Some of the emails we receive may be related to some pending issue in our decision. Like for example in the web development world we usually depend on some graphic work that should be delivered from graphic designers, so every now and then I receive some e-mails about those new website designs, those new icons. I think those icons should better be placed like this. What do you think? Try them on the existing work and give us our opinion, these sort of things. In this case these emails interrupt you because they make you change your perspective. You are provided with new ideas like in this case a new way to place the icons, and this makes you change some of the code in order to try out these new designs in your work. You have to make it fast and prepare for the next deployment or the next release so these emails are good because they help you to learn how to do something in a different and better way. (Software development engineer 2, Eta)</td>
<td>P7</td>
<td></td>
</tr>
</tbody>
</table>
Hybrid Interruptions

The inductive portion of our data analysis uncovered a new IT interruption type that is a hybrid of intrusions and interventions. For this type of interruption, individuals were interrupted with informational, communicational, or actionable events that – while having content that is different from the primary task – were related to the focal project or to other development projects they were involved in, and hence, fell within their overall project portfolio. These hybrid interruptions are partly intrusions, because they divert attention from the primary task activities, and partly interventions, because their contents are related to the individual’s project portfolio and thus they help focus attention on some other project-related aspects. For hybrid informational and communicational interruptions, the intervention component is such that useful information is disseminated to or exchanged among NPD project members, which helps orient their attention to some other task or project in their project portfolio. For hybrid actionable interruptions, individuals switch their attention from the primary task to execute a secondary task that is part of the focal project or part of another project in their portfolio. Those interruptive secondary tasks generate useful feedback – either from knowledge gained of the task itself or from IT-mediated feedback generated by others – that can be imported by individuals into performing their overall project work. Also, when the interruptive tasks in hybrid interruptions are similar in nature to the primary tasks that are interrupted, opportunities for cross-learning occur.

Hence, hybrid interruptions are not just any interruptive activities that concern tasks within the project portfolio other than the primary task. For a hybrid interruption – whether informational, communicational, or actionable – to be considered a hybrid between intrusions and interventions, its content needs to focus on tasks other than the primary task, but it must also
provide feedback that can be imported by individuals back into the primary task or to other tasks that fall within their project portfolio. Qualitative evidence for the existence of hybrid interruptions is summarized in Appendix 9.

**Hybrid Informational Interruptions**

The first subtype of hybrid interruptions that emerged from the data was that of hybrid informational interruptions. Here, project members experienced mostly email interruptions that diverted attention from the primary tasks, yet contained useful information about other NPD tasks from the same or from other projects. Such interruptions consisted mostly of (1) status updates and information on NPD projects, and (2) competitive intelligence. For example, some members provided internal updates, feedback, and inspiration about product development issues (Q1 and Q2, Appendix 9). Others were externally-oriented updates about competitors and market trends (Q2, Q3).

**Hybrid Communicational Interruptions**

Like hybrid informational interruptions, hybrid communicational interruptions came mostly from email. Some such interruptions focused on technical discussions about technologies and competition (Q5). Others also referred to email information requests about past or future projects (Q6).

**Hybrid Actionable Interruptions**

Hybrid actionable interruptions were experienced by NPD project members where they were required to switch attention from the primary task to execute other NPD tasks. These other
tasks could be part of their focal project (Q7, Q9) or other projects in their project portfolio (Q8, Q10). For the latter category, such interruptions came from clients and were about addressing issues concerning products or product features that were already released.

Furthermore, hybrid actionable interruptions were manifest in the development environments of both physical and digital products. In the former case, NPD project members mentioned interruptions that required shifting their attention to other project tasks (Q7). In the latter case, they were manifested as software bug fixes for product components other than the ones developers were currently working on (Q8, Q9, and Q10).

**Effects of Hybrid Actionable Interruptions on Individual Project Performance**

Since the extant literature is focused on interruptions to singular, contrived tasks, it does not provide a solid ground from which to develop performance propositions for hybrid technology interruptions that affect tasks embedded in interrelated projects. Hence, we develop those propositions inductively, based on insights from the qualitative inquiry. As we show below, hybrid actionable interruptions entailed tradeoffs between efficiency and learning.\(^\text{11}\) Also, NPD project members perceived both benefits and detriments to quality from such interruptions. The quotes that guide our proposition development efforts are summarized in Table 5.

**Efficiency (Project Time).** Overall, the effects of hybrid actionable interruptions on the structural dimension of efficiency were more complex than for the respective IT intrusions and IT interventions. With actionable intrusions, such interruptions consumed additional project time because attention shifted to non-project activities. With actionable interventions, additional project time was consumed because reorienting attention to the primary task to close

\(^{11}\) To remain consistent with the propositions developed for the IT intrusion and intervention subtypes, we present here propositions related only to hybrid actionable interruptions.
performance discrepancies entailed effort and time to redo the work, figure out how to close the gap, and so forth. However, in the case of hybrid actionable interruptions, attention is shifted from the primary task to other project tasks or other projects within the project portfolio. So for those hybrid interruptions that entail information transfers or switches to secondary tasks within the project portfolio, the time it takes to complete the primary task may be increased. However, it is not necessary for such interruptions that total project time will be increased or that projects will be blocked and/or delayed. In fact, there may even be efficiencies due to load-balancing between projects and project tasks. As an assistant product designer from Epsilon observed for email interruptions about other tasks in the project portfolio:

*I cannot really say they are entirely positive [...] It depends on how you look at them because they are integral, you know. They help you do your work on this project or on other projects. When you communicate with teams and deal with people across different continents – it is such a big production – you are going to have lots of tactical or technical queries about it. So if you think about what is my task at hand, I am doing something so all that is sort of interrupting and taking time from what I am doing but this is also part of the bigger picture of what I am supposed to be doing.*

Overall, the data do not suggest that the structural component of efficiency is negatively affected by hybrid actionable interruptions.

**Efficiency (Switching Costs).** NPD project members seemed to perceive the switching costs of hybrid actionable interruptions similarly to how they perceived them for actionable intrusions. Such costs consisted mainly of the time it took to effectively switch attention between task components across the project portfolio. First, cognitive losses were incurred when project members had to find themselves back in the primary task activities after switching attention to other projects or project components (Q1 and Q2, Table 5). Second, there were cognitive losses when they had to switch to new projects that interjected their current task flow (Q3). Third,
project members (e.g., Director of post-production, Zeta) also described temporal costs due to switching from the main task to tasks that were performed in the past such as backtracking to resolve issues about previously released movies.

**Quality.** NPD project members indicated that hybrid actionable interruptions have benefits as well as drawbacks to the quality of individual work. On one hand, hybrid actionable interruptions – such as email interruptions with bug fix requests – are beneficial to the quality of work because they enable project members to get insights about how to fix discrepancies in the product’s performance (Q5, Q6, Q7, and Q8). This effect is similar to actionable interventions, and it similarly played out via informational (Q5, Q6), motivational (Q9), and reflective (Q7) mechanisms.

However, project members also indicated that the intrusive nature of hybrid actionable interruptions may be detrimental to quality as a result of cognitive load (Q4). Moreover, this occurred especially when such interruptions affected creative work. For example, the director of post-production at Zeta described interruptions from other projects as breaking the creative flow of music production which needs to be considered as one piece.

**Learning.** Like actionable interventions, hybrid actionable interruptions provide learning opportunities by orienting attention toward performance discrepancies and motivating individuals to learn new ways to close such discrepancies (Q9). Beyond these simple learning effects, hybrid actionable interruptions also allowed for cross-learning among NPD tasks and projects (Q6, Q8, Q10, and Q11).

**Proposition Development.** We propose – based on this evidence – that hybrid actionable interruptions entail tradeoffs between efficiency and learning, and carry both benefits and detriments to quality. On one hand, they allow project members to gain access to new insights
and knowledge that can be integrated into their primary tasks and across projects in a way that enhances an individual’s contribution to the quality of product deliverables. However, having to split one’s attention between the primary task and other tasks (or other information contents) within the project portfolio can lead to attentional residues that elicit cognitive overload and negatively affect performance efficiency and effectiveness (Leroy 2009). The tradeoffs between efficiency and learning were noted by project members, who attached different values to such tradeoffs. For example, a product manager from Gamma concluded that the loss of productivity was not worth the gain in learning:

[Referring to bug fixes for other projects] For [a single issue we got so many interruptions] – one online meeting, two conference calls and 16 emails. And that is still ongoing. This is all just about a single customer issue for a free product! [...] Some lessons learned yes but is it worth the time investment? I don’t think so.

A software development engineer from Eta expressed the opposite value:

[Referring to email interruptions about bugs in released products] It may affect my [time] performance but it is worth it. In an organization like [company name], if you fix some urgent bug you learn from it and you take credit for it and you may get your time reallocated to do whatever was delayed.

We revisited the literature to see whether we could provide some theoretical grounding for our inductively-developed propositions on hybrid actionable interruptions. While such interruptions have not been studied explicitly, we found some evidence from adjacent literatures to support such effects. For example, O’Leary et al. (2011) suggested that multiple team membership variety increases context switching, which is conducive to learning as a result of accessing new and diverse inputs that could be immediately integrated into primary task contexts. However, they also suggested that time losses resulting from switching to different task (and team) contexts decrease productivity. While quality effects were not explicitly modeled, one
could argue that exposure to diverse ideas may enhance quality but that switching costs – as per cue utilization theory – can also be detrimental to quality. Similarly, implicit support for the effects of such hybrid interruptions was found in Miller (2002), where individuals working in groups on a simulated radar control task were provided critical task-related information that was only needed for a future sub-task. The study found that such interruptions negatively influence productivity in terms of decision time as individuals had to “start over” after the interruption, but have mixed effects on the quality (accuracy) of the decision. We formulate the following propositions for hybrid actionable interruptions:

**Proposition 10**: Hybrid actionable interruptions are detrimental to the efficiency of NPD project members as a result of fragmentation of attention between the primary task and other project activities, which incurs cognitive switching costs.

**Proposition 11**: Hybrid actionable interruptions are beneficial to the quality of work of NPD project members because they enable them to get insights about how to fix discrepancies in product performance. However, they are also detrimental to the quality of work of NPD project members by breaking the flow of their creative development work.

**Proposition 12**: Hybrid actionable interruptions are beneficial to the learning of NPD project members because they (1) reorient their attention to areas of discrepancy in the performance of their primary tasks, and (2) enable learning across NPD tasks and projects.
### Table 5: New Propositions for Hybrid Actionable Interruptions

<table>
<thead>
<tr>
<th>Supporting Evidence</th>
<th>Propositions Suggested</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Q1</strong> With many email requests about other projects this can really distract you from your actual project and it takes time to find yourself back in. (Software development engineer, Eta)</td>
<td>P10 (-)</td>
</tr>
<tr>
<td><strong>Q2</strong> Here we have a lot, a lot, a lot of such email interruptions [relating to already released products] for a small company I find. You are running like a chicken without a head, you know. So it’s just stuff like ‘Using this tool, it is not working why?’ Then you stop what you are doing and investigate […] I feel I get nothing done in the day, and then I struggle to get back into the high-level thinking. It is really hard to wear different hats all the time. (Product strategist, Gamma)</td>
<td>(-)</td>
</tr>
<tr>
<td><strong>Q3</strong> When the deadline is coming around and we suddenly get an email that ends up becoming another project on board everything stops. If I am juggling too much on my plate, everybody burns out […] My output ends up not being in the same timely fashion as if I did not have that application deadline and the market next week and a deliverable due tomorrow. It will also slow down the flow of my work. (Distribution and marketing manager, Zeta)</td>
<td>(-)</td>
</tr>
<tr>
<td><strong>Q4</strong> [Referring to same event as Q3]: Of course the quality of my work will probably not be as strong as if I only had to work on the application or if I only had to work on the market […] When I am exhausted and I am overworked and just completely overwhelmed of course it will affect the quality. (Distribution and marketing manager, Zeta)</td>
<td>(-)</td>
</tr>
<tr>
<td><strong>Q5</strong> Normally this kind of interruption when we get emails about bugs in released products is good. Yeah, it helps the quality of your performance because some of the issues might not be related to your immediate work [but] to other work or a third-party product that you plug yourself into. Normally web development has to be done and tested across all the browsers […] So when I get a bug like that it helps me gain the perspective of how that browser or that third-party software behaves and helps me enhance our product to support it in the future more across the different browsers. (Software development engineer 2, Eta)</td>
<td>(+)</td>
</tr>
<tr>
<td><strong>Q6</strong> [Referring to an interruption where she had to split attention between tasks comprising testing different product features]: But I would also say that sometimes this would help the quality of the job. Because in your mind when you only work on a particular task, you probably have no knowledge for potential problems. But if you work on another one and they are similar and you get an idea and you double check, so it gives you new knowledge that you can apply. (Quality assurance specialist, Alpha)</td>
<td>(+) (+)</td>
</tr>
<tr>
<td><strong>Q7</strong> [Referring to email interruptions with bug fix requests]: All of this, the purpose of it is to make the product better and by better I define that as clients like it better. So any disruptions that come from the client that you have to solve or react to enhancement so it forces a lot of thinking… forces you to evaluate what a client wants, then it corrects your thinking as you may have gone off […] for a couple of months and maybe the market’s moved a little bit and this allowed you to limus-test it. (VP marketing research, Gamma)</td>
<td>(+) (+)</td>
</tr>
<tr>
<td><strong>Q8</strong> Feedback on released products is always good you know. Yes, it interrupts the tasks I am doing, but it also makes for better quality of my work for the next and other product releases and for new product iterations; enhancing the product and responding to clients’ needs you know […] Many projects we do have commonality in terms of the user experience, usability comments, and stuff like that. So the next time around when you do another product you’re like ‘Aha!’ (Product strategist, Gamma)</td>
<td>(+) (+)</td>
</tr>
<tr>
<td><strong>Q9</strong> [Referring to the effects of email interruptions about bugs in released products]: It actually makes you in a way motivated to go back and discover the bug because in many cases it is your own bug so it puts your mind in an urgent state that wants you to completely leave the task you do and do the context switching we were speaking about and go back and fix it […] So it makes you motivated and it puts you in a learning mode. (Software development engineer 1, Eta)</td>
<td>(+)</td>
</tr>
<tr>
<td><strong>Q10</strong> [Referring to email interruptions triggering switching to other projects]: Definitely I think as I do more and more you sort of build a better mousetrap and I become more efficient. I learn the tricks on how to get it done more efficiently. Although every project</td>
<td>(+)</td>
</tr>
</tbody>
</table>

96
is different and it is always different people so there is different politics, which make it complicated, but there is a lot of crossover between the projects. I get the same request for three different projects and I have to figure out which is the best way to address all these requests. They are slightly different but they pertain to a lot of the same information. So there are ample opportunities for learning from these interruptions across projects. (Director of post-production, Zeta)

**Q11** [Referring to email interruptions relating to other projects in the portfolio]: It is learning all the time. Even in urgent tasks. For example, if you are in the middle of development and the testing engineer emails you to request something for another project, this interrupts you, but it also may trigger something in your mind and you look at the issues from a different perspective. So these interruptions they widen your perspectives and your vision. That is the learning opportunity. Going ahead with this may open issues that you did not really consider in your core components even. (Software development engineer 1, Eta)

<table>
<thead>
<tr>
<th>Interruption Type / Performance Effect</th>
<th>Efficiency</th>
<th>Quality</th>
<th>Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Structural Costs</td>
<td>Cognitive Switching Costs</td>
<td></td>
</tr>
<tr>
<td>System Intrusions</td>
<td>Detrimental: project time (P1)</td>
<td>No effect</td>
<td>No effect (P3 not supported)</td>
</tr>
<tr>
<td>Actionable Intrusions</td>
<td>Detrimental: project time (P2a)</td>
<td>Detrimental: fragments attention (P2b)</td>
<td>Detrimental: more errors (P4)</td>
</tr>
<tr>
<td>Actionable Interventions</td>
<td>Detrimental: project time (P7)</td>
<td>No effect</td>
<td>Beneficial: fix discrepancies (P8)</td>
</tr>
<tr>
<td>Hybrid Actionable Interruptions</td>
<td>No effect</td>
<td>Detrimental: fragments attention (P10)</td>
<td>• Beneficial: fix discrepancies (P11) • Detrimental: more errors; loose creative flow (P11)</td>
</tr>
</tbody>
</table>
DISCUSSION & CONCLUSION

The qualitative inquiries provide preliminary support for our IT interruptions taxonomy and the propositions linking some of the IT interruption subtypes to individual performance in a project environment. This enhances our understanding of the distinct relationships between some IT interruption subtypes and their corresponding project performance outcomes. Convergent with cue utilization theory, we found negative effects of the IT intrusion subtypes (see Table 6, which summarizes the results of the deductive and inductive analysis). Specifically, both intrusion subtypes debilitated efficiency (system intrusions influenced only the project time dimension). Additionally, actionable intrusions were detrimental to quality and learning. Note that this does not mean that intrusions are unanimously negative to individual performance. In several cases, such intrusions were job-related and mandated by superiors (e.g., providing information to managers). However, the detrimental effects that we recorded were restricted to dimensions related to the product development projects, depended in some cases on the frequency of interruption, and depended on the criteria by which NPD project members were evaluated. In contrast to intrusions – and in line with mindfulness theory – actionable interventions were beneficial to all performance outcomes except for their consumption of additional project time (see Table 6). As for hybrid actionable interruptions – while several informants told us that they were part of the job description in a dynamic product development environment where individuals constantly shift their attention among project tasks – they still seemed to have profound impacts on performance. The effects of hybrid actionable interruptions were in between the two extremes of intrusions and interventions. Specifically, hybrid actionable interruptions were detrimental to efficiency, enabled various types of learning within and across projects, and had both beneficial and detrimental effects on quality.
Whereas organizational work is fraught with interruptions that occur in project environments where tasks are interrelated and embedded in larger projects, this paper is – to our knowledge – the first attempt to uncover the effects of IT-based interruptions in such project environments. Earlier attempts have overwhelmingly focused on interruptions at the single task level. By expanding the focus to the portfolio-of-projects level, we unmasked a new type of hybrid IT interruption that intrudes on primary tasks while providing useful input to the larger project or the portfolio of an individual's projects. Figure 1 illustrates the distinctions between IT intrusions, IT interventions, and hybrid interruptions with respect to the relation of the interruptive event to the primary task within an individual’s project portfolio. In previous research, hybrid interruptions were not visible (the B categories) since the focus was at the singular task-level. Such interruptions would then be perceived simply as intrusions to the primary task. This may explain why we found so many examples of actionable intrusions in the literature review but not so many in the qualitative inquiry. By adjusting our lens to the project environment rather than to isolated tasks, it becomes clear that many interruptions that would previously be identified as actionable intrusions are actually experienced by project members as hybrid actionable interruptions.

This finding suggests that it is very important to conceptualize IT interruptions within the context of the interrupted individual. Stated differently, interruptions are in the eye of the beholder. While in previous research interruptions largely occurred in the context of isolated tasks and were artificially imposed, this research suggests that an individual’s task boundaries have a direct influence on the conception and consequences of his or her interruptions. If an individual’s task responsibilities are defined too narrowly, then many interruptions that are not directly related to such tasks will be perceived as intrusions. However, by expanding the task
boundaries such as we did in the NPD project environment, intrusions take on a more extreme position outside of the project’s boundaries and a new category of hybrid interruptions appears in-between intrusions and interventions. Thus, whether a given interruption has a positive or negative consequence will depend on specifying the individual’s task boundaries performance domain (e.g., whether performance is assessed for the individual task or for an overall project).

![Image of Figure 1: Representation of Different Types of IT Interruptions]

Like any research, this paper has limitations. First, apart from distinguishing among system and human activity as sources of technology interruptions, our framework did not distinguish among human sources of interruption (e.g., manager vs. coworker), although
preliminary analyses by some researchers suggest that these may trigger different outcomes (Zellmer-Bruhn 2003). We forwent this distinction in the interest of parsimony and because our research focuses on the nature and role of IT interruptions rather than on developing a general theory of work interruptions. Second, an implicit assumption in this framework has been that actors respond to IT interruptions, even though it has been suggested that work interruptions can be ignored (Staudenmayer et al. 2002). Consequently, future research could examine the degree of voluntariness in responding to technology interruptions and what factors influence the decision to respond as well as corresponding outcomes. Third, whereas this framework centered on the role of IT interruptions, a future step would be to determine whether IT interruptions behave differently from non-technology interruptions (e.g., face-to-face). Research on interruption modality provides initial clues that there could indeed be differences (Nagata 2003).

A final limitation is that our data collection tool relied on informants recollecting their experiences with interruptions, which may introduce recollection bias. However, several techniques were used to mitigate this bias: (1) asking some informants to write email logs that record their email interruptions experiences over a period of two days; (2) inquiring about general patterns and types of interruptions rather than prompting informants to recall specific interruptive events. We still found, however, that some informants would recall specific interruptions instances, which further curbs the potential for recollection bias. Future researchers may employ more granular data collection tools (e.g., diary studies; direct observation) in order to dig deeper into the framework of IT interruptions that we developed.

Those issues notwithstanding, this research has implications for research and practice. It has integrated insights from prior, disparate research streams (e.g., feedback literature; technology features literature; interruptions literature) to produce a new framework of IT
interruptions that improves our understanding about this phenomenon and its potential consequences. The central message in this paper has been that not all IT interruptions are equivalent in nature or have similar consequences. This departs from prior literature where interruptions were seen in a monolithic, mostly negative light. Indeed, seemingly similar forms of IT interruptions have distinct effects on performance depending on the particular content of the event, its relation to the primary task, and the performance dimension being assessed. The framework developed in this paper can extend prior research in several ways. First, it can open new lines of inquiry that enable us to better conceptualize and operationalize phenomena related to IT interruptions and to better study such phenomena in their natural workplace environments (in situ). Second, the framework of IT interruptions can be enhanced and refined by incorporating more interruptive events, developing formal hypotheses that link IT interruptions to performance, focusing on factors that may moderate the relationships, and so forth. Third, the framework can be applied to other organizational contexts, such as to study the effects of IT interruptions on managerial work. Finally, our discussion of hybrid interruptions and the importance of defining task boundaries around interruptions has implications for researchers to adopt an interpretive view of IT interruptions, which considers them as socially constructed events rather than objective artifacts manipulated in the laboratory.

For practitioners, this paper may provide a metric that can be used to disentangle the effects of various IT interruptions they encounter in their organizations. Consequently, managerial policies and interventions can be tailored around this framework, depending on the specific interruption types that need to be dealt with. One important intervention could be the management of the timing of interruptions. For complex tasks, it is better to introduce intrusions when critical points in the task have reached closure. Conversely, feedback interventions should
be introduced at the height of an individual’s engagement in the task in order to aid them in improving performance. If introduced after individuals have already switched their attention to other project tasks, such interruptions may then be experienced as hybrid interruptions that provide useful feedback yet interfere with current task performance.
REFERENCES


Ducheneaut, N., and Bellotti, V. "E-mail as habitat: an exploration of embedded personal information management," *interactions* (8:5), 2001, pp 30-38.


Addas (Essay #1)  

Taxonomy and Performance Investigation of Technology Interruptions


Scott, S. D., Mercier, S., Cummings, M. L., and Wang, E. "Assisting Interruption Recovery in Supervisory Control of Multiple Uavs," Proceedings of the 50th Annual Meeting of the


## APPENDIX 1: IT INTERRUPTIONS IN PRIOR STUDIES OF WORK INTERRUPTIONS

<table>
<thead>
<tr>
<th>Authors</th>
<th>Definition of Interruption</th>
<th>Interruption Type</th>
<th>Interruption Subtype</th>
<th>Role of IT</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Adamczyk &amp; Bailey 2004)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated interruption</td>
</tr>
<tr>
<td>(Altmann &amp; Trafton 2007)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>(Ang et al. 1993)</td>
<td>Not defined</td>
<td>Intervention</td>
<td>• Informational intervention</td>
<td>• IT-induced</td>
</tr>
<tr>
<td>(Arroyo &amp; Selker 2003)</td>
<td>Not defined</td>
<td>Intrusion or distraction</td>
<td>N/a (alert with no particular content)</td>
<td>Only primary task is IT-based</td>
</tr>
<tr>
<td>(Avrahami et al. 1993)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Informational intrusion</td>
<td>IT-mediated (alert)</td>
</tr>
<tr>
<td>(Bailey &amp; Konstan 2006)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated interruption</td>
</tr>
<tr>
<td>(Bailey et al. 2000)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>• Informational intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>(Bailey et al. 2001)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>• Informational intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>(Beeftink et al. 2008)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated interruption</td>
</tr>
<tr>
<td>(Burmistrov &amp; Leonova 1996)</td>
<td>“Events which result in the suspension of ongoing activity, and its subsequent resumption after a lapse of time” (p. 21)</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated interruption</td>
</tr>
<tr>
<td>(Burmistrov &amp; Leonova 2003)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated interruption</td>
</tr>
<tr>
<td>(Cades et al. 2006)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated interruption</td>
</tr>
<tr>
<td>(Cades et al. 2007)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>(Carton &amp; Aiello 2009)</td>
<td>A disruptive event (initiated by a human actor) that impedes progress toward accomplishing organizational tasks) [None]</td>
<td>Intrusion</td>
<td>Not specified</td>
<td>Unknown</td>
</tr>
<tr>
<td>(Cutrell et al. 2000)</td>
<td>Not defined</td>
<td>Intrusion Intervention</td>
<td>• Informational intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>(Cutrell et al. 2001)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>(Czerwinski et al. 2000)</td>
<td>Not defined</td>
<td>Intrusion Intervention</td>
<td>• Informational intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>(Dabbish &amp; Kraut 2004)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>• Communicational intrusion</td>
<td>• IT-induced (system properties)</td>
</tr>
<tr>
<td>Author(s)</td>
<td>Definition</td>
<td>Type</td>
<td>Actions</td>
<td>Example</td>
</tr>
<tr>
<td>----------</td>
<td>------------</td>
<td>------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>Dabbish &amp; Kraut (2008)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>• Communicational intrusion</td>
<td>IT-induced (system properties) • IT-mediated interruption</td>
</tr>
<tr>
<td>Dabbish et al. (2007)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Communicational intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Dodhia &amp; Robert (2009)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Earley et al. (1990)</td>
<td>Not defined</td>
<td>Intervention</td>
<td>• Informational intervention</td>
<td>IT-induced</td>
</tr>
<tr>
<td>Edwards &amp; Gronlund (1998)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Einstein et al. (2003)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Eyrolle &amp; Cellier (2000)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>France et al. (2005)</td>
<td>An event that diverts attention from primary task</td>
<td>Intrusion</td>
<td>• Actionable intrusion</td>
<td>Unknown</td>
</tr>
<tr>
<td>Garrett &amp; Danziger (2008)</td>
<td>A synchronous interaction which was not initiated by the subject, was unscheduled, and resulted in the recipient discontinuing their current activity (O'Connaill &amp; Frohlich 1995)</td>
<td>Intrusion</td>
<td>Various interruptions</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Gievska &amp; Sibert (2004)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Gievska et al. (2005)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Gillie &amp; Broadbent (1989)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Gluck et al. (2007)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>• Informational intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Gong (2006)</td>
<td>Unexpected events that break the continuity of primary or planned tasks (Jett &amp; George 2003)</td>
<td>Intrusion</td>
<td>Various (see their Appendix B)</td>
<td>Some interruptions IT-mediated</td>
</tr>
<tr>
<td>Ho &amp; Intille (2005)</td>
<td>Interruption defined as an event that breaks the user's attention on the current task to focus on the interruption temporarily (p. 910)</td>
<td>Intrusion</td>
<td>Informational intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Ho et al. (2001)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Ho et al. (2004)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Hodgetts &amp; Jones</td>
<td>A common, everyday occurrence that</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated</td>
</tr>
<tr>
<td>Year</td>
<td>Description</td>
<td>Type</td>
<td>Context</td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>------------</td>
<td>--------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>2006a</td>
<td>Involves both the unexpected suspension, and subsequent resumption, of task goals</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td></td>
</tr>
<tr>
<td>(Hodgetts &amp; Jones 2006b)</td>
<td>A common, everyday occurrence that involves both the unexpected suspension, and subsequent resumption, of task goals (p. 103)</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td></td>
</tr>
<tr>
<td>(Hodgetts &amp; Jones 2007)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td></td>
</tr>
<tr>
<td>(Hopp et al. 2005)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td></td>
</tr>
<tr>
<td>(Hopp-Levine et al. 2006)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td></td>
</tr>
<tr>
<td>(Iqbal &amp; Bailey 2005)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td></td>
</tr>
<tr>
<td>(Iqbal &amp; Bailey 2006)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td></td>
</tr>
<tr>
<td>(Iqbal &amp; Horvitz 2007)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td></td>
</tr>
<tr>
<td>(Jackson et al. 2003)</td>
<td>Any distraction that makes a developer stop his planned activity to respond to the interrupt's initiator (p. 6)</td>
<td>Intrusion or distraction</td>
<td>Various</td>
<td></td>
</tr>
<tr>
<td>(Johansson &amp; Aronsson 1984)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>System intrusion (availability of technology resources)</td>
<td></td>
</tr>
<tr>
<td>(Jolly &amp; Reardon 1985)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>N/a (break in routine and alert with no particular content)</td>
<td></td>
</tr>
<tr>
<td>(Kapitsa &amp; Blinnikova 2003)</td>
<td>A certain event which interferes with work process and results in the cessation and suspension of human activity</td>
<td>Intrusion</td>
<td>• Communicational intrusion</td>
<td></td>
</tr>
<tr>
<td>(Kirmeyer 1988)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td></td>
</tr>
<tr>
<td>(Latorella 1998)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td></td>
</tr>
<tr>
<td>(Law et al. 2004)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td></td>
</tr>
<tr>
<td>(Madjar &amp; Shalley 2008)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td></td>
</tr>
<tr>
<td>(McCrackard et al. 2003)</td>
<td>An event within the notification system prompting transition of attention focus from a primary task to a notification</td>
<td>Intrusion</td>
<td>Informational intrusion</td>
<td></td>
</tr>
<tr>
<td>(McDaniel et al. 2004)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td></td>
</tr>
<tr>
<td>(McFarlane 2002)</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td></td>
</tr>
<tr>
<td>Reference</td>
<td>Type</td>
<td>Description</td>
<td>Mediation</td>
<td>Interruption</td>
</tr>
<tr>
<td>-----------</td>
<td>------</td>
<td>-------------</td>
<td>-----------</td>
<td>--------------</td>
</tr>
<tr>
<td>Miller 2002</td>
<td>Not defined</td>
<td>Intervention</td>
<td>• Informational intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Monk et al. 2002</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Monk 2004</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Monk et al. 2004b</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Monk et al. 2008</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Nagata 2003</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Nagata 2006</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>O'Conaill &amp; Frohlich 1995</td>
<td>A synchronous interaction which was not initiated by the subject, was unscheduled, and resulted in the recipient discontinuing their current activity</td>
<td>Intrusion</td>
<td>Not specified</td>
<td>Some interruption tasks IT-mediated</td>
</tr>
<tr>
<td>Okhuysen 2001</td>
<td>Not defined</td>
<td>Intrusion (e.g., joking)</td>
<td>• Communicational intervention</td>
<td>Unknown</td>
</tr>
<tr>
<td>Okhuysen &amp; Eisenhardt 2002</td>
<td>Not defined</td>
<td>Intervention</td>
<td>• Communicational intervention</td>
<td>Unknown</td>
</tr>
<tr>
<td>Oulasvirta &amp; Saariluoma 2004</td>
<td>Discrete event during which attention is abruptly redirected to process information that is irrelevant to the ongoing main task</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Oulasvirta &amp; Saariluoma 2006</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated interruption</td>
</tr>
<tr>
<td>Perlow 1999</td>
<td>Not defined</td>
<td>Various interruptions</td>
<td>Interruptions not specified</td>
<td>Unknown</td>
</tr>
<tr>
<td>Ratwani et al. 2007</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Schiffman &amp; Greist-Bousquet 1992</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Informational intrusion</td>
<td>Unknown</td>
</tr>
<tr>
<td>Scott et al. 2006</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated interruption</td>
</tr>
<tr>
<td>Speier et al. 1997</td>
<td>Externally generated, randomly occurring, discrete event that breaks continuity of cognitive focus on a primary task (Coraggio 1990)</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Speier et al. 1999</td>
<td>Externally generated, randomly occurring, discrete event that breaks continuity of cognitive focus on a primary task (Coraggio 1990)</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Source</td>
<td>Description</td>
<td>Type</td>
<td>Intervention</td>
<td>Intervention Description</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------------------</td>
<td>---------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Speier et al. 2003</td>
<td>Uncontrollable, unpredictable stressors that produce information overload, requiring additional decision-making effort. It breaks attention on primary task and turns it toward the interruption, if only temporary (p. 772-773)</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Staudenmayer et al. 2002</td>
<td>Not defined</td>
<td>Intrusion Intervention</td>
<td>• System intrusion (availability of technology resources)   • System intervention</td>
<td>IT-induced</td>
</tr>
<tr>
<td>Thum et al. 1995</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>System intrusion (system properties - system response time)</td>
<td>IT-induced</td>
</tr>
<tr>
<td>Trafton et al. 2003</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Trafton et al. 2005</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Tyre &amp; Orlikowski 1994</td>
<td>Not defined</td>
<td>Intrusion Intervention</td>
<td>• System intrusion (availability of technology resources)   • System intervention</td>
<td>IT-induced</td>
</tr>
<tr>
<td>van den Berg et al. 1996</td>
<td>An externally generated, temporary cessation in the current flow of behavior, typically meant for the subject to execute activities that belong to a secondary set of action (p. 236)</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated interruption</td>
</tr>
<tr>
<td>Weisband et al. 2007</td>
<td>Incidents or events that disrupt the continuity of work, or the process of coordinating abrupt changes in people's activities (p. 2)</td>
<td>Intrusion Intervention</td>
<td>• Informational/actionable intrusion   • Informational/actionable intervention</td>
<td>IT-mediated (alert and interruption)</td>
</tr>
<tr>
<td>Wickens et al. 2005</td>
<td>Not defined</td>
<td>Intrusion</td>
<td>Actionable intrusion</td>
<td>IT-mediated interruption</td>
</tr>
<tr>
<td>Woolley 1998</td>
<td>Not defined</td>
<td>Intervention</td>
<td>Communicational intervention</td>
<td>Unknown</td>
</tr>
<tr>
<td>Zellmer-Bruhn 2003</td>
<td>Not defined</td>
<td>Intrusion Break Intervention</td>
<td>• Actionable intrusion   • System intrusion (availability of technology resources - changes in technology)   • System intervention</td>
<td>Some interruption tasks IT-mediated</td>
</tr>
<tr>
<td>Zijlstra et al. 1999</td>
<td>Events that result in the cessation and postponement of an ongoing task</td>
<td>Intrusion</td>
<td>• Communicational intrusion   • Actionable intrusion</td>
<td>IT-mediated interruption</td>
</tr>
</tbody>
</table>
# APPENDIX 2: LIST OF INTERVIEWEES

<table>
<thead>
<tr>
<th>Company</th>
<th>Participant Role</th>
<th>Product</th>
<th>Team Size</th>
<th>Task Interdependence</th>
<th>Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NPD manager</td>
<td>Digital</td>
<td>Physical</td>
<td>Small</td>
<td>Large</td>
</tr>
<tr>
<td>Alpha</td>
<td>Other team members</td>
<td>Software development team lead</td>
<td>Software solutions for NPD</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Software developer 1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Software developer 2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Quality assurance specialist</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Beta</td>
<td>Integrated product team manager</td>
<td>-</td>
<td>-</td>
<td>Gas turbine engines for power generation</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Technical lead / Mechanical specialist</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Gamma</td>
<td>VP, marketing analysis</td>
<td>Web analytics software</td>
<td>-</td>
<td>-</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Product strategist</td>
<td>-</td>
<td>-</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Product manager 1</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Product manager 2</td>
<td>-</td>
<td>-</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>Delta</td>
<td>Chief technology officer (CTO)</td>
<td>-</td>
<td>-</td>
<td>Software for system testing devices</td>
<td>Semi-conductor testing devices</td>
</tr>
<tr>
<td></td>
<td>Senior member of technical staff</td>
<td>-</td>
<td>-</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Senior software developer</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Company</td>
<td>Position</td>
<td>Industry/Project</td>
<td>Experience</td>
<td>Performance</td>
<td>Years</td>
</tr>
<tr>
<td>-----------</td>
<td>------------------------------------</td>
<td>-------------------------------------------</td>
<td>------------</td>
<td>-------------</td>
<td>-------</td>
</tr>
<tr>
<td>Epsilon</td>
<td>Assistant product designer</td>
<td>Denim jeans</td>
<td>3</td>
<td>Low</td>
<td>2 ½</td>
</tr>
<tr>
<td>Zeta</td>
<td>VP, development and distribution</td>
<td>Film productions and interactive digital media</td>
<td>5</td>
<td>Low</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Distribution and marketing manager</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1 ½</td>
</tr>
<tr>
<td></td>
<td>Director, post-production</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>12</td>
</tr>
<tr>
<td>Eta</td>
<td>Software development engineer 1</td>
<td>Web-based machine translation software</td>
<td>-</td>
<td>Low</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Software development engineer 2</td>
<td>Web-based productivity software</td>
<td>-</td>
<td>Low</td>
<td>2 ½</td>
</tr>
<tr>
<td></td>
<td>Software development engineer 3</td>
<td>-</td>
<td>-</td>
<td>Low</td>
<td>½</td>
</tr>
<tr>
<td>Theta</td>
<td>Head of strategic planning and product development</td>
<td>Bank deposit accounts</td>
<td>3</td>
<td>Low</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6</strong></td>
<td><strong>15</strong></td>
<td><strong>6</strong></td>
<td><strong>3</strong></td>
<td><strong>10</strong></td>
</tr>
</tbody>
</table>
APPENDIX 3: SAMPLE PARTICIPATION LETTER

Research on Technology Interruptions in the Product Development Process

This study addresses the following research question: What are the different types of IT-based interruptions that are faced by product development team members, and how do they affect the product development process?

Goal of the study
This research project aims at better understanding the impact of using IT tools in the new product development (NPD) process. Specifically, it focuses on the various ways by which IT trigger interruptions, how interruptions are addressed, and the effects of such interruptions on the NPD process.

Your participation
To successfully achieve the research objectives, we would like to encourage your participation to facilitate a 45min-1 hour meeting with one of your NPD managers, who is at present or has recently (within the last 3 months) been involved in managing an NPD project. Additional meetings with and observations of NPD team members will also be highly appreciated. Your participation is entirely voluntary and no information will be disseminated that reveals your identity, the identity of your teams, company, or any sensitive information on the product that you are developing.

Our contributions to your organization
This project is an opportunity for you to learn about positive and negative effects of interruptions on the product development process, and how these interruptions can best be addressed. The results of the study can help provide a benchmark to your company, as well as provide guidelines for managerial interventions that can be used to improve the NPD process. Our research team is committed to fully analyzing the data generated from this project, and, upon request, a copy of the final report will be provided to you upon the study's completion. This report does not identify specific individuals or teams.

If you have any questions about the project, please feel free to contact us at the coordinates given above. Your cooperation is most valuable and will be greatly appreciated.

Sincerely,

Shamel Addas  
Ph.D. candidate, McGill University

Alain Pinsoneault, McGill University
Jimasso Chair of IS
James McGill Professor

McGill  Desautels Faculty of Management
Professor Alain Pinsoneault
Chair of MIS
James McGill Professor
Shamel Addas
PhD Candidate
Information Systems
McGill University
1001 Sherbrooke Street West
Montreal, QC H3A 1G5 Canada
Tel: (514) 398-4905  Fax: (514) 398-3876
Email: alain.pinsoneault@mcgill.ca
APPENDIX 4: INTERVIEW GUIDE

FIRST TWO PARTS “OPENING STATEMENT” AND “QUALIFICATION QUESTIONS” COULD BE PART OF SELECTION PROCESS (I.E., BEFORE I ACTUALLY MEET WITH THE PERSON)

**Opening Statement** (establishes boundaries and context with informant):

Thank you for accepting this opportunity to participate and contribute to this research project. We are interested in the new product development process, how NPD team members work together during that process, and how the process can be improved. We are particularly interested in the notion of technology interruptions. Technology interruptions can be any events that are brought forward by information technology and that interrupt individuals and the group as they are working on their NPD tasks. By interruptions, we are adopting a neutral stance and not necessarily assuming that they are good or bad. Through this interview, I would like to get your insights about these issues.

Any shared information will remain confidential. Any published reports will maintain complete anonymity to protect individuals’ identities, the identity of teams, the company, and any sensitive information on the products being developed.

I would like to ask you a few screening questions to ensure that your work setting fits our target sample.

**Qualification Questions** (to screen informants):

- Is your company currently involved or has it been recently involved (within the past year) in any NPD projects? (exclude if NO)
- Do you use NPD teams to develop products in your company? (exclude if NO)
- Are you part of a NPD team? (exclude if NO)
- When was the last project you worked on? (exclude if the time is more than 1 year)
- What is/was the nature of the product? Product/service, etc. (exclude if service)
- Did you use any information technology tools to communicate and collaborate with team members on this project? (by information technology tools I mean: email; chat; web meetings; integrated product solutions) (exclude if NO)

**Interview Protocol** [BRIEFLY GO THROUGH THE INTERVIEW PROTOCOL WHEN I MEET THE INFORMANT IN PERSON: 1-2 MINUTES]
All data related to this project will be stored on a protected personal computer. To assure confidentiality, only I, my supervisor and our research assistant will have access to the computer. Also, any published reports will maintain complete anonymity to protect individuals’ identities, the identity of teams, the company, and any sensitive information on the products being developed. This interview will not last more than 60 minutes.

If you agree, I would like to record what you say to make sure that I capture everything. If at any time during the interview you do not want to record some information, you may stop the recorder or ask me to do it. You may also skip any questions you do not wish to answer.

In some interviews, it is useful to provide additional materials to complement the interviews (e.g., company newsletter; documentation). This is also entirely voluntary on your part. Finally, if you wish, we can provide you with a copy of the final report from the case studies. Now before we start, I would like you to review and sign the consent form. Any questions before we begin?

I’m going to break the interview into two parts. First, I will ask you some general questions about your typical NPD projects. Then, I will ask about the technology interruptions that you experience in your NPD work, the effects of those technology interruptions, and how they are managed.

Part I: Descriptive Questions

1. Could you give a quick overview of the last NPD project you worked on or the current project you are working on? **PROBE:**
   - Brief description of product service
   - What are the different stages/milestones of the project? [If project is ongoing then ask: And at what stage are you currently?]
   - What was your role in the project?

2. Just very briefly, how do you manage the different stages of your new product development project? **PROBE:**
   - What are the different departments/teams involved in the project?
   - Do the different project stages happen simultaneously or in sequence?
   - What kinds of interaction/communication mechanisms do you use within the teams? Across the teams?
   - **OPTIONAL:** How do you coordinate activities and manage knowledge within the teams? Across the teams?
• Could you tell me about all the different information technologies that you use to help you with the
  project (e.g., to communicate, coordinate, design)?

Transition: We’ve been talking about the general aspects of the NPD project and team. Now I would like to ask
you about some of the technology interruptions that you experience in your work as individuals and as teams.

Part II: Technology Interruptions & their Effects

3. A key part of this research project is to understand about the different types of technology interruptions that
  you face in your NPD project in order to see how they can best be managed. So, I would like us to focus on
technology interruptions.

• These interruptions are delivered by technology. Examples of these are interruptions by email, instant
  chat, BlackBerries, viruses, spam, system breakdowns, etc.

• They can be of any sort (e.g., work-related; task-related; social; personal).

• They can be either good for your task, bad, or have no effect.

If you think about the project you just described, I would like to ask you to list for me the most important
types of technology interruptions that you (or your team) face when working on the NPD project.

PROBE: Anything else? Can you think of any more interruptions? [Write down the different interruptions on
post-it notes or cards (Spradley 1979)]

a. Try to probe for the different technology interruptions including:

   (1) Informational intrusions

   (2) Communicational intrusions

   (3) Actionable intrusions

   (4) System intrusions

   (5) Informational interventions

   (6) Communicational interventions

   (7) Actionable interventions

b. Can you also think of examples of good technology interruptions? [Ask this prompt if informant
does not identify any “good” technology interruptions]

c. Optional: How do interruptions X differ from interruptions Y? [These questions will help me find
out what are the important dimensions of interruptions and validate the construct dimensionality.]
Transition: Now I would like to focus on the most important technology interruptions you faced in the last (or current) project. I want to take these technology interruptions one by one and try to understand their nature and their effects on you individually, their effects on the NPD group, and the project as a whole [Questions 4-9 will be asked iteratively for each technology interruption.]

4. Ok, let’s go into these technology interruptions one-by-one. Let’s start with interruption x [refer to one of the technology interruptions that are identified as most important]. Can you think of a specific event in your NPD project that represented this type of technology interruption? Could you describe to me a little bit this technology interruption?
   a. What was this interruption about? What was its content?
   b. What were you doing when it occurred?
   c. How did it occur?

5. Did this interruption help your NPD project or hurt it? Why?

6. Could you describe to me how this technology interruption affected your NPD work individually? **PROBE:**
   a. Emotionally?
   b. Attention to the task?
   c. Workload?
   d. Task performance?

7. Now let’s think about the team. How did this technology interruption affect the work of the team as a whole? **PROBE:**
   a. How do they affect the team emotionally / team dynamics?
   b. Team’s attention to the task?
   c. Team’s workload?
   d. The way the team works together? Team’s interaction and knowledge management process?
   e. Team’s performance?

8. This question is about trying to understand how an interruption at your level could affect the overall NPD process. Did the effects of this technology interruption spill over and affect other tasks in the NPD process? **PROBE:**
   a. Did it affect another task you were performing which is also part of the NPD project? How?
   b. Did it affect another task performed by someone else? How?
c. Did it affect other group members working with you on that task? How?

d. Did it affect the group as whole or just individuals? How?

9. How did you respond to this technology interruption?

**PROBE:**

a. Do you have mechanisms in place for responding to these technology interruptions?

b. Can information technology be used to respond to this technology interruption?

c. What is the best approach for dealing with this technology interruption?

10. [Take the next technology interruption and ask questions 4-9.]

11. Can you also think of examples of technology interruptions that affect the group as a whole? [This question can be asked only if answers to it were not obtained in the preceding questions, especially question #9. Then, ask questions #5, #6, and #8.]

Describe to me a little bit about this interruption. **PROBE:**

1. What was this interruption about?

2. What were you doing when it occurred?

3. How did it occur?

Did this interruption help your NPD project or hurt it? Why?

Now let’s think about the team. How did this technology interruption affect the work of the team as a whole? **PROBE:**

1. How does it affect the team emotionally / team dynamics?

2. Team’s attention to the task?

3. Team’s workload?

4. The way the team works together? Team’s interaction and KM process?

5. Team’s performance?

**Final Statement**

That covers the things I wanted to ask. Is there anything you feel you would like to add or any questions you think I should have asked? Well then, I would like to thank you very much for participating in this research project. If I have any follow-up questions regarding the interview today, would it be OK if I contact you? Again, thank you very much for your time.
APPENDIX 5: SAMPLE CONSENT FORM

Consent Form (Case Study)

Title: Technology Interruptions in the New Product Development Process

Purpose of the Research
This research project aims at better understanding the impact of using information technology (IT) tools in the new product development (NPD) process. Specifically, it focuses on the various ways in which IT triggers interruptions, how interruptions are addressed, and the effects of such interruptions on product development team members.

Benefits of Participating in the Study
Benefits of participation include a research report that will be disseminated to you upon request. The report will not provide information specific to any particular company. It will provide overall insights gathered from the study into the impact of different types of interruptions faced by NPD teams and how these interruptions can best be managed.

Conditions of Participation
Data will be primarily collected through interviews with NPD managers and team members, lasting no more than one hour each. If you so desire, additional data collection methods may include studying company documentation (e.g., NPD project plans, annual reports) and observing NPD team members meetings. Your participation in this research is voluntary. If you choose to participate in this study, you may decide to withdraw at any time. In the process of the interview, you may skip any questions you don’t wish to answer.

The data collected from the study will be coded to mask your identity, and it will be stored on a password-protected database. Access to the database will be granted to the principal researcher's supervisor and research assistant, but only the principal researcher will have access to research results associated with your identity. Data will be used for scientific purposes only. Any data generated from your participation will not contain names or other identifying characteristics. Confidentiality will be expected and no information that discloses the identity of the participant will be released to another party or published in any report. The results of the present study will be published in leading academic and practitioner journals.

Questions
If you have any questions about this study, please contact the principal researcher, Shamal Addas, or his supervisor, Alain Pinsonneault. They can be reached at (514) 398-4805. If you have questions about your rights as a research participant, you may contact The Research Ethics Board at 514-398-6831, llynda.gcemail@mcgill.ca. You will receive a copy of this consent form.

Consent to Participate
I certify that I have read this form and volunteer to participate in this research study. I understand that the data generated from my participation will be used as described in the section “Conditions of Participation” above.

I agree to have the interview tape-recorded: ☐ YES ☐ NO
APPENDIX 6: CHAIN OF EVIDENCE FOR EFFECTS OF SYSTEM INTRUSIONS ON EFFICIENCY

<table>
<thead>
<tr>
<th>Citation</th>
<th>First-order dimension</th>
<th>Aggregate dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>“For tiny minor code changes you have to spend 20-30 minutes” (Alpha)</td>
<td>Increases in task completion time</td>
<td></td>
</tr>
<tr>
<td>“Whenever you are given a task you make an estimate of the number of hours that you will be working on it, so let us say I put 40 hours for a task and because of hardware crashes or other system issues some of those hours are lost. So I have to go back and spend those hours but then you have project pressures, ‘you said 40 hours. We gave you 40 hours where is my results?’” (VS, Beta)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Photoshop freezes and delays the task. If it is a big picture it can take up to 10 minutes and then every time I save, it will be another 5 minutes” (Zeta)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“It really slows down the overall turnaround time as it slows down development” (Alpha)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“It delayed the project about 7 to 10 days” (VS, Beta)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“So what happened is the project slipped by I would say by 8 weeks because of that” (Delta)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Normally and theoretically from the minute you have the product idea and financial projections until you are able to launch the product it should not take more than two months. But [because of these system issues] sometimes it can take up to 8 months” (Theta)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“You come in to work and the network is down so you cannot access your multiple drives where you store your information, and you have to do a presentation. You did not back it up. You did not put it on your hard drive. You cannot access it through the network” (NPD manager, Beta)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“[When Photoshop freezes] it is time consuming and frustrating because you cannot do anything else” (Zeta)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“If you are for example fixing something on a remote machine and the network is down, the task is completely blocked and you have to figure out another way to connect to this machine” (ISD1, Eta)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Then the system is crashed and you cannot do anything so you find yourself completely handicapped and we have just to wait until the system goes back online” (Theta)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“They were distracted by either having to support the old code or by having to learn the new code” (Delta)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“You are trying to accomplish very specific tasks and for reasons that are completely out of your hands you are set off-track” (Theta)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Citation

Efficiency

Task blocking

Task/project delays

Increases in task completion time

Attention diversion to non-productive activities
### APPENDIX 7: DATA SUPPORTING THE IT INTERRUPTIONS TAXONOMY – IT INTRUSIONS

<table>
<thead>
<tr>
<th>Interruption Type/Subtype</th>
<th>Supporting Evidence from Qualitative Inquiries</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Informational Intrusions</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Q1</strong></td>
<td>Many of the emails I get do not have any value for my projects, just emails circulating within the company. Some of them are HR-related [...] They can really be disruptive if too many are flying around. (Software developer 1, Alpha)</td>
</tr>
<tr>
<td><strong>Q2</strong></td>
<td>I am copied on emails that have no relevance to my work or are at a level that I do not need to know. For instance, sometimes you manage a project and there might be a technical issue that arises but that issue could be easily resolved within the technical people and you do not necessarily need to know about it but people still tend to copy you because they think you need to be aware or they want to show that they are actually working on it. But to me it is being an annoyance because it just distracts me and I do not need to know about it. (NPD manager, Beta)</td>
</tr>
<tr>
<td><strong>Q3</strong></td>
<td>It is basically always about the same pattern so let us say some machine is not working and somebody cannot access a certain machine on a remote site, and they send emails to everybody and the person who probably knows something about it replies to everybody. When you get those notifications, you kind of hope that it stops at a certain point. You’re back doing your task and then BOOM: another notification, another, another! It goes on and on. This kind of stuff takes my attention away and distracts me from the main programming tasks. (Team leader, Alpha)</td>
</tr>
<tr>
<td><strong>Communicational Intrusions</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Q4</strong></td>
<td>Should I focus more on developing and running the programs for vibration tests on our engines, or on answering the constant emails from our other departments about HR stuff, corporate issues, company events, or what have you? I think the answer is clear. Even when the information they ask from me is available or easy to get, these emails disturb the engineering process that is involved in vibration testing. (Vibrations specialist, Beta)</td>
</tr>
<tr>
<td><strong>Q5</strong></td>
<td>Because I report directly to the CEO so I have to handle a lot of emails about things that have nothing to do with product development. I do this on a daily basis several times. I would stop immediately what I am doing and then go back to it after I have finished or responded or taken action or made plans for whatever else it was that required my attention. (Head of strategic planning and product development, Theta)</td>
</tr>
<tr>
<td><strong>Actionable Intrusions</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Q6</strong></td>
<td>I need to report numbers to Finance and to the board on the membership of our clients. This is also interrupting to the development work [...] I have to go myself in Excel, play with the columns and numbers, and craft something that is going to finally make sense. (Product manager 2, Gamma)</td>
</tr>
<tr>
<td><strong>Q7</strong></td>
<td>From time to time we are definitely asked to shift to different things. For example, we have to fill up some kind of online logbook journal. It is kind of a nuisance and a distraction for developers to do extra documentation work; especially that it is not directly related to the project. (Software developer 1, Alpha)</td>
</tr>
<tr>
<td><strong>Q8</strong></td>
<td>Well I am working on a jean design and then I get an email: ‘Oh, I am meeting a buyer and I am missing some information. Can you prepare a presentation that includes so, so and so and have it ready in the next hour?’ So that is a major annoyance because first of all it is something that was not provided beforehand, was unplanned and I will be doing it as a favor because it’s not really part of my work. (Assistant product designer, Epsilon)</td>
</tr>
<tr>
<td><strong>System Intrusions</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Q9</strong></td>
<td>Yes, the IT infrastructure gives us some hiccups from time to time. And it might be annoying and slowing down the overall process [...] [The IT department] make processes and features to suit their own people not vice versa. (Software developer 2, Alpha)</td>
</tr>
<tr>
<td><strong>Q10</strong></td>
<td>I work a lot with Photoshop for example to design posters which we send to the television networks. There have been several instances where I will work on something and my entire computer will freeze or crash. Oh God! Photoshop is a big one that hinders the flow of my work. (Distribution and marketing manager, Zeta)</td>
</tr>
<tr>
<td><strong>Q11</strong></td>
<td>We experience system failures and network failures. Those are bad interruptions. If you are for example fixing something on a remote machine and the network is down, the task is completely blocked and you have to figure out another way to connect to this machine. (Software development engineer 1, Eta)</td>
</tr>
</tbody>
</table>
## APPENDIX 8: DATA SUPPORTING THE IT INTERRUPTIONS TAXONOMY – IT INTERVENTIONS

<table>
<thead>
<tr>
<th>Interruption Type/Subtype</th>
<th>Supporting Evidence from Qualitative Inquiries</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Informational Interventions</strong></td>
<td>Q1 <em>Ok so for example, last night my quality control colleague sent me the status of the two modules we were debugging: [...] “On module 1, here is the symptom that was reported. Here is the chain of the circuit. Here is where I found the problem in that chain. Next module: this is the symptom that you described. Here is what I found. --- thanks, [name].”</em> (Senior member of technical staff, Delta)</td>
</tr>
<tr>
<td><strong>Communicational Interventions</strong></td>
<td>Q2 <em>[Referring to “Tweets” and blog comments from clients who are using a beta product undergoing development]: It helps me understand what people do with my product and how to use it, and sometimes what are the limitations or what are the feature that people want. People comment and it is great that you get an answer so fast.</em> (Product manager 1, Gamma)</td>
</tr>
<tr>
<td><strong>Actionable Interventions</strong></td>
<td>Q3 <em>We have a shared workspace and we integrate our codes with each other. This electronic environment gives us the opportunity to provide feedback on each other’s work. So while working on a particular task, other developers can interrupt me with feedback and discussions that help to improve the code and catch errors and so on.</em> (Software developer 2, Alpha)</td>
</tr>
<tr>
<td></td>
<td>Q4 <em>[Referring to email interactions between developers that relate to current project work]: To me these are the best emails because they are always geared towards improving what I am actually doing now because that is really my job. When it is something about development stuff before release, it is usually where I am most present, you know [...] It is not a problem for me because they are issues that need to be addressed and it is part of my daily work [...] So these interruptions help the actual work.</em> (Product strategist, Gamma)</td>
</tr>
<tr>
<td></td>
<td>Q5 <em>We mostly get information-based feedback by email on stuff we work on so when it comes back it is feedback you know, like ‘The tape is ok but why did you do this?’ It is mostly discussions that trigger a change, you know, like ‘We have a problem with the tape, there is this and this. What’s your take on that?’</em> (Distribution and marketing manager, Zeta)</td>
</tr>
<tr>
<td></td>
<td>Q6 <em>Some of the emails we receive may be related to some pending issue in our decision. Like for example in the web development world we usually depend on some graphic work that should be delivered from graphic designers, so every now and then I receive some emails about those new web site designs, those new icons. ‘I think those icons should better be placed like this. What do you think? Try them on the existing work and give us our opinion.’ These sorts of things. In this case these emails interrupt you because they make you change your perspective.</em> (Software development engineer 2, Eta)</td>
</tr>
<tr>
<td></td>
<td>Q7 <em>Well, most interruptions like that would be changes in the required specifications or in the features. So you are developing a feature and they [email you,] ‘No, instead of taking one 32-bit register, we need two or three’ [...] This interruption allows me to just adjust some expectation about the way I am working on the product.</em> (Senior software developer, Delta)</td>
</tr>
<tr>
<td></td>
<td>Q8 <em>[Referring to email feedback received during a design task]: It is not interruption; it is positive disruption. Because merchandisers would email us and tell us that is the feedback we are getting from the retailers, and we need to change this. So basically even while you are working on something, you get feedback, you have to reorganize your entire focus, re-categorize, redirect, realign.</em> (Assistant product designer, Epsilon)</td>
</tr>
</tbody>
</table>
### APPENDIX 9: DATA SUPPORTING THE IT INTERRUPTIONS TAXONOMY – HYBRID IT INTERRUPTIONS

<table>
<thead>
<tr>
<th>Interruption Type/Subtype</th>
<th>Supporting Evidence from Qualitative Inquiries</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hybrid Informational Interruptions</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Q1</strong></td>
<td><em>I would say 30% of them [referring to email interruptions] provide some extra additional information for the project. Not just necessarily related to the current project but related to overall development […] They are work-related.</em> (Software developer 1, Alpha)</td>
</tr>
<tr>
<td><strong>Q2</strong></td>
<td><em>We would get interruptions that are for example inspirational. So we will get emails with pictures: ‘Oh, check this out! This is something happening.’ So it does interrupt from the task I am working on at the moment but it is also part of the greater picture. This is sort of the direction we have so we have to look into it.</em> (Assistant product designer, Epsilon)</td>
</tr>
<tr>
<td><strong>Q3</strong></td>
<td><em>There are several email interruptions that provide updates on development stuff. Not necessarily stuff I am currently working on. ‘Have you seen these guys how they do pricing? Have you seen these guys or the features?’</em> (Product strategist, Gamma)</td>
</tr>
<tr>
<td><strong>Q4</strong></td>
<td><em>[…] you cannot focus on a contract which needs focused attention when you have a constant stream of email information coming in, even if that information is still about project-related stuff […]</em> (VP, development and distribution, Zeta)</td>
</tr>
<tr>
<td><strong>Hybrid Communicational Interruptions</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Q5</strong></td>
<td><em>A part of the interruptions I face come as emails with technical discussions that help me know about the competition, know about the existing new technologies and what people say about them […] These interactions are like forum discussions. One of us finds something new released so he posts it, we reply, everyone puts their opinion, we try it out, we suggest how we can do something better than the competition, all these kinds of things.</em> (Software development engineer 2, Eta)</td>
</tr>
<tr>
<td><strong>Q6</strong></td>
<td><em>[Referring to email interruptions about past or future projects]: These things are mostly information requests, about what we have, what we do not have, when something will be completed, the format that it will be completed in, people looking for work trying to get on to the show, etc. […] Basically it is information about what is going on with the other shows so I am current on everything that is happening.</em> (Director of post-production, Zeta)</td>
</tr>
<tr>
<td><strong>Hybrid Actionable Interruptions</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Q7</strong></td>
<td><em>Email is a big issue because we get a lot of emails on project-related stuff. I get every day maybe 30-40 emails and all of them require attention. It is not like easy one-liners; you have to research and talk to people so for example if you are doing a task-at-hand, there is a lot of interruptions because you have to leave what you are doing and then go address that issue and that may involve communicating with retailer/merchandisers, researching two or three files electronically, emailing people up, you know.</em> (Assistant product designer, Epsilon)</td>
</tr>
<tr>
<td><strong>Q8</strong></td>
<td><em>Other email interruptions would be for products that are already released. So [as a] recent example, we did integration with Google Analytics. So recently we get an email from [product name] clients saying that the data just doesn’t make sense. ‘How come I am not seeing this data?’ […] So if I get that then I will leave the stuff I am working on, go spend some time trying to investigate this, or I escalate again.</em> (Product strategist, Gamma)</td>
</tr>
<tr>
<td><strong>Q9</strong></td>
<td><em>[Referring to email interruptions]: In some cases they can change the thing I am doing right now. You are working on this component and you have to switch to this component because it is urgent […] Sometimes you do not have the time or the luxury to look what you have actually done or to hibernate your state before switching to another state.</em> (Software development engineer 1, Eta)</td>
</tr>
<tr>
<td><strong>Q10</strong></td>
<td><em>If for example you work on two big projects, one that is released and people are using it all the time and you are working on your next project, and all of a sudden they discovered a failure or some problem in the released project, this will completely interrupt you from the current task you do. You have to jump back to the released project to fix this problem because it is used right now.</em> (Software development engineer 1, Eta)</td>
</tr>
</tbody>
</table>
CHAPTER III (ESSAY #2). EMAIL INTERRUPTIONS AND TASK PERFORMANCE: A TALE OF TWO INTERRUPTION TYPES

ABSTRACT

While information technology interruptions continue to punctuate day-to-day organizational work, our understanding about the impacts of such interruptions on individual performance is equivocal. Extant research is characterized by mixed empirical results and the lack of considering the context in which the interruptions take place (e.g., properties of the technology that influence the outcomes; distinct interruption types). Also, little is known about the moderating and mediating factors. Drawing upon a taxonomy of work interruptions and psychological theories of attention allocation, this paper develops and tests an empirical model that examines the direct and indirect effects of email interruptions on task performance in a business-to-business sales context. The results of a survey of 365 sales professionals show that different types of email interruptions exhibit distinct effects by leveraging attention allocation mechanisms that either enhance or inhibit performance. Additionally, those effects are influenced by two factors emanating from the asynchrony of email (perceived control and multitasking self-efficacy). This paper contributes to the literature by extending research on IT-mediated interruptions. Additionally, it unearths the cognitive attention allocation mechanisms that relate email interruptions to performance, and identifies the compensating mechanisms that reduce the adverse effects of email interruptions.

INTRODUCTION & MOTIVATION

Interruptions are ubiquitous in today’s work environment (Gonzales & Mark 2004; Wajcman & Rose 2011). For example, knowledge workers spend no more than three minutes working on their tasks before being interrupted by other events (Gonzales & Mark 2004). When working on email tasks, this figure drops to two minutes (Gonzales & Mark 2004). According to Basex consulting, more than 28% of the average knowledge worker’s time is spent dealing with interruptions (Spira & Feintuch 2005).

Information technology (IT) tools are the main contributors to such interruptions by directly inducing the interruptions (e.g., system errors), but mostly by providing a medium on which the interruptive events occur (e.g., email information requests; instant messaging
discussions). Such interruptions to knowledge workers come through various devices (e.g.,
desktop PCs; laptops; smart phones) and various IT tools such as email, instant messaging,
voice-over-IP, social networking tools, and a myriad other informational and communicational
technologies (McFarlane 2002; Nagata 2003; Wajcman & Rose 2011). For instance, more than
70% of instant messaging users have reported interrupting their coworkers multiple times a day
(Garrett & Danziger 2008). As another example, knowledge workers deal with over 70 email
interruptions per day (Jackson et al. 2003). Remarkably, the recovery times from a single email
interruption have ranged between one minute (Jackson et al. 2003) and as much as 24 minutes
(Hemp 2009).

Given the momentous importance of IT interruptions, it is not surprising that this
phenomenon has received much attention in scholarly research, especially in the area of Human-
Computer Interactions (HCI). Researchers have devoted their efforts to studying several aspects
of IT-mediated interruptions such as interruptibility, interruption coordination strategies, and
interruption impacts. First, interruptibility research identifies subtask boundaries as representing
the most opportune periods of interruption due to lower levels cognitive load (Adamczyk &
Bailey 2004; Bailey et al. 2001). By controlling the timing of such interruptions, the adverse
effects on cognitive and behavioral outcomes can be reduced (Adamczyk & Bailey 2004; Bailey

Second, research on coordination strategies has developed a taxonomy including several
interruption response configurations such as immediate, negotiated, scheduled, and mediated
(McFarlane 2002). Among those, negotiated interruption response has been identified as the
strategy most conducive to task performance (Gievska et al. 2005; Gievska & Sibert 2004;
McFarlane 2002; Robertson et al. 2004).
Third, a large body of research has focused on the impacts of IT-mediated interruptions on cognitive and behavioral performance outcomes. The overwhelming majority of such research examines the negative impacts of interruptions such as negative emotional reactions (e.g., Bailey et al. 2001; Gievska et al. 2005), losses in the efficiency of both resuming and completing the interrupted tasks (e.g., Arroyo & Selker 2003; Bailey et al. 2000; Monk et al. 2004b), and decrements in performance effectiveness as a result of increased errors (e.g., Kapitsa & Blinnikova 2003; McFarlane 2002; Speier et al. 1997) and a reduced ability to remember interrupted task details (McDaniel et al. 2004; Oulasvirta & Saariluoma 2004). Conversely, a separate – yet much smaller – body of research focuses on the positive impacts such as enhanced learning (Robertson et al. 2004), improved idea generation (Jung et al. 2010), and enhanced task effectiveness (Ang et al. 1993 1990; Gluck et al. 2007).

While these findings have shed light on important aspects of IT interruptions, several gaps in knowledge remain that appear critical to address. First, despite being a commonality across all studies of IT-mediated interruptions, the IT component has not been systematically examined (Wajcman & Rose 2011). In fact, the technology in most prior studies was present implicitly, with the focus being on the interruption delivered by the technology (e.g., Adamczyk & Bailey 2004; Altmann & Trafton 2007; Bailey et al. 2001; Cutrell et al. 2001; McDaniel et al. 2004; McFarlane 2002). However, particular properties of the technology can influence how interruptions are experienced and the way they affect the work of individuals. For example, individuals may perceive more control over email interruptions than instant messaging.
Email Interruptions and Task Performance

interruptions as a result of the higher degree of asynchrony of email\textsuperscript{12} (Barley et al. 2011; Iqbal & Horvitz 2007).

Second, the empirical results mentioned above relating IT interruptions to individual performance are equivocal. This conflicting evidence raises an important question about what the effects of IT interruptions are on the work of individuals. While mixed results on IT impacts can result from various factors (e.g., different research approaches; different measures of performance), one important explanation of this problem is the lack of taking context into account (Johns 2006). Indeed, such context has not been systematically considered in the literature on IT interruption impacts. Much of the prior research models interruptions as isolated, artificial events in a laboratory environment with much of the context being removed from such interruptions (e.g., Adamczyk & Bailey 2004; Bailey & Konstan 2006; Beeftink et al. 2008; Cutrell et al. 2001; Cutrell et al. 2000; Czerwinski et al. 2000). Also, contextual factors that moderate the relationship were mostly manipulated temporal characteristics of the interruption such as frequency (Gievska et al. 2005; Ho et al. 2001; Monk et al. 2008; Zijlstra et al. 1999) and timing (Cutrell et al. 2001; Edwards & Gronlund 1998; Hodgetts & Jones 2007), rather than stemming from the context of the person being interrupted.

Finally, with some exceptions (e.g., Cutrell et al. 2000), prior research considers interruptions as a monolithic entity that varies along simple temporal dimensions such as frequency, duration, and timing (e.g., Adamczyk & Bailey 2004; Ang et al. 1993; Beeftink et al. 2008; Burmistrov & Leonova 1996; Cutrell et al. 2000; Einstein et al. 2003). This approach does not distinguish types of interruptions that are qualitatively different. However, it has been

\textsuperscript{12}While it is true that instant messaging can be used asynchronously and email can be used near-synchronously, typical usage of instant messaging is characterized by a higher degree of synchronicity than email (Barley et al. 2011; Iqbal & Horvitz 2007).
pointed out that differentiating interruption types – especially based on content – may contribute to our understanding of the different effects of interruptions (Jett & George 2003; Speier et al. 2003).

To extend the prior research, this paper explicitly examines the cognitive and behavioral impacts of different types of interruptions occurring via email. First, focusing on the performance effects of email interruptions allows us to explicitly include factors influencing the relationship that stem from the specific properties of the technology. Second, it fills a gap in the literature providing anecdotal evidence of the interruptive nature of email (Barley et al. 2011; Hemp 2009; Middleton & Cukier 2006), descriptive statistics about email interruptions (Burgess et al. 2005; Jackson et al. 2003; Renaud et al. 2006; Russell et al. 2007; van Solingen et al. 1998), and empirical evidence of email – but not email interruptions – as a source of overload and stress (Barley et al. 2011; Bellotti et al. 2005; Dabbish & Kraut 2006; Hair et al. 2007; Mackay 1988). Third, email interruptions have a substantive content that is meaningful to the interrupted individuals.

Drawing upon our taxonomy of IT interruptions developed elsewhere (Addas & Pinsonneault 2010), and psychological theories of attention allocation (Easterbrook 1959; Kahneman 1973; Langer 1989), the paper develops an empirical model that examines the direct and indirect effects of email interruptions on individual task performance. It is suggested that different types of email interruptions have distinct effects on performance by leveraging different attention-allocation mechanisms that enhance or inhibit performance. Also, the effects are suggested to be moderated by factors emanating from the asynchrony of email (perceived control and the individual’s multitasking ability).
The paper makes four contributions. First, it extends the extant literature on IT-mediated interruptions by focusing on email interruptions that (1) represent real interruptive events faced by individuals performing their organizational work, (2) comprise exchanged messages with a tangible content (informational, communicational, or action-oriented) that can be evaluated relative to the individual’s primary tasks, and (3) involve a degree of control over the interruption response and timing. The empirical model developed and tested in this paper jointly examines the impacts of different types of email interruptions that are related and unrelated to an individual’s primary tasks, which enhances our understanding about the positive and negative effects on task performance. Second, the paper provides insights into the cognitive attention allocation mechanisms that relate email interruptions to task performance. Third, we identify compensating mechanisms and show their effects of reducing the adverse effects of email interruptions. Finally, the paper presents a complementary approach to the IT impacts literature, which traditionally looks at the performance effects of using IT in ongoing tasks without regard to the continuity or discontinuity of such tasks. By contrast, this paper looks explicitly at the positive and negative performance outcomes that ensue when such usage of IT interrupts the continuity of the primary tasks.

The paper is structured as follows. The next section synthesizes key findings from the literature on IT-mediated interruptions. Then, the notion of email interruptions is delineated. This is followed by describing two complementary theoretical lenses that explain the impacts of email interruptions. We then present the research hypotheses that relate email interruptions to task performance. The methodology is described next, followed by a presentation of the results. The paper ends with a discussion of the results and implications for research and practice.
LITERATURE REVIEW

This section reviews previous research on the impacts of IT-mediated interruptions. Table 1 summarizes the empirical studies by separating the effects of different interruption attributes on emotional/cognitive outcomes (subjective workload) and behavioral outcomes (task performance efficiency and effectiveness). Subjective workload is defined as a hypothetical construct that represents the cost incurred by a human operator to achieve a particular level of performance (Hart & Staveland 1988, p. 140). It has been used in the interruptions literature to represent cognitive loads (time pressure; information load) and emotional loads (e.g., stress; annoyance; frustration; anxiety) experienced by individuals as they perform their tasks (Adamczyk & Bailey 2004; Gluck et al. 2007).

The studies are also summarized according to the type of IT that mediates the interruption. The different media examined include customized PC applications, programmed screen pop-ups, email, instant messaging, and mobile devices.

Finally, the studies are summarized by how the response to the interruption is coordinated. Such coordination – illustrated by the circular icon image next to each table entry – reflects whether individuals have control over the interruption response and timing, or whether no such control exists and interruptions are handled immediately (McFarlane 2002). Interruptions through media with higher degrees of asynchrony – such as email – allow individuals (at least in theory) to coordinate their responses by controlling the nature and timing of the response.
# Table 1: Empirical Studies on IT-Mediated Interruptions

<table>
<thead>
<tr>
<th>Authors (year)</th>
<th>Predictor Variables [Moderators]</th>
<th>Effects on Cognitive/Emotional Load</th>
<th>Effects on Efficiency</th>
<th>Effects on Effectiveness</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Adamczyk &amp; Bailey 2004)</td>
<td>Interruption timing (introduced randomly vs. at subtask boundaries)</td>
<td>☒ PC (+) Annoyance (+) Frustration (+) Time pressure</td>
<td>☒ PC (+) Perceived effectiveness (ns) Objective performance</td>
<td>☒ PC (+) Answer accuracy</td>
<td>Intrusion</td>
</tr>
<tr>
<td>(Ang et al. 1993)</td>
<td>Interruption modality (IT vs. F2F)</td>
<td></td>
<td>☒ PC (-) Reading speed</td>
<td></td>
<td>Intervention</td>
</tr>
<tr>
<td>(Arroyo &amp; Selker 2003)</td>
<td>Interruption presence</td>
<td></td>
<td>☒ PC (+) Task completion time</td>
<td></td>
<td>Intrusion</td>
</tr>
<tr>
<td>(Bailey et al. 2000)</td>
<td>Interruption presence</td>
<td>☒ PC (+) Annoyance (+) Anxiety</td>
<td>☒ PC (+) Task completion time (3-27% longer)</td>
<td>☒ PC (+) Number of errors (200% more)</td>
<td>Intrusion</td>
</tr>
<tr>
<td>(Arroyo &amp; Selker 2003)</td>
<td>Interruption presence (introduced randomly vs. at subtask boundaries)</td>
<td>☒ PC (+) Annoyance (31-106% more) (+) Anxiety (200% more)</td>
<td>☒ PC (+) Task completion time (3-27% longer)</td>
<td>☒ PC (+) Number of errors (200% more)</td>
<td>Intrusion</td>
</tr>
<tr>
<td>(Bailey &amp; Konstan 2006)</td>
<td>Interruption timing (introduced randomly vs. at subtask boundaries)</td>
<td>☒ PC (+) Annoyance (31-106% more) (+) Anxiety (200% more)</td>
<td>☒ PC (+) Number of errors (200% more)</td>
<td></td>
<td>Intrusion</td>
</tr>
<tr>
<td>(Basoglu et al. 2009)</td>
<td>Interruption frequency</td>
<td>☒ PC (+) Cognitive load</td>
<td>☒ PC (+) Number of errors</td>
<td></td>
<td>Intrusion</td>
</tr>
<tr>
<td></td>
<td>Multitasking self-efficacy</td>
<td>☒ PC (-) Cognitive load</td>
<td>☒ PC (-) Number of errors</td>
<td></td>
<td>Intrusion</td>
</tr>
<tr>
<td>(Burmistrov &amp; Leonova 1996)</td>
<td>Interruption presence</td>
<td>☒ PC (+) Task completion time</td>
<td></td>
<td></td>
<td>Intrusion</td>
</tr>
<tr>
<td></td>
<td>[Interruption complexity]</td>
<td>☒ PC (ns) Task completion time</td>
<td></td>
<td></td>
<td>Intrusion</td>
</tr>
<tr>
<td>(Burmistrov &amp; Leonova 2003)</td>
<td>Interruption presence x task complexity</td>
<td>☒ PC (+) Task completion time</td>
<td></td>
<td></td>
<td>Intrusion</td>
</tr>
<tr>
<td>(Cades et al. 2006)</td>
<td>Interruption frequency</td>
<td>☒ PC (+) Resumption lag</td>
<td></td>
<td></td>
<td>Intrusion</td>
</tr>
<tr>
<td>(Cades et al. 2007)</td>
<td>Interruption complexity</td>
<td>☒ PC (+) Resumption lag</td>
<td></td>
<td></td>
<td>Intrusion</td>
</tr>
<tr>
<td>(Carroll &amp; Kay 1988)</td>
<td>Interruption presence</td>
<td>☒ PC (+) Confusion (+) Cognitive overload (from large amount of discrepant information)</td>
<td>☒ PC (-) Learning efficiency (from large amount of feedback)</td>
<td>☒ PC (+) Error rate (with too much information provided, which overwhelms and confuses) (-) Error rate (by directing attention and limiting)</td>
<td>Intervention</td>
</tr>
<tr>
<td>(Carton &amp; Aiello 2009)</td>
<td>Perceived control over interruption</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------------------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>(Cutrell et al. 2000)</td>
<td>Interruption timing (early vs. late)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interruption relevance (relevant vs. irrelevant)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Cutrell et al. 2001)</td>
<td>Interruption presence</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interruption timing (early vs. late)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Czerwinski et al. 2000)</td>
<td>Interruption timing (early vs. late)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interruption relevance (relevant vs irrelevant)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Dabbish &amp; Kraut 2006)</td>
<td>Control over interruption</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interruption timing (early vs. late)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Dodhia &amp; Robert 2009)</td>
<td>Interruption presence</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Earley et al. 1990)</td>
<td>Interruption presence</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Edwards &amp; Gronlund 1998)</td>
<td>Interruption timing (introduced randomly vs. at subtask boundaries)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interruption similarity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Task complexity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Einstein et al. 2003)</td>
<td>Interruption presence</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Eyrolle &amp; Cellier 2000)</td>
<td>Interruption frequency</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interruption presence x task complexity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Temporal strain from interruption</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Gillie &amp;</td>
<td>Interruption duration</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Email Interruptions and Task Performance**

- Information states to be analyzed
- Intrusion

- Stress
- Resumption lag
- Task completion time
- Memory accuracy
- Response likelihood
- Promptness in response
- Memory recovery
- Task completion time
- Error rate
- Proportion of forgetting task intentions
- Performance quality
- Promptness in response
- Proportion of forgetting task intentions
- Error rate
- Error rate
- Task completion time
<table>
<thead>
<tr>
<th>Study</th>
<th>Interruption Factor</th>
<th>Effect on Task Performance</th>
<th>Intrusion Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadbent (1989)</td>
<td>Interruption complexity</td>
<td>☒ PC (+) Task completion time</td>
<td>Intrusion</td>
</tr>
<tr>
<td></td>
<td>Interruption similarity</td>
<td>☒ PC (+) Task completion time</td>
<td>Intrusion</td>
</tr>
<tr>
<td>(Gievska &amp; Sibert 2004)</td>
<td>Interruption timing (immediate vs. delayed response)</td>
<td>☒ PC (+) Number of errors</td>
<td>Intrusion</td>
</tr>
<tr>
<td>(Gievska et al. 2005)</td>
<td>Interruption frequency</td>
<td>☒ PC (+) Annoyance (+) Frustration (+) Cognitive workload (+) Distractiveness</td>
<td>Intrusion</td>
</tr>
<tr>
<td></td>
<td>Interruption timing (immediate vs. delayed response)</td>
<td>☒ PC (+) Annoyance (+) Frustration (+) Cognitive workload</td>
<td>Intrusion</td>
</tr>
<tr>
<td></td>
<td>Interruption frequency x timing</td>
<td>☒ PC (+) Cognitive workload</td>
<td>Intrusion</td>
</tr>
<tr>
<td>(Gluck et al. 2007)</td>
<td>Interruption timing (matching interruption relevance with attention draw)</td>
<td>☒ PC (-) Annoyance (ns) Workload</td>
<td>☒ PC (+) Perceived effectiveness (ns) Performance accuracy</td>
</tr>
<tr>
<td>(Ho et al. 2001)</td>
<td>Interruption frequency</td>
<td>☒ PC (+) Initiation delays</td>
<td>Intrusion</td>
</tr>
<tr>
<td>(Ho &amp; Intille 2005)</td>
<td>Interruption timing (introduced randomly vs. at subtask boundaries)</td>
<td>☒ PC (+) Disruptiveness</td>
<td>Intrusion</td>
</tr>
<tr>
<td>(Hodgetts &amp; Jones 2006a)</td>
<td>Interruption presence</td>
<td>☒ PC (+) Resumption lag</td>
<td>Intrusion</td>
</tr>
<tr>
<td>(Hodgetts &amp; Jones 2006b)</td>
<td>Interruption presence</td>
<td>☒ PC (+) Resumption lag</td>
<td>☒ PC (ns) Number of errors (attributed to lack of complexity)</td>
</tr>
<tr>
<td></td>
<td>Interruption duration</td>
<td>☒ PC (+) Resumption lag (but effect levels off)</td>
<td>Intrusion</td>
</tr>
<tr>
<td></td>
<td>Interruption complexity</td>
<td>☒ PC (+) Resumption lag</td>
<td>Intrusion</td>
</tr>
<tr>
<td>(Hodgetts &amp; Jones 2007)</td>
<td>Interruption presence</td>
<td>☒ PC (+) Resumption lag</td>
<td>Intrusion</td>
</tr>
<tr>
<td></td>
<td>Interruption duration</td>
<td>☒ PC (+) Resumption lag (but effect levels off)</td>
<td>Intrusion</td>
</tr>
<tr>
<td></td>
<td>Interruption complexity x</td>
<td>☒ PC (+) Resumption lag (especially at early</td>
<td>Intrusion</td>
</tr>
<tr>
<td>Timing/Duration</td>
<td>Presence</td>
<td>Points with Higher Load</td>
<td>Notes</td>
</tr>
<tr>
<td>-----------------</td>
<td>----------</td>
<td>-------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>(Iqbal et al. 2005)</td>
<td>Interruption timing (introduced randomly vs. at subtask boundaries)</td>
<td>☻ PC (+) Annoyance (-) Respect</td>
<td>☻ PC (+) Resumption lag</td>
</tr>
<tr>
<td>(Iqbal &amp; Bailey 2006)</td>
<td>Interruption timing (introduced randomly vs. at subtask boundaries)</td>
<td>☻ PC (+) Annoyance (-) Respect</td>
<td>☻ PC (+) Resumption lag</td>
</tr>
<tr>
<td>(Iqbal &amp; Horvitz 2007)</td>
<td>Interruption presence</td>
<td>☻ EM (-) Efficiency – spillover effects as email alert leads to examining multiple emails</td>
<td>Intrusion</td>
</tr>
<tr>
<td>(Kapitsa &amp; Blinnikova 2003)</td>
<td>Interruption presence</td>
<td>☻ PC (+) Total work time</td>
<td>☻ PC (+) Number of errors</td>
</tr>
<tr>
<td>(McDaniel et al. 2004)</td>
<td>Interruption presence</td>
<td>☻ PC (+) Proportion of forgetting task intentions</td>
<td>Intrusion</td>
</tr>
<tr>
<td>McFarlane 2002</td>
<td>Interruption frequency</td>
<td>☻ PC (+) Task completion time</td>
<td>☻ PC (+) Decision time</td>
</tr>
<tr>
<td>(Miller 2002)</td>
<td>Interruption timing (early vs. late)</td>
<td>☻ PC (+) Memory interference between intervention content and task resumption details</td>
<td>☻ PC (+) Decision time</td>
</tr>
<tr>
<td>(Monk et al. 2002)</td>
<td>Interruption timing (early vs. late)</td>
<td>☻ PC (+) Resumption lag</td>
<td>Intrusion</td>
</tr>
<tr>
<td>(Monk et al. 2004b)</td>
<td>Interruption frequency</td>
<td>☻ PC (+) Resumption lag</td>
<td>☻ PC (ns) Error rate</td>
</tr>
<tr>
<td></td>
<td>Interruption duration</td>
<td>☻ PC (+) Resumption lag (but effect levels off)</td>
<td>Intrusion</td>
</tr>
<tr>
<td>(Monk et al. 2008)</td>
<td>Interruption frequency</td>
<td>☻ PC (+) Resumption lag</td>
<td>Intrusion</td>
</tr>
<tr>
<td></td>
<td>Interruption duration</td>
<td>☻ PC (+) Resumption lag (but effect levels off)</td>
<td>Intrusion</td>
</tr>
<tr>
<td>(Nagata 2006)</td>
<td>Interruption presence</td>
<td>☻ MD (+) Task completion time</td>
<td>Intrusion</td>
</tr>
<tr>
<td>Addas (Essay #2)</td>
<td>Email Interruptions and Task Performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>----------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Interruption modality (mobile device vs. PC)</strong></td>
<td>MD</td>
<td>(+) Task completion time</td>
<td></td>
</tr>
<tr>
<td><strong>Interruption complexity</strong></td>
<td>MD</td>
<td>(-) Task completion time</td>
<td></td>
</tr>
<tr>
<td><strong>Interruption predictability</strong></td>
<td>MD</td>
<td>(-) Task completion time</td>
<td></td>
</tr>
<tr>
<td><strong>[Multitasking ability]</strong></td>
<td>MD</td>
<td>(-) Task completion time</td>
<td></td>
</tr>
<tr>
<td><strong>(Oulasvirta &amp; Saariluoma 2004)</strong></td>
<td>Interruption presence</td>
<td>PC</td>
<td>(-) Recall accuracy</td>
</tr>
<tr>
<td><strong>(Perlow 1999)</strong></td>
<td>Interruption timing (“quiet time” strategy)</td>
<td>VA</td>
<td>(+) Productivity</td>
</tr>
<tr>
<td><strong>(Ratwani et al. 2007)</strong></td>
<td>Interruption presence</td>
<td>IM</td>
<td>(+) Resumption lag</td>
</tr>
<tr>
<td><strong>(Robertson et al. 2004)</strong></td>
<td>Control over interruption (controlled response vs. immediate)</td>
<td>PC</td>
<td>(+) Productivity (ns) Promptness in response</td>
</tr>
<tr>
<td><strong>(Speier et al. 1997)</strong></td>
<td>Interruption presence x task complexity</td>
<td>PC</td>
<td>(+) Task completion time</td>
</tr>
<tr>
<td><strong>(Szalma et al. 2006)</strong></td>
<td>Interruption frequency x task complexity</td>
<td>PC</td>
<td>(+) Task completion time</td>
</tr>
<tr>
<td><strong>(Trafton et al. 2005)</strong></td>
<td>Interruption presence</td>
<td>PC</td>
<td>(+) Resumption lag</td>
</tr>
<tr>
<td><strong>(Zijlstra et al. 1999)</strong></td>
<td>Interruption frequency</td>
<td>PC</td>
<td>(-) Positive emotions and well-being</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PC</td>
<td>(+) Total work time (-) Time on primary task</td>
</tr>
</tbody>
</table>

**Coordination of Interruption Response**

- **X** Immediate response
- **O** Delayed response
- **🙂** Controlled response

**Interrupting Medium**

| MD | Customized PC application |
| EM | Email |
| VA | Various |
| IM | Instant messaging |
Three broad observations can be made about the reviewed literature. First, little attention has been paid to the role of the IT medium in shaping the effects of the IT interruptions. Second, previous research has focused mostly on the impacts of simple temporal characteristics of the interruption (e.g., frequency; duration; timing) without distinguishing qualitatively different types of interruptions. Third, attention is needed to better understand the conditions under which interruptions exhibit their effects (the moderating factors) and the mechanisms by which such effects are exhibited (the mediating factors). Below, we discuss each of these three observations separately in light of the reviewed literature.

The Role of the IT Medium

Previous studies largely considered IT as a passive medium that simply delivers the interruption, and the focus was on how attributes of the interruption influence task outcomes. As shown in Table 1, the most frequently used IT medium to deliver interruptions was customized PC applications. These interruptions occurred via screen pop-ups programmed by the experimenters. Such pop-ups suspended the subjects’ primary tasks (with or without warning) and propelled them toward other computer-based tasks (e.g., Adamczyk & Bailey 2004; Burmistrov & Leonova 2003; Dodhia & Robert 2009; Gievska et al. 2005; Iqbal & Bailey 2006; McFarlane 2002; Speier et al. 1997). While some studies considered other IT media such as instant messaging (Cutrell et al. 2001; Cutrell et al. 2000; Czerwinski et al. 2000; Ratwani et al. 2007), they still put the technology in the background and did not consider how aspects of the technology may influence the performance impacts of interruptions.

Although most previous studies did not pay attention to the IT medium of interruption, some exceptions exist. For example, Dabbish (2006) examined the influence of the awareness
Email Interruptions and Task Performance

display feature of instant messaging and found that it ameliorates the joint performance of the interruption source and target. However, too much information on the display also harmed the interruption source (Dabbish & Kraut 2004; 2006). Another study found that email cue visibility significantly reduces task resumption time after an interruption (Iqbal & Horvitz 2007). Nagata (2003) explicitly modeled the effect of the technology by comparing interruptions via different IT tools (instant messaging and phone on mobile devices and desktop PCs). She found that interruptions on mobile devices lead to longer task completion times than those on desktop PCs. Also, instant messaging interruptions were more disruptive than phone/intercom interruptions to individuals’ web performance because of content similarity. Another finding was that the IT medium moderates the relationship between interruption anticipation and performance. While the confidence in the results may not be very high because of the small sample size, that study – combined with the other findings – provide preliminary evidence that the specific IT tool studied may matter in identifying the effects of IT interruptions on performance.

Email is a particularly interesting tool to study from an interruptions viewpoint. On one hand, it may be argued that the asynchrony of email makes it non-interruptive (Rennecker & Godwin 2005; Rudy 1996). This is because individuals can control whether and when to handle their messages (e.g., by switching off the email client, ignoring email, or delaying the response until task completion). However, email shares with other electronic messaging systems – such as instant messaging and text messaging – three features that curb such control and render email a fertile ground for interruptions: (1) notification alerts; (2) reviewability; (3) parallelism.

First, email messages include a notification alert that provides a time lag before the onset of the impending interruption. The alert is often multimodal, providing a range of visual, auditory, and tactile cues (e.g., sound, popup, and icon display in the system tray for email; ring
tone, popup, and vibrator for messages on smartphones). This is in contrast to traditional F2F and phone interruptions that either produce no alerts before the interruption or produce alerts with a limited range of cues. Media with notification alerts allow individuals with perceived control to “negotiate” their interruptions (McFarlane 2002) by selecting opportune moments of interruptions such as by tying them to message urgency (Ho et al. 2004) or to natural breakpoints in the task in which cognitive loads are lower (Bailey & Konstan 2006; Iqbal & Bailey 2006).

Also, the delay provided by the alert can be used to create a mental picture of the task environment to facilitate subsequent resumption of the interrupted task (Altmann & Trafton 2002).

On the other hand, media with multimodal notification alerts place attentional demands (Grandhi & Jones 2010) and propel individuals to rapidly switch to the interruption. For example, multimodal alerts (auditory and visual) were found to trigger faster interruption rates than uni-modal alerts (Mahadevan 2009). Similarly, tactile cues were found to lead to more efficient switching to the interruption (Hopp et al. 2005). A study of mobile email found that “It is common for BlackBerry users to respond in a Pavlovian fashion to the beeps and buzzes that indicate the arrival of messages, grabbing at the device immediately to see what is new” (Middleton 2007, p. 169). As one informant noted, “You really don’t need to check every email you receive, you really don’t, but you feel like you should if it vibrates” (Middleton & Cukier 2006, p. 255).

Second, email technology is characterized by reviewability (ability to review messages after being received). Like the notification alert affordance, media with reviewability allow individuals to exercise control over the onset and timing of the interruption. However, reviewability also leads individuals to become more interrupted by repeatedly revisiting and/or
responding to the received messages to understand more about them (e.g., context; urgency; details) as a way to reduce uncertainty in the absence of nonverbal cues (Antheunis et al. 2011; Grandhi & Jones 2010). Dennis et al. (2008) theorized that reviewability leads individuals to “spend more time decoding messages” (p. 587) and to “[revisit] prior messages for additional considerations” (p. 587).

Also, social properties of email use combine with the reviewability feature to curb the level of perceived control and increase the intensity of interruptions. More specifically, individuals feel compelled to constantly check, and often immediately respond to, their incoming email (Barley et al. 2011; Jackson et al. 2003; Mazmanian et al. 2005; Orlikowski 2007). This is attributed to social aspects such as the anxiety of email buildup (Barley et al. 2011), the fear of falling behind (Barley et al. 2011), job directives (Orlikowski 2007), and email response expectations (Mazmanian et al. 2005; Orlikowski 2007). Hence, rather than assume that email affords full control over the interruption, a better approach – followed in this paper – is to explicitly model perceived control as a variable that is influenced by the material and social properties of the system.

Third, email allows for parallelism. This feature refers to the extent to which multiple interactions can take place simultaneously over the medium. In F2F conversations, two or more people form a sequence of turns that typically does not include intervening turns from outside conversations (Clark & Brennan 1991). In other words, the interruptive event is isolated in a sequence, which proceeds from start to finish before a new sequence of communication (e.g., a new F2F interruption) can take place. Similarly, phone interruptions do not exhibit high parallelism since a phone interruption typically occupies the channel such that a new phone interruption would be silently and invisibly queued up in the recipient’s voicemail (Rennecker &
Godwin 2003). Even if recipients had call-waiting features and would be drawn into the second call, they would typically ignore the second call, pick it up briefly to inform the caller that they would call back later, or terminate the first call (Rennecker & Godwin 2003).

By contrast, email interruptions allow for multiple threads of conversations to take place at the same time, without requiring the medium to clear (Clark & Brennan 1991; Dennis et al. 2008). For example, an individual may be writing an email when she gets interrupted by another email requesting some important information about an unrelated task. While reading the second email, she realizes that she needs to send a third email to her subordinate to get the required information in the second email. Indeed, the interruptions literature refers to email creating “chains of diversions” that capture the attention of the interruption target to deal with multiple threads of issues and conversations before returning to the primary task activities (Iqbal & Horvitz 2007). Hence, the parallelism feature of email often produces a cognitively demanding web of interruptive events nested within each other. Individuals with high multitasking capabilities may be able to partly offset the challenges associated with such interruptions.

Together, the properties reviewed above suggest that email interruptions are a distinct phenomenon that warrants investigation. Rather than assume such email to be non-interruptive, a more fruitful approach is to explicitly model the degree of perceived control over such interruptions and to what extent it influences impacts on work outcomes. Overall, email interruptions trigger high levels of cognitive load and require special work capabilities to deal with their adverse effects (perceived control and multitasking self-efficacy).
Differentiating Types of IT Interruptions

In examining performance effects, previous studies have also not distinguished different types of interruptions beyond simple variations in temporal characteristics (e.g., frequency; duration; timing). As Table 1 indicates, the performance effects of IT interruptions vary from positive (e.g., Ang et al. 1993; Jung et al. 2010; Robertson et al. 2004) to negative (e.g., Bailey et al. 2001; Cutrell et al. 2001; Speier et al. 1997). While the temporal characteristics may exhibit some direct effects on performance (Basoglu et al. 2009; Eyrolle & Cellier 2000; Zijlstra et al. 1999), or mitigate some of the adverse effects of the interruptions (e.g., Edwards & Gronlund 1998; Nagata 2006; Speier et al. 1997), they do not explain the opposite signs in performance.

However, there is some evidence that variations in the sign of the performance outcomes may be partly due to interruption types that are qualitatively different with respect to content relevancy to the primary task. Indeed, much of the reviewed literature – while not explicitly conceptualizing interruption content – indicates that non-relevant IT-mediated interruptions increase emotional load (e.g., Bailey et al. 2001; Gievska et al. 2005), lower the efficiency of both resuming and completing the interrupted tasks (e.g., Arroyo & Selker 2003; Bailey et al. 2000; Monk et al. 2004b), and debilitate performance effectiveness as a result of increased errors (e.g., Kapitsa & Blinnikova 2003; McFarlane 2002; Speier et al. 1997) and a reduced ability to remember interrupted task details (McDaniel et al. 2004; Oulasvirta & Saariluoma 2004). One study that explicitly looked at content found that interruptions that are irrelevant to – but that have content similar to – the primary task increase task completion time (Gillie & Broadbent 1989). On the other hand, some studies found IT-mediated interruptions that provide useful informational content to generally enhance task performance (Ang et al. 1993; Robertson et al. 2004). One study compared interruptions with relevant and irrelevant contents and found the
former to lead to shorter resumption lags and task completion times (Cutrell et al. 2000; Czerwinski et al. 2000). Since email content may also be relevant (e.g., 23% of all tasks that individuals are responsible for are email tasks; cf. Czerwinski et al. 2004) or irrelevant (e.g., between 43% and 69% of emails received are unrelated to business tasks; cf. Jackson et al. 2000) to the task-at-hand, an important question is whether differences in email interruption types result in variations in task performance outcomes.

**Mediating and Moderating Factors**

As a final observation, much of the empirical results do not systematically explain the mechanisms through which the particular performance effects occur (mediating factors) and the conditions under which they occur (moderating factors) within the context of the interruption. On the former, the literature is mostly mute. With respect to the latter, several studies indeed present moderating effects (e.g., Cutrell et al. 2001; Edwards & Gronlund 1998; Nagata 2006; Speier et al. 1997). However, these stem mostly from the properties of the interruptions manipulated in the laboratory environment rather than the actual context of the individuals being interrupted. One of the most important moderating effects identified relates to the timing of the interruption. Most of the studies summarized in Table 1 involved “immediate response” interruptions that were not controlled by individuals. Such interruptions were handled immediately, either by pre-empting the primary task or being performed simultaneously with it (Ho et al. 2001). However, studies that manipulated the timing of interruptions in this immediate response group found mitigation effects on subjective workload and performance when the interruptions were introduced at more opportune moments (e.g., Bailey & Konstan 2006; Cutrell et al. 2001; Ho & Intille 2005; Iqbal &
Bailey 2006; Monk et al. 2002). This may suggest that if individuals have authority over the timing of their interruptions, they may experience less adverse effects from the interruptions.

Similarly, another group of studies classified in the “delayed interruptions” group also involved interruptions that were not controlled by individuals, but these were preceded by alerts that announced the impending interruption. Here too, mitigating effects were found for on cognitive and emotional responses (Gievska et al. 2005) and task completion time (Gievska & Sibert 2004).

Finally, studies where the interruptions were explicitly controlled by individuals – shown in the “controlled response” group – found that such control may produce less detrimental effects on performance (Dabbish & Kraut 2006; McFarlane 2002), albeit while slowing response promptness (McFarlane 2002).

Email interruptions may be seen as a special case of these controlled response interruptions. Indeed, the asynchrony of email allows individuals to coordinate their interruption response through their perception of control over the interrupting email. More specifically, email is a case where control over the interruption response and timing resulting from the asynchrony of email is countered by limits to such control due to individuals’ compulsion to interrupt their primary tasks and handle the email. Hence, rather than artificially controlling the timing of the email interruptions or assuming that individuals have full control, a more adequate approach, which is followed in this paper, is to explicitly measure the degree of perceived control over the email response and timing. This allows us to model its moderating effects on task performance in a way that better captures the context in which the interruptions take place.

A second moderating factor identified from the previous literature is multitasking self-efficacy, which captures the individual’s ability to interleave the execution of interrupting and
primary tasks. Indeed, Table 1 indicates that multitasking ability mitigates the adverse effects of IT interruptions on primary task completion time, especially those delivered over mobile devices (Nagata 2003; Nagata 2006). Similarly, a study of 257 subjects involved in decision making tasks found that while IT interruptions indirectly increase decision making errors via cognitive load, multitasking self-efficacy exhibits compensating effects that reduce cognitive load (Basoglu et al. 2009) and improved performance (Basoglu et al. 2009).

Multitasking self-efficacy is important to include in the study of email interruptions. Because of the asynchrony of email, individuals are provided more opportunity and flexibility for coordinating the interruption response via task interleaving (Barley et al. 2011), especially when compared to more synchronous media (Aral et al. 2006). This is because email discussions and tasks cannot be completed until obtaining a response (or multiple rounds of responses), which requires the ability to manage multiple interleaved tasks (Bellotti et al. 2005; Gonzales & Mark 2005). Hence, from an interruptions viewpoint, it is important to understand to what extent an individual’s multitasking ability compensates for disruptions caused by constant threads of email interruptions.

**Summary**

While only a single study in the review explicitly examines email interruptions (Iqbal & Horvitz 2007) – attesting to the scarcity of research in this area – we can use the empirical results of the performance impacts of IT-mediated interruptions to inform our study of email interruptions. Similar to other IT-mediated interruptions, email interruptions comprise different contents that may or may not be related to the primary tasks. To better understand the impacts of email interruptions, we conceptualize the notion of email interruptions in the next section and
then draw upon theories of attention allocation that allow us to explain their impacts on performance.

THEORETICAL DEVELOPMENT

To help build a research model of the impacts of email interruptions, it becomes necessary to first draw boundaries around the terms “email” and “interruption.” While email may also refer to the method of exchanging digital messages, we use the term email\textsuperscript{13} henceforth to refer to the digital message itself that is created by an individual using an email client, disseminated through an email server residing on a network, and retrieved by one or more individuals through the email server(s). For the purpose of studying the effects of email interruptions, we focus on the receiving side of the email. The email message may comprise text, multimedia, documents, links, data, and applications (Sproull & Kiesler 1986).

Email messages may be classified according to their content being informational, communicational, or actionable. First, informational emails are for disseminating information and they do not typically require the recipient to respond or take any action. Examples may include disseminated documentation or reports (Kettinger & Grover 1997; Russell et al. 2007), scheduled meetings or events (Dabbish et al. 2005), general FYI information (Mackay 1988; Mazmanian et al. 2005), announcements and reminders (Bellotti et al. 2005; Sproull & Kiesler 1986), and feedback or comments.

Second, communicational emails involve two-way communications and exchanges. Such emails require the receiver to respond, but they do not typically trigger the execution of particular action. Examples include requesting documentations and information (Ducheneaut &

\textsuperscript{13} We use the terms “email” and “email message” interchangeably throughout the paper.
Bellotti 2001; van Solingen et al. 1998), requesting opinions (Kettinger & Grover 1997), initiating discussions (Bellotti et al. 2005; Ducheneaut & Bellotti 2001), and questions or queries (Bellotti et al. 2005; Russell et al. 2007).

Third, actionable emails involve the execution of behavioral action, and are thus more cognitively demanding. Examples of actions that may be triggered by email are the “To Dos” that are kept in the Inbox as pending tasks (Steve & Candace 1996), assigned task responsibilities (Bellotti et al. 2005; Ducheneaut & Bellotti 2001), decision-making emails (Ducheneaut & Bellotti 2001), and problem-solving emails (Kettinger & Grover 1997; Markus 1994).

**Conceptualizing Email Interruptions**

An email interruption is conceptualized as a subset of work interruptions (Jett & George 2003; Speier et al. 1997) and defined as the temporary suspension of an individual’s primary task to process the content of an incoming email message. Hence, email interruptions describe behaviors or actions in which cognitive attention turns from a primary task toward the content of the incoming email. Primary tasks are the ongoing tasks for which individuals are primarily responsible (Iqbal & Horvitz 2007). Processing the content of the email may include reading, responding to, and/or executing actions that are called for in the email.

Drawing upon Jett & George’s (2003) taxonomy of work interruptions, we identify two main types of email interruptions: email intrusions and email interventions. Intrusions describe email contents that are unrelated to – and divert attention from – an individual’s primary task activities. For example, an email from Human Resources requesting a product designer to urgently fill in her employee hours may be classified as an intrusion to the primary design tasks.
On the other hand, interventions usually pertain directly to performing the primary task activities. The content of such email interruptions reveals discrepancies between actual and desired task performance and they direct attention toward the source of those discrepancies. In essence, they interrupt ongoing behavior and motivate behavioral changes in order to address the task performance discrepancies (Jett & George 2003). For example, an email sent to a software developer containing customer feedback on product features may be considered as an intervention.

Two Theories of Attention Allocation

Our theorization of the interruptive effects of email interruptions is based upon two complementary theories of attention allocation: cue utilization theory (Easterbrook 1959) and the notion of mindfulness (Langer 1989). Together, those two theories help explain the effects of the different types of email interruptions.

Cue Utilization Theory

Cue utilization theory is premised on the idea that attention is a scarce resource that is drawn from a finite pool of an individual’s attention capacity in order to process information cues and meet various task demands (Kahneman 1973). Attentional resources are allocated for executing a new task or when an existing task demands more attention. Since attention capacity is limited, increased task demands trigger a coping mechanism in which attention contracts to conserve attention resources (Easterbrook 1959). Such contraction means that information cues used in processing the primary task are dismissed. Selective attention makes it feasible to first dismiss peripheral cues that are less important for performing the primary task. But with
increasing demands, central and immediately relevant cues also begin to be dismissed, which makes it difficult to maintain performance proficiency (Easterbrook 1959). Consequently, performance suffers due to shrinkage in the range of cue utilization.

Cue utilization theory can be used to help explain the influence of interruptions, and particularly intrusions. Specifically, intrusions are a primary cause for increasing task demands since they introduce secondary tasks that compete with the primary task over capturing the individual’s attention. For example, email intrusions can break the continuity of a primary task and channel attention toward the email content. Since such intrusions are accompanied by cues requiring processing (e.g., reading, responding to, or acting upon the content of the email), they deplete attentional resources and may result in capacity interference or cognitive interference (Kahneman 1973). Capacity interference occurs when the intrusion cues exceed the individual’s available attentional capacity. This triggers the attentional contraction mechanism described earlier. Additionally, attentional capacity overload can manifest via cognitive switching costs from juggling back and forth between the demanding intrusions and primary task, which requires re-ordering of task priorities and suppressing/activating cues associated with those tasks. Such detrimental effects can be further exacerbated by cognitive interference (Kahneman 1973; Wickens et al. 2005) when the primary task and intrusion draw on similar resources in a way that confuses attentional allocation (e.g., if both activities are visual in nature, or if both use similar IT tools). Overall, such cognitive debilitations are likely to be detrimental to task performance since individuals end up taking longer to perform the task, forgetting key task aspects, reducing information cues associated with the task, taking shortcuts, and/or opting for satisficing decisions (Easterbrook 1959; Kahneman 1973; Speier et al. 1997).
Mindfulness Theory

Mindfulness is defined as a state of cognitive functioning through which an individual performing his or her primary tasks exhibits alertness to distinction, openness to novelty, orientation in the present, and implicit, if not explicit, awareness of multiple perspectives (Langer 1989; Roberts et al. 2007). The theory of mindfulness is based on the same assumption as cue utilization theory, namely that individuals have scarce attentional resources. In an effort to cope with such limits, they process task information in an automatic (mindless) manner (Langer 1989). Mindless activity leads individuals to miss important information and opportunities. However, contextual factors in the task environment – such as novelty, discrepancy or deliberate requests for attention – have been shown to motivate individuals to switch to more “mindful” states of cognitive processing (Langer 1989; Louis & Sutton 1991). Such mindful states induce individuals to pay more explicit attention to their tasks, actively attend to new information, become open to different points of views, and heedfully relate their actions to those of others collaborating with them (Langer 1989).

Mindfulness theory can be used to help explain the influence of interventions. Interventions – such as emails that provide feedback on an ongoing task – introduce novelty and/or reveal a discrepancy between the way the task is supposed to be performed and the way it is actually performed. This stimulates individuals to redirect attention to the problem source, recognize the need for change, and switch from automatic processing to more mindful and reflective action (Jett & George 2003). Hence, interventions can actually improve problem solving, enable learning and adaptation (Jett & George 2003), and enhance knowledge sharing capabilities (Okhuysen & Eisenhardt 2002; Zellmer-Bruhn 2003).
In summary, whereas cue utilization theory is about the contraction of attention from demanding interruptions, which is detrimental to performance, mindfulness theory helps us explain how some types of interruptions and other events can actually expand attentional capacity and subsequently improve performance.

**RESEARCH MODEL & HYPOTHESES**

The research model is illustrated in Figure 1. As shown in the model, the two types of email interruptions influence individual task performance by leveraging distinct attention allocation mechanisms – described by cue utilization theory and mindfulness theory – that either improve or hinder performance. Task performance is assessed using a holistic view, which includes both efficiency and effectiveness (Hackman 2002; O'Leary et al. 2011). The model also highlights the moderating roles of perceived control and multitasking self-efficacy. Below, we develop the research hypotheses that predict the various relationships shown in the model.
Email Intrusions and Individual Performance

Direct Effects of Email Intrusions on Individual Performance

IT-mediated intrusions capture scarce cognitive attention and divert it from primary task activities. Hence, intrusion intensity is likely to be detrimental to performance through two different mechanisms.¹⁴ The first is structural. Since intrusions allocate attention and time away from primary task activities, such activities end up being delayed and/or postponed. Such efficiency losses may multiply especially if the individual’s activities are interdependent and temporally tied to one another and to an overall project with given time limits (e.g., a salesperson prospecting clients in a sales project, interacting with prospective clients, preparing and making

¹⁴ We use intensity as a measure of email interruptions. As we elaborate later, intensity comprises the frequency and duration of the interruption.
sales materials and presentations, overcoming prospective client obstacles, and closing the sale).

Intrusions from email are not immune to such losses since individuals feel compelled to interrupt their ongoing tasks to handle the incoming emails (Orlikowski 2007; Orlikowski & Barley 2001). Additionally, email intrusions are likely to trigger spillover effects in which an initial attention switch to the email inbox leads to a “chain of diversions” where individuals handle multiple emails before returning to their primary task activities (Iqbal & Horvitz 2007).

Performance losses can even occur from informational email intrusions that do not require a response or trigger behavioral action. This is because individuals still stop their tasks to attend to the email intrusions, evaluate their content, and determine whether or not they are relevant to their ongoing tasks. For example, a study of 50 individuals involved in various problem-solving tasks found that irrelevant stock news announcements displayed on the PC intruded on their tasks and increased their task completion times by 3-27% (Bailey & Konstan 2006). A similar increase in task completion time was observed in a study of 16 subjects who were performing a media task and were subsequently interrupted with an intruding pop-up displaying a problem-solving task (Adamczyk & Bailey 2004). Other studies also mirrored those results (Burmistrov & Leonova 2003; Eyrolle & Cellier 2000; Nagata 2003).

The second mechanism that decreases performance from email intrusions involves cognitive switching costs. These costs are incurred when individuals switch attention between the demands of the primary task and intrusion. Each switch involves suppressing cues in memory associated with the previous task or event and activating cues needed for the current task or event. First, engaging in a new interruptive task or event takes time and effort as individuals deal with cognitive tensions from the uncompleted task and attempt to free up cognitive resources for handling the intrusion. This effect was empirically substantiated in various contexts where
interrupted individuals switched from their primary tasks to other, computer-based tasks that were irrelevant to their main tasks (Bailey et al. 2000; Bailey et al. 2001; McFarlane 2002; van den Berg et al. 1996). Second, when an interrupted task is resumed, performance losses occur as individuals try to refocus on the task, remember task details, and regain momentum (Altmann & Trafton 2007; Hodgetts & Jones 2006b; Monk et al. 2008; Oulasvirta & Saariluoma 2004; Ratwani et al. 2007). For example, Speier et al. (1997) found that frequent intrusions increase cognitive switching costs, which is detrimental to decision making accuracy and task completion time. In an example from email research, the employees of an office equipment vendor were found to require over a minute to recover from each email interruption they encountered (Jackson et al. 2003). In another field study of 27 professionals performing software development and document editing tasks, it took individuals more than 15 minutes on average after completing the email intrusions in order to be able to return to the same state of their primary tasks (Iqbal & Horvitz 2007). This result held for both emails that were handled immediately and emails that were coordinated and handled later.

Hypothesis 1: Email intrusion intensity is negatively associated with individual performance.

Indirect Effects of Email Intrusions on Individual Performance through Subjective Workload

Email intrusions and subjective workload. Any task performed by an individual – whether interrupted or not – places demands on attentional resources from the individual's collective pool of attentional capacity (Easterbrook 1959; Kahneman 1973). When those demands are high, they are translated to the set of experienced cognitive and emotional loads (Weick 1990), which we have referred to earlier as subjective workload (Adamczyk & Bailey
2004). Intrusions are likely to influence the various aspects of subjective workload. First, since they break the continuity of primary task activities, this may lead to postponing such activities to first deal with the interruption (McFarlane 2002; O'Conaill & Frohlich 1995). Consequently, individuals perceive pressures with respect to how much time they have to fulfill the demands of both the primary task and interruption (Gong 2006; Perlow 1999). Adamczyk et al. (2004) reported an increase of perceived time pressure of 55% for intrusions introduced at the worst timings and 37% for intrusions introduced randomly. This effect is expected to be especially salient when time is an important part of the job environment. For example, commission-based salespersons are likely to experience substantial time pressures when their primary activities of generating new sales are interrupted by secondary activities (e.g., servicing existing accounts; working on sales orders) (Moncrief 1986).

Second, consistent with cue utilization theory, intrusions trigger competing task demands that increase the amount of information cues that require processing (Easterbrook 1959; Kahneman 1973). This may overload the individual’s information processing capacity and compel one to rely on fewer cues. Indeed, the research reviewed in Table 1 supports a positive link between IT-mediated intrusions and cognitive load (Basoglu et al. 2009; Carroll & Kay 1988; Gievska et al. 2005). Email intrusions are also expected to trigger such cognitive overload. For example, evidence from the sales literature shows that salespersons are compelled to swiftly process email information coming from various sources, which evokes information overload (Hunter & Goebel 2008).

Third, intrusions disrupt primary tasks, tax attentional capacities, and create cognitive tensions from uncompleted tasks that linger without closure. This is likely to elicit adverse emotional responses such as stress, anxiety, and frustration (Gong 2006; Zijlstra et al. 1999). For
example, in a study of 50 individuals performing problem-solving tasks, intruding stock news announcement pop-ups were found to increase their annoyance and anxiety (Bailey et al. 2001). Such emotional responses were also found to occur in the case of both simple and complex intrusive tasks (Kapitsa & Blinnikova 2003). Another study reported a doubling of the amount of annoyance and anxiety when intrusions are not introduced at opportune moments (Bailey & Konstan 2006). In the context of sales, interruptive situational variables (such as too many meetings and activities that provided little contribution to sales results) were found to increase stress and subsequently debilitate performance (Lapidus et al. 1996).

Compared to other IT-mediated intrusions, email intrusions are expected to be especially taxing on subjective workload. First, it is easy and relatively cost-free to diffuse messages, communication exchanges, and action requests by email to single or multiple recipients. This property of email, in addition to social pressures to respond quickly to the email, increase subjective workload by creating a perception of increased amounts of work that must be handled promptly (Bellotti et al. 2005; Mackay 1988).

Second, the interruptive aspect of email is particularly overloading since such email directly competes with the primary task over attentional resources. In this case, it is not a matter of email creating more work, but rather that such work impinges on the work being done, which opens up avenues for cognitive and capacity interferences as well as negative emotional reactions. For example, in a study of IT support engineers and other professionals, Barley et al. (2011) found that the time spent doing email increased stress and overload. The authors further showed that the adverse effects of email were not due to the extra work created by it, but rather through the intertwining of material and social properties of the technology that compelled individuals to interrupt their tasks to deal quickly with the email. Hair et al. (2007) found that
individuals who perceived email as distractive possessed a “stressed” orientation, in which they formed a negative pressure to respond.

**Hypothesis 2a:** Email intrusion intensity is positively associated with subjective workload.

**Subjective workload and individual performance.** Consistent with cue utilization theory, attentional resources are drawn from a fixed pool of attentional capacity to offset the increasing demands elicited by task intrusions. This leads to capacity interference as attentional demands exceed capacity (Kahneman 1973). To cope with the increased workload and conserve attentional resources, individuals dismiss information cues by order of least importance. Given that the combined demands of the primary task and intrusion are high, decrements in primary task performance are expected upon resumption.

Empirical results support a mediation effect on performance occurring through subjective workload. For example, a field study of 10 telecommunications operators performing customer service tasks found that error rate did not increase as a result of intrusions, and the authors speculated that this was because temporal strain was low (Eyrolle & Cellier 2000). They then tested this notion in a subsequent experiment and found that following a task switch intrusion, temporal strain was indeed responsible for increasing the error rate. Essentially, individuals adjusted to the increasingly demanding intrusive task but at the cost of committing more errors (Eyrolle & Cellier 2000). Similarly, an experiment of subjects performing reading tasks attributed the adverse effect of the intrusions to time pressure (Oulasvirta & Saariluoma 2006). Specifically, intrusions elicited a rapid pace of task processing, which hampered the subjects’ ability to effectively encode information and led to increased errors and decreased memory
accuracy. In the sales literature, there is widespread agreement that stress and overload are detrimental to salesperson performance (Baum & Singh 1994; Behrman & Perreault 1984; Rod et al. 2008). Moreover, it was shown that intrusive activities enhance such stress (Lapidus et al. 1996) and overload (Hunter & Goebel 2008), which subsequently debilitates salesperson performance (Hunter & Goebel 2008; Lapidus et al. 1996). Hence, we hypothesize that the subjective workload elicited by email intrusions debilitates individual performance.

Hypothesis 2b: Subjective workload is negatively associated with individual performance.

Hypothesis 2c: Subjective workload mediates the negative impact of email intrusion intensity on individual performance.

Email Interventions and Individual Performance

Indirect Effects of Email Interventions on Individual Performance through Mindfulness

Email interventions and mindfulness. Consistent with mindfulness theory, interventions lead individuals to perceive a discrepancy between expected and actual performance and direct their attention toward the source of the discrepancy. This may disrupt routine and automatic information processing (Zellmer-Bruhn 2003). Individuals begin to actively and reflectively process the task information in new and meaningful ways rather than

---

15 We do not posit a direct relationship between interventions and task performance. According to feedback intervention literature, the positive effect of feedback interventions on performance occurs through two paths: motivation and learning (Kluger & DeNisi 1996; Ilsen et al. 1979). The first path is already covered in Hypothesis 3c. It reflects the motivation to seek a mindful state and devote more attention to the task environment in order to reduce the discrepancy and improve performance (Kluger & DeNisi 1996; Jett & George 2003). As for the second path, evidence linking learning to performance is contradictory (Kluger & DeNisi 1996). Additionally, research on instructional feedback interventions found that learning occurs through mindful processing of the intervention content (Bangert-Drowns et al. 1991; Hattie & Timperley 2007); i.e., when individuals reflect on the discrepancy to adopt new strategies and gain new insights. Hence, no direct effect between interventions and performance is hypothesized.
rely on pre-existing, abstract knowledge representations (Jett & George 2003). Interventions thus trigger a state of mindful attention by enhancing cognition, motivation, and effort, and channeling them toward the source of discrepancy (Ilgen et al. 1979; Jett & George 2003; Zellmer-Bruhn 2003).

While no studies explicitly modeled the relationship between interventions and mindfulness, some indirect support can be identified. First, interventions were found to be empirically related to active task engagement, one of the operational dimensions of mindfulness (Haigh et al. 2010; Langer 1989). This was corroborated, for example, in a study of the impact of supervisor feedback on subordinate task engagement (Harackiewicz & Larson 1986), and in another study that detected increases in task motivation and engagement from both feedback relating to the task and feedback relating to one’s performance in the task (Sansone 1986).

Second, evidence from the sales literature relates feedback interventions to motivation for change, one of the key aspects of a mindful approach (Carson & Langer 2006). More specifically, it was found that interventions motivate salespersons both to expend more effort (work harder; e.g., by contacting more prospective clients) and to channel it in the right directions (work smarter; e.g., by putting more effort into matching product offerings with prospective client needs) (Jaworski & Kohli 1991).

Finally, evidence relating intervention intensity to mindfulness can be found implicitly in studies on interventions. For example, an experimental study of team problem solving found that introducing interventions that prompt discussions of task strategy and interpersonal issues shifted team members to a more mindful thought process after being initially engaged in mindless problem solving where they did not hear each other’s opinions (Woolley 1998). In a case study of email use (Markus 1994), a customer service VP received an email that pointed her attention
to a violation in regulatory compliance with accounts payable. While her initial response seemed automatic and indicated that she had not acknowledged the discrepancy, further emails by her supervisor convinced her to recognize the discrepancy, mindfully reflect on the problem, and apply corrective measures. The flow of emails between the VP and others in the organization showed various aspects of mindfulness in handling the task subsequent to the intervention such as paying more attention to the task, attending to the new information by the supervisor, being open to different points of view after initially insisting that there was no problem, and heedfully relating action with others (e.g., coordinating with her subordinate and supervisor to solve the issue).

**Hypothesis 3a: Email intervention intensity is positively associated with mindfulness.**

**Mediation effect of mindfulness.** Mindfulness theory allows us to suggest a mediating effect of mindfulness between email interventions and task performance. Essentially, interventions trigger a mindful state that expands attentional capacity and syncs it with a wide set of environmental cues relevant to performing the primary task activities (Jung et al. 2010). This helps individuals attend to information in new and meaningful ways that facilitate effective task performance (Jett & George 2003).

Evidence of the mediation effect of mindfulness can be furnished by separately presenting evidence of a relationship between interventions and mindfulness – which was done in the previous subsection – and a relationship between mindfulness and task performance. While the latter relationship is supported mostly conceptually (Dane 2010; Juillerat 2010), some empirical evidence exists showing that mindfulness reduces cognitive failures (Herndon 2008),
and that individuals perform better when they possess cognitive flexibility (a dimension of mindfulness) (Rani & Rao 2000).

We also provide some additional evidence on the overall mediation effect beyond the two separate direct effects. For example, extant research found that real-time IT interventions enhance task performance through motivating individuals to focus more on the task and expend more effort, which improves the quantity and quality of generated ideas (Jung et al. 2010) and leads to more accurate investment decisions (Earley et al. 1990). A study of 38 end-users debugging a spreadsheet application investigated “controlled response” interventions that were similar to email interventions in that they provided task-relevant information on debugging without forcing users to switch immediately to the messages (Robertson et al. 2004). The study showed that users in the controlled response condition learn better and are more accurate in resolving bugs than those in the “immediate response” condition. Deeper analysis revealed that even though users in the immediate condition received more explanations and received them more promptly, users in the controlled response condition performed better because they acted further on the interventions by actively seeking explanations of the discrepancies through the “tool tips” option provided by the system. They also were more engaged in editing formulas in order to understand how to best fix the bugs.

In the context of sales, researchers proposed that email interventions provide salespersons with pertinent information that allows them to better understand their customers’ needs, and motivates them to work harder and smarter to fix discrepancies and satisfy such needs (Hunter & Goebel 2008; Long et al. 2007). The motivational aspect of interventions is expected to be especially salient in the sales context, where salespersons are at least partially compensated by commissions and there is a continual need to achieve (Sujan et al. 1994). Essentially, this
prompts salespersons to mindfully consider discrepancies in their selling activities in order to fix them and improve their performance. Indeed, there is empirical evidence in the sales literature that feedback interventions improve performance effectiveness by making salespersons more attentive to their selling activities and motivating them to work harder and smarter in those activities (Jaramillo & Mulki 2008; Sujan et al. 1994). We hypothesize:

\textit{Hypothesis 3b: Mindfulness is positively associated with individual performance.}

\textit{Hypothesis 3c: Mindfulness mediates the positive impact of email intervention intensity on individual performance.}

\textbf{The Compensation Mechanisms of Perceived Control and Multitasking Self-Efficacy}

\textbf{The Mitigating Role of Perceived Control}

Perceived control refers to the perceived latitude of an individual over whether and when to handle potential email interruptions. It is a property of the asynchrony of email, which does not force individuals to respond immediately to an email. However, the perception of control may also be influenced by the organizational environment (e.g., if there are norms for responding to email), the task environment (e.g., pressures from urgent tasks; see Ho et al. 2004), or individual values and beliefs (e.g., anxiety of email; see Barley et al. 2011; Mazmanian et al. 2005). Hence, rather than assuming that the asynchrony of email automatically affords individuals full control, we assume that the degree of perceived control varies as a result of the tension between the asynchrony of email and the compulsion to react to incoming email.
Perceived control is likely to exhibit moderating effects on subjective workload and individual performance. When individuals have perceived control over handling an impending email intrusion, they are able to choose opportune moments for the interruption to occur such as at subtask boundaries (Adamczyk & Bailey 2004; Bailey & Konstan 2006; Bailey et al. 2001), natural breakpoints (Bailey & Konstan 2006; Iqbal & Bailey 2005; Iqbal & Bailey 2006), and/or after stabilizing some aspect of the task (Edwards & Gronlund 1998). At those periods, individuals have released attentional resources that are associated with the primary task, which frees up some resources for dealing with the impending email intrusions without significantly disrupting their execution of the primary task. In turn, this should mitigate the adverse effects of the intrusions on cognitive/emotional load and performance (e.g., switching costs) since individuals have a mastery over coordinating their response (McFarlane 2002). Absent such control, they may feel overwhelmed and respond randomly, failing to take advantage of periods of reduced cognitive activity.

Support for interaction effects of email intrusion intensity and perceived control on workload and performance can be derived from the HCI literature on IT-mediated interruptions. There is wide agreement in that literature (see Table 1) that control over the intrusions (achieved by introducing intrusions at subtask boundaries and/or preceding them by alerts) leads to reduced levels of subjective workload such as annoyance (Adamczyk & Bailey 2004; Bailey & Konstan 2006; Bailey et al. 2001; Gievska et al. 2005; Iqbal & Bailey 2005; Iqbal & Bailey 2006), anxiety (Bailey & Konstan 2006; Bailey et al. 2001), frustration (Adamczyk & Bailey 2004; Gievska et al. 2005), disruption (Ho & Intille 2005), time pressure (Adamczyk & Bailey 2004), and overload (Gievska et al. 2005). Similarly, such control enhances performance efficiency as measured by resumption lag (Iqbal & Bailey 2005; Iqbal & Bailey 2006; Monk et al. 2002) and
task completion time (Bailey & Konstan 2006; Bailey et al. 2001), and effectiveness as measured by reduced error rates (Bailey & Konstan 2006; Bailey et al. 2001). These results do not provide direct support for an interaction effect between perceived control and intrusions because control was not directly measured independently of the intrusions. Rather, it was indirectly derived through experimental manipulations where subjects being interrupted were either awarded no control (e.g., if the intrusions were introduced randomly) or some implicit control (e.g., if intrusions were introduced at subtask boundaries). Hence, the notion of control in those studies is roughly analogous to a nested factor in the ANOVA language because the levels of control (random vs. delayed) could only occur within one level of intrusions (where intrusions are always present) and they could not occur in a situation where intrusions are not present in the experiment. Consequently, an interaction effect could not be estimated in those models.

Nevertheless, a moderating effect of perceived control can be extrapolated from these findings as well as via insights from cue utilization theory. More specifically, we argue that individuals, being cognitive misers who are naturally inclined to conserve attentional resources (Easterbrook 1959; Kahneman 1973), would – if given the chance in a situation where the level of email intrusion intensity varies – choose to handle their intrusions at moments were some part or the entirety of their tasks are concluded (subtask boundaries) (McFarlane 2002; Zijlstra et al. 1999). Stated differently, perceived control over email is likely to result in actual behaviors in which individuals facing an impending intrusion would continue to work on their tasks until a more opportune breakpoint was reached before switching to the intrusion (McFarlane 2002; Zijlstra et al. 1999). Such behaviors are similar to the ones that were found in the HCI interruptions literature to decrement subjective workload and enhance performance. Therefore, in situations where there can be variations in the level of email intrusion intensity, such intrusions
would influence subjective workload less negatively and performance more positively when individuals have high perceived control than when such perceived control is low.

Additionally, there is some direct evidence in the HCI interruptions literature for such interaction effects. For example, Gievska et al. (2005) modeled an interaction effect between interruption control (immediate and mediated coordination) and intrusion frequency and found a significant impact on the cognitive component of workload. McFarlane (2002) estimated an interaction effect of intrusions and perceived control because he included a base condition in which participants were not interrupted, an “immediate” condition in which they had no control over when to handle the intrusion, and a “negotiated” condition in which they had full control of when to handle the intrusion. He found that compared to the base condition, participants in the immediate condition had lower levels of performance efficiency and effectiveness, but that this was partly mitigated in the negotiated condition. A field study of software development engineers also reported increased productivity when a “quiet time” strategy was introduced to control the timing of interruptions rather than have them occur randomly (Perlow 1999).

Results in related areas also provide additional support for an interaction effect of perceived control on subjective workload. In the email literature, it was hypothesized that email management tactics (especially control over message flow) interacts with email volume (which was posited to influence overload through its interruptive nature) to decrease email overload (Bellotti et al. 2005; Dabbish et al. 2005). In the job control literature, it is widely posited that there is an interaction between perceived control over the job environment and the task demands of such environment, and that high control coupled with low demands is the most likely configuration to reduce job stress and overload (Edwards & Cooper 1990; Karasek 1979). While those studies focus on task demands and not intrusions, the latter can be considered a proxy for
task demand because, as per cue utilization theory, intrusions influence subjective workload by raising task demands to the point of creating cognitive and capacity interference (Gong 2006; Kahneman 1973). Finally, while not explicitly referring to an interruptions context, sales research shows that perceived task control mitigates the role tensions and stress experienced by salespersons when having to deal with the constantly changing expectations and demands of customers and management (Singh 2000). Together, the previous arguments allow us to present the following hypotheses:

**Hypothesis 4a:** Perceived control mitigates the adverse effects of email intrusion intensity on subjective workload.

**Hypothesis 4b:** Perceived control mitigates the adverse effects of email intrusion intensity on individual performance.

**The Reinforcing Role of Perceived Control**

Perceived control over the nature and timing of email response is also likely to reinforce the effects of email interventions on mindfulness. While not necessarily in an IT-mediated context, social psychology research found that individuals like to feel in control when given feedback and are unlikely to be motivated to follow the feedback if provided in a controlling manner (Harackiewicz & Larson 1986; Ilgen et al. 1979). With respect to control over timing, research on individuals working in group contexts found that the timing of interventions matters with respect to whether or not they will motivate individuals and allow them to actively attend to the discrepancies revealed by the interventions. For example, Hackman (2002) found that group
members become more engaged and motivated when interventions are introduced at the beginning of their tasks. Others distinguished between task-related strategy interventions and interpersonal interventions (Woolley 1998). This line of research found that task-related interventions are more effective when introduced at the midpoint of the tasks because they allow group members to reflect on prior performance and reorient their efforts to better complete their tasks (Gersick 1989; Woolley 1998). In a context similar to email interventions, it was found that when end-user debuggers have control over turning to the intervention messages, this motivates them to actively seek explanations for the discrepancies and to become more engaged when editing formulas to fix the problem bugs (Robertson et al. 2004). We thus predict:

_Hypothesis 4c: Perceived control accentuates the positive effects of email intervention intensity on mindfulness._

**The Mitigating Role of Multitasking Self-Efficacy**

Multitasking self-efficacy refers to the individual's belief in his or her ability to effectively shift attention among ongoing tasks. When an individual experiences an email intrusion, his or her attention is shifted away from the primary task to the email message, which may be providing information, eliciting discussions, or calling upon actions related to secondary tasks and activities. Hence, while intrusions trigger adverse effects on subjective workload and performance, they also provide an opportunity for individuals who have a good ability to multitask. Stated differently, individuals with high multitasking self-efficacy may be better able to mitigate the detrimental effects of the intrusions. This is especially true for email intrusions
because the asynchrony of email creates task discontinuities that are best handled by individuals with high multitasking ability who can perform multiple interleaved tasks (Aral et al. 2006).

While these relationships have not been empirically examined in the context of email intrusions, some support exists in related research on IT-mediated interruptions. For example, McFarlane (2002) found that individuals with a good multitasking ability are able to cognitively simulate both the primary task and IT-mediated intrusion in their minds and predict how long each would take. This allowed them to interleave the execution of the primary task and intrusion in ways that mitigate the adverse effects of the intrusion. He observed, for instance, that some individuals would merge the two tasks while others would preplan moves associated with the primary task even while performing the intrusion task. Such strategies allowed them to minimize the damage caused by the intrusion since they were able to resume the primary task faster while committing fewer errors. Similarly, another study found that multitasking self-efficacy (cognitive switching ability, in their terms) mitigates the adverse effects of intrusions on web task performance when such intrusions are presented on desktop PCs (Nagata 2006). In a study of 257 business students performing financial accounting tasks, Basoglu (2009) hypothesized an interaction effect of IT-mediated intrusion frequency and multitasking self-efficacy. This interaction factor was found to mitigate the effects of the intrusions on cognitive overload. We thus present the following hypotheses:

_Hypothesis 5a: Multitasking self-efficacy mitigates the adverse effects of email intrusion intensity on subjective workload._
Hypothesis 5b: Multitasking self-efficacy mitigates the adverse effects of email intrusion intensity on individual performance.

RESEARCH METHODOLOGY

In this section, we first describe the specific context in which the research model was tested. We then discuss how we operationalize the main constructs of the model following MacKenzie et al.’s (2011) three-step process: (1) develop an operational definition of the construct; (2) generate measurement items to represent the construct; (3) assess the content validity of the measures. Then, the sampling and data collection processes are described. This is followed by a presentation of some issues pertinent to the final survey design. Finally, we discuss how the data are analyzed.

The Context of Business-to-Business Sales

We chose to conduct this research in the context of B2B sales. First, B2B salespersons use email in their selling activities regularly (Long et al. 2007), and more frequently than in B2C contexts that are subject to privacy restrictions such as the CAN-SPAM act. Second, they face significant consequences when their selling activities are interrupted (Verbeke & Bagozzi 2000). Third, B2B salespersons are evaluated based on the efficiency and effectiveness of their selling activities (Ahearne et al. 2008). This allows us to examine their performance from multiple dimensions. Finally, they often work in time-pressured, “performance pay” contexts that are likely to be sensitive to interruptions.
Construct Operationalization and Item Development (Steps 1 and 2)

To complete Step 1 of the MacKenzie et al. (2011) procedure (develop an operational definition of the construct), we first examined how each construct has been used in prior research. Second, we specified the nature of the construct’s conceptual domain (i.e., the property it represents and the entity to which it applies). Taking subjective workload, for example, the entity to which this construct applies is the individual and its general property is a feeling (rather than a belief) toward how demanding the task execution is.

Third, we specified the construct’s conceptual theme (dimensionality; stability; inclusiveness). For instance, subjective workload was operationalized as a construct with three dimensions: emotional, cognitive, and temporal. This step also involved establishing whether each construct is formative or reflective. As examples of stability, we determined that mindfulness and perceived control are states that vary over time whereas multitasking self-efficacy is a stable individual trait. For inclusiveness, we defined some constructs in terms of applications to specific situations. As examples, email interruptions applies only to incoming emails, mindfulness is a state that occurs during primary task execution, knowledge is defined in terms of information held by salespersons on facts and procedures relating to the product/service and market, and salesperson performance is defined in terms of perceived outcomes relating only to primary selling activities.

Finally, we defined the construct in unambiguous terms. To achieve this, we avoided wordings with negative connotations (e.g., we used the term “temporary suspension” rather than “interruption”) and we defined the construct positively rather than stating what it does not include (MacKenzie et al. 2011).
In Step 2 of MacKenzie et al.’s (2011) procedure, we generated items to represent each construct. Measures were adapted from validated instruments or developed explicitly for this study. For the latter category, several sources were used to guide the measurement development including prior theoretical work and practical suggestions from sales experts (MacKenzie et al. 2011; Moore & Benbasat 1991). Attention was paid to ensure that the entire content domain of each construct was covered without introducing redundancy. Special care was also taken in writing the item wording to avoid common biases such as leading and multi-barreled items, and to avoid biasing the responses positively or negatively (e.g., this was done by introducing reverse-coded items). Below, we present the operational definition and item development process of each construct.

**Email Interruption Intensity**

Two broad operational properties have been used in the literature to assess interruption intensity: cognitive/temporal properties (e.g., frequency; duration; content) and social properties (e.g., source of interruptions). In this study, we focus on cognitive/temporal properties of interruptions. First, extant interruptions research has widely used such properties as frequency (Cades et al. 2006; Eyrolle & Cellier 2000; Gievska et al. 2005; Ho et al. 2001; Monk et al. 2004b; Speier et al. 1997; Zijlstra et al. 1999) and duration (Gillie & Broadbent 1989; Hodgetts & Jones 2006b; McDaniel et al. 2004; Monk et al. 2008) as the main indicators of interruption intensity. Second, they are more relevant than social properties to the attention allocation perspective used here to study interruptions because the temporal characteristics directly influence cognitive processing (e.g., the more frequent and the longer the interruption, the more information cues that have to be processed) (Speier et al. 1997; Spiekermann & Romanow 2008).
Finally, as our review shows, the impacts of IT-mediated interruptions on performance have been largely driven by such interruption properties.

Two common ways to model interruption intensity are to examine the underlying dimensions separately, or to treat it as a single concept operationalized by summing the scores on the dimensions. The first approach has been followed in the extant literature summarized in Table 1. This body of literature is largely comprised of experimental studies where the goal was to manipulate the separate dimensions of frequency and duration to detect precise differences when small changes are made in the levels of each dimension. Hence, while this approach achieves precision and accuracy, it is less suitable when the goal is to examine a whole theoretical concept. The second approach – present in a wide base of literature on IT usage – achieves that level of breadth and generality by presenting usage as a single aggregate concept comprised of frequency and duration (DeLone 1988; Igbaria et al. 1995; Raymond 1985; Thompson et al. 1991). However, this approach lacks the clarity and accuracy of the first approach. Hence, a middle-ground solution has been adopted in this study, which combines some of the precision and clarity of the first approach and the generality and simplicity of the second approach (Edwards 2001). Specifically, we treat interruption intensity as a general concept formed by its underlying set of dimensions.

Our choice of using a formative construct follows standard practices used in the literature (Chin 2010; Pavlou & El Sawy 2006; Petter et al. 2007). First, the two dimensions of frequency and duration are not necessarily highly correlated, which renders a reflective construct less appropriate (e.g., you can have frequent interruptions that are each very short or very long, or infrequent interruptions that are each very short or very long). Second, a change in the magnitude of one dimension (e.g., an interruption becoming more frequent) would bear little influence on
the other dimension (whether each interruption will be of longer or shorter duration). Third, the two dimensions represent complementary aspects that together tap into the content domain of the interruptions construct. Indeed, Table 1 indicates that much of the prior literature used interruption frequency and duration to represent interruptions. Finally, this conceptualization is consistent with prior IS studies that conceptualized frequency and duration as formative indicators representing the intensity of exposure to some IT-related phenomenon (Leimeister et al. 2008; Wan et al. 2008).

A self-reported instrument was used to measure interruption frequency and duration. To minimize negatively biased responses, we used the term “temporary suspension” rather than “interruption” in all questions asked to respondents. To distinguish between email interventions and email intrusions on the frequency and duration dimensions, we used the content property of interruptions. The content of the email that was used as a differentiator was conceptualized as two types of email: primary emails that were directly pertinent to performing the primary task activities (e.g., in the context of sales these would be activities related to the generation of new sales such as information about prospective customer needs or feedback about selling performance), and secondary emails that were related to secondary task activities (e.g., servicing accounts; training/recruiting) or activities outside of the work domain (e.g., general work; personal/social activities).

**Frequency of email interruptions.** This dimension of email interruption intensity is defined as *the perceived rate at which an individual temporarily suspends his or her primary task activities to handle (read, respond to, and/or act upon) the different types of incoming email messages.* The construct was operationalized by directly asking respondents to recall the number of times they temporarily suspended their primary selling activities to handle incoming emails.
over the past workweek. After recalling the total number of suspensions, respondents were asked to distribute this number first among their primary selling activities performed over the past workweek, and then among the two different types of incoming email: primary and secondary emails (see Appendix 1 for the measurement items). A validity check was programmed into the survey to force the sums of the component numbers to equal the total number of interruptions estimated before.

The choice for setting the past workweek as a reference period was made for four reasons. First, setting a specific reference period improves the accuracy of recall compared to asking about an abstract general pattern of interruptions such as “a typical day” (Converse & Presser 1986). Second, this reference period is narrowed to specific activities performed in the immediate past, which makes it more reliable than inquiring about a general pattern that may extend over a longer period of time (Converse & Presser 1986). Third, the workweek is a period that is most consistent with the organizing of business tasks (including sales activities). Finally, and as we discovered during the pre-testing phase, not all sales activities are performed homogenously on typical days. Hence, asking respondents to report how frequently and for how long their different primary selling activities are interrupted on a typical day introduces biased estimates because a typical day does not necessarily capture the gamut of primary selling activities. Indeed, Vermaas and van de Wijngaert (2005, p. 124) stated that the reporting period should be “long enough to capture behavioral patterns of interest without putting at risk the completion by making it too much of a burden for the respondents.”

**Duration of email interruptions.** This dimension is defined as the average duration of time spent by an individual each time he or she suspends the primary task activities to handle (read, respond to, and/or act upon) incoming email messages. We operationalized this variable
by directly asking respondents: “Over the past workweek, what has been the average duration (in minutes) of a single typical suspension of your primary selling activities so as to handle incoming emails?” To distinguish between email intrusions and interventions on the duration dimension, we simply asked respondents whether the durations were similar for the two types of interrupting email contents. If a negative response was entered, the survey branched to a follow-up item that asked respondents to estimate the typical duration of each type of interruption. The items are shown in Appendix 1.

Subjective Workload

Drawing upon extant research on subjective workload (Adamczyk & Bailey 2004; Gluck et al. 2007; Hart & Staveland 1988), we define this construct operationally as the extent to which an individual feels his or her whole task execution (including primary tasks and interruptions) is demanding (a) emotionally, (b) temporally, and (c) mentally. Following standard practices in interruptions research, our measures of subjective workload are based on the modified NASA TLX index (Adamczyk & Bailey 2004). However, we omitted items that reflect the “own performance” dimension in the Adamczyk and Bailey scale because this dimension taps into outcomes rather than perceived workload, and since such items would correlate highly with our performance measures. We also introduced some positively worded items to avoid negatively biasing the response. For the emotions items, we followed Beaudry and Pinsonneault (2010) to capture items that reflect both loss emotions and deterrence emotions. Finally, the items were framed in relation to the respondent’s feelings about having to perform the whole set of activities (including primary selling activities and handling emails). A 7-point Likert scale was used to rate the items, as shown in Appendix 1.
Mindfulness

Whereas much of the IS literature has defined mindfulness at the group and organizational levels (Fichman 2004; Swanson & Ramiller 2004; Teo et al. 2003), we presented earlier our definition of mindfulness as a state of cognitive functioning operating at the individual level. This definition was derived from Langer’s conceptualization of mindfulness in the psychology literature, and it has been used in IS by Roberts et al. (2007). Our conceptualization also differs from other conceptualizations in the organizations literature derived from meditative contexts, where mindfulness is viewed as a self-reflective phenomenon. More specifically, we consider mindfulness as a state of active cognitive operations on stimuli from the external environment (e.g., seeking multiple inputs to resolve a task problem brought up in an incoming email) rather than an internal state of self-observation (Brown & Ryan 2003; Dane 2010).

However, while Langer (1989) described mindfulness as a state, the items in her measurement scale are reflective of mindfulness as a trait or stable cognitive ability (Krech 2006; Sternberg 2000). In this study, we believe it is important to focus on mindfulness as a situation-specific and transitory state in which individuals interact with their external environment (Krech 2006). Hence, we took care to orient our measures toward capturing the state aspect. First, we removed terms that reflected trait-aspects such as “always” and “rarely.” Second, following the guidance of Spielberger and Sydeman (1994), we used particular wordings that prompt a state response. Third, we anchored the mindfulness items on respondents’ actual experience in their primary selling tasks.
Our final instrument – adapted from the Langer Mindfulness Scale (Langer 2004) – is based on a global measure of mindfulness with four underlying dimensions: novelty seeking; novelty producing; flexibility; engagement (Haigh et al. 2010; Langer 2004). The items were rated on a 7-point Likert scale and are shown in Appendix 1.

**Perceived Control over Email Interruptions**

Since no prior measures of perceived control over interruptions exist, we developed a measurement scale for that construct following Moore and Benbasat (1991). We first specified the content domain of the construct by investigating three relevant areas: the job control literature (Greenberger et al. 1989; Karasek 1979); the time management literature (Macan et al. 1990; Moen et al. 2008); the interruptions literature (McFarlane 2002). Based on those literatures, we operationally define perceived control over email interruptions as the perceived latitude of an individual over whether to accept and when to handle potential task suspensions from incoming emails. Whereas the job control literature focused on the whether component in individuals’ perceived control over their jobs (Greenberger et al. 1989; Karasek 1979), the time management literature stressed the when of individuals’ perceived control over their work time (Macan et al. 1990; Moen et al. 2008). In the interruptions literature, both components are combined in the concept of perceived control over interruptions, where individuals negotiate whether to accept or decline an impending interruption and when to handle it (immediate vs. delayed response) (McFarlane 2002).

We specify perceived control as a second-order formative construct comprised of personal control and social control as underlying dimensions (cf. Connell 1985; Monson & Snyder 1977). Whereas in both types of control the control agent is the self, the two differ with
respect to the means through which control is exerted (Skinner 1996). More specifically, while personal control is believed to result through internal means (e.g., individual beliefs about email), social control is expected to materialize via external means (e.g., the asynchrony of email; the job context; social pressures to respond). By highlighting this multidimensional nature of the construct, we note that perceived control is a cognitive state that may change across situations and environments rather than a stable individual trait (Greenberger et al. 1989). While the job control literature focuses on the external job context as the means of perceived control (Karasek 1979), the time management literature focuses on transitory individual beliefs about time control (Greenberger et al. 1989; Macan et al. 1990). Barley et al.’s (2011) study of email overload relates control over email to external job conditions (e.g., norms about how and when to respond), social pressures (e.g., desire not to keep others waiting), and individual beliefs (e.g., anxiety of email; fear of falling behind). To the extent that the internal and external means of control represent unique yet complementary aspects of control, a formative conceptualization is deemed adequate. Also, a change in one dimension does not necessarily cause a change in the other. For example, one may have a personal sense of control over when to check for email, yet the expectations within the company she works for may be such that she needs to respond to email right away (or vice versa).

After specifying the construct domain, we searched existing scales that tap into aspects of the first-order constructs (which were specified as reflective). While we did not find any scales that provide a perfect fit with our context, we adapted some items from the job control and time management literatures and used them along with newly generated items to form an initial pool of items. When generating items in the pool, we took explicit care to (1) capture the content domain of the constructs without introducing redundancy, (2) avoid leading and double-barreled
questions, and (3) avoid biasing the response positively or negatively (e.g., by introducing reverse-coded items). As we report in a later section, the initial 7-point Likert scale was then further developed – along with the other measures – through a series of testing procedures. The final list of items is shown in Appendix 1.

**Multitasking Self-Efficacy**

Multitasking self-efficacy refers to the individual's belief in his or her ability to effectively shift attention among ongoing tasks. We developed a general self-efficacy scale that is oriented toward assessing the perceived ability to multitask. The items that tap into the self-efficacy expressions were derived from Chen et al. (2001), and items that tap into multitasking behaviors were derived from the Multitasking Preference Inventory (Poposki & Oswald 2010). Additional items were included from Basoglu et al. (2009). All items were rated on a 7-point Likert scale, as shown in Appendix 1.

**Salesperson Performance**

Salesperson performance is a complex, multidimensional construct that depends on many factors (Behrman & Perreault 1984; Sujan et al. 1994). Prior sales literature has identified two different aspects of performance: behavioral performance and outcome performance (Babakus et al. 1996; Baldauf & Cravens 2002; Kohli & Jaworski 1994). The former is a more granular representation, which reflects behaviors that are evaluated or measured in terms of their contribution to sales goals. Conversely, outcome performance refers to quantitative sales results for which an individual is at least partially responsible (e.g., sales quota achieved). Indeed, Campbell et al.’s (1973) theory of performance posits that such outcome performance is likely to
include aspects that are not directly under the control of the individual (e.g., market conditions). Additionally, prior sales research found that there are many steps that come in-between a salesperson’s behaviors and his or her end performance (Churchill et al. 1985; Hunter & Goebel 2008). Since in our context the effects of email intrusions and interventions are more likely to manifest in the more proximate behavioral components of performance (e.g., the efficiency of interactions with customers), we focus on behavioral salesperson performance. This is also consistent with prior sales research that assessed behavioral salesperson performance, while noting that current behavioral performance is an indicator of future outcome performance (Johlke 2006; Oliver & Anderson 1994; Weitz 1981).

Hence, we draw upon Hunter and Goebel (2008) to operationally define salesperson performance as the perceived behaviors reflecting a salesperson’s ability to efficiently and effectively achieve sales objectives in his or her primary selling activities. Efficiency refers to the extent to which the salesperson accomplishes his/her primary selling activities in a timely manner. Effectiveness denotes the extent to which he/she is able to close sales and build profitable relationships with prospective customers (Long et al. 2007).

Another decision about the operationalization of sales performance reflects whether to use objective measures or subjective measures that are either self-reported or reported by others (e.g., managers). In this study, we chose self-reported subjective measures. First, contrary to some claims about the quality of self-reported measures, there is no evidence in the sales literature that such measures perform worse than objective measures or supervisor ratings. For example, a meta-analysis of 116 studies that compared self-reported salesperson performance measures with objective measures found no inflation of results in the former category (Churchill 16 Nevertheless, we also measured some aspects of salesperson outcome performance and found no significant effects on those measures.
et al. 1985). The authors concluded that “that there is no basis for generalizations that higher correlations can be expected when particular types of performance measures are used as criteria” (p. 113). Another study found self-reported subjective measures to have less range restriction, less leniency, and less halo error than supervisor ratings (Heneman 1974). This occurred when respondents were advised that their ratings were strictly confidential and will be used solely for research purposes, rather than for evaluation or decision-making purposes (a condition that is met in this study). Behrman and Perreault (1984) noted that objective measures of salesperson performance can introduce various inequalities among sales regions, product lines, and customer accounts, and may be attributable to factors beyond the salesperson’s control.

Second, self-reported subjective measures were found to be more appropriate for boundary-spanning individuals such as salespeople (Behrman & Perreault 1984; Harris & Schaubroeck 1988), especially when evaluating the behavioral component of performance (Behrman & Perreault 1984). In particular, much of the efforts and behaviors in a salesperson’s activities are not directly observable by managers (e.g., email interactions with customers), do not typically reflect in performance reports, and cannot be accurately captured by the more distal objective measures.

Finally, self-reported measures are more readily available and are commonly used in the sales literature (Behrman & Perreault 1984; Eggert & Serdaroglu 2011; Sohi 1996; Sujan et al. 1994; Verbeke 1997).

While much of the sales literature recognized the multidimensional nature of salesperson performance, this construct has been frequently conceptualized as a first-order reflective construct with a mix of items reflecting efficiency and effectiveness aspects (Behrman & Perreault 1984; Jaramillo & Mulki 2008; Johlke 2006; Kohli & Jaworski 1994; Sujan et al.
However, to best capture the multidimensional nature of salesperson performance, we specify this construct as a second-order formative construct, with the first-order constructs of efficiency and effectiveness having formative indicators (Type IV). We chose a formative specification for three reasons. First, all components at both the indicators level (e.g., see items Eff4 and Eff5 in Appendix 1) and the first-order constructs level (efficiency and effectiveness) tap into different aspects of the salesperson performance domain and thus do not necessarily covary highly (Petter et al. 2007). This can be easily verified by observing, for example, that a change in the ability to solve prospective customers’ problems or objections (Eff4) may or may not be accompanied by a change in the ability to develop new customers from established contacts (Eff5). Similarly, a change in a component at one level (e.g., a change in salesperson performance) does not necessarily result in a change in the components at the lower levels (Petter et al. 2007). For example, a change in salesperson performance does not necessarily result in a change in both efficiency and effectiveness. Likewise, a change in effectiveness does not necessarily lead to changes in Eff4 and Eff5.

Second, formative specification becomes necessary when the indicators are not interchangeable (Petter et al. 2007). This applies both at the indicator level (e.g., Eff4 and Eff5) and the first-order construct level (efficiency and effectiveness) since the components at each level address different themes.

Finally, temporal precedence is from the lower levels to the higher levels. For example, you need to first deliver your presentations quickly (Efc2) among other things to be considered an efficient salesperson, and you need to be efficient (and effective) to have a good overall sales performance.
Furthermore, our choice to use a second order specification rather than a single factor or a two factor solution was made for three reasons. First, collapsing a second-order formative construct into a single construct that does not distinguish between the separate dimensions of efficiency and effectiveness can compromise validity and lead to measurement problems (Petter et al. 2007). Second, a second order specification is more parsimonious than a two-factor solution comprising efficiency and effectiveness as separate dimensions. Finally, this specification is consistent with leading studies on construct specification, which recommend modeling performance as a second-order construct (Cenfetelli & Bassellier 2009; Jarvis et al. 2003; Petter et al. 2007), with efficiency and effectiveness as its first-order constructs (Cenfetelli & Bassellier 2009). In fact, Petter et al. (2007) identified a study by Rai et al. (2006) – which has a model structure of performance similar to the one in our paper – as correctly specifying firm performance as a Type IV second-order construct. In that study, firm performance was a second order formative construct with three first-order formative constructs that tapped into different aspects of performance (operational excellence; customer relationship; revenue growth). The indicators for the first-order constructs were also formative because they tapped into different aspects (e.g., for the operational excellence construct these were product delivery cycle time, timeliness of after sales service, and productivity improvements).

We developed a new instrument for salesperson performance based on items from the sales literature (Ahearne et al. 2008; Behrman & Perreault 1984; Hunter & Goebel 2008; Kohli & Jaworski 1994), taking into account the two dimensions of performance (efficiency and effectiveness). In generating the performance items, we also made sure that they covered the entire content domain of primary selling activities, from prospecting to closing the sale. Items

---

17 However, we also modeled efficiency and effectiveness separately in the post-hoc analysis.
were rated on a 7-point comparative scale (Behrman & Perreault 1984). Respondents were asked to refer to their current sales cycles in their responses. The items are shown in Appendix 1.

**Control Variables**

Several factors previously found to influence salesperson performance were measured in order to control their effects. We also controlled for some of the relationships in the model.

**Work/role experience.** Building upon Dierdorff and Surface (2008), we define work/role experience as *the degree of exposure that an individual accumulates in relation to performing the requirements of his or her work roles.* A composite experience measure was formed by averaging the z-scores of three tenure-based experience indices (Rapp et al. 2006): years and months of total sales experience; years and months spent at the current organization; years and months spent in the current sales position.

**Knowledge.** We operationally define knowledge as *information held by salespersons on facts and procedures relating to the product/service and market.* The items were adapted from the salesperson knowledge scale used by Rapp et al. (2006), which includes aspects of both technical knowledge and market knowledge. Following Leigh and McGraw (1989), our items also tap into both declarative knowledge (the set of situational cues that enable a salesperson to classify a particular selling situation as an instance of a more general selling category) and procedural knowledge (the set of learned behavioral routines that fit various selling situations). The items were rated on a 7-point Likert scale and are shown in Appendix 1.

**Effort.** Effort is defined as *the amount of energy that an individual allocates to his or her primary selling tasks.* Effort is a behavioral factor that is distinct from behavioral performance. While the former describes the intensity of selling behaviors in general, the latter reflects the
evaluation of behaviors that are directly tied to achieving sales objectives. Our scale – adapted from Jaramillo and Mulki (2008) – taps into two dimensions: level of effort (“working hard”) and direction of effort (“working smart”). The items were rated on a 7-point Likert scale and are shown in Appendix 1.

**Negative link between perceived control and subjective workload.** We controlled for the negative effect of perceived control on subjective workload since – although not directly related to interruptions – it was previously found to be significant. Indeed, this negative link is supported in the job control literature (Karasek 1979) and time management literature (Macan et al. 1990), which are the two primary sources from which our conceptualization of perceived control over email is derived.

**Assessing the Content Validity of the Measures (Step 3)**

In Step 3 of the MacKenzie et al. (2011) procedure, the content validity of the measures was assessed via two rounds of card-sorting analysis with academic expert panels (Moore & Benbasat 1991), and via pre-testing of the final instrument with sales experts in the field.

**Card-Sorting Analysis**

To establish the content validity (as well as preliminary convergent and discriminant validity) of the developed scales, we performed two rounds of card-sorting analysis where 20 academic experts forming two panels of ten judges were each asked to sort the items into separate pre-defined categories based on similarities and differences (Moore & Benbasat 1991). An email was sent to the experts asking them for participation, describing the nature of the card-sorting exercise, and providing a hyperlink to take them to the website that hosted the exercise.
As shown in Appendix 2 (Tables A2A and A2B), the experts who followed the hyperlink landed on a page that provided them with a general introduction about this research, a description of the context they needed to put themselves into to be able to complete the sorting analysis, and the general instructions to be followed (e.g., instructions to avoid guessing; to go back to the construct definitions if unsure about the placement of an item; to write comments about ambiguous items). Participants were then presented with definitions of all the constructs before being asked to place the items into the appropriate categories. They were also provided the opportunity to write comments next to items they found to be ambiguous as well as general comments about the card-sorting analysis (those comments sections were found very useful in revealing the issues some participants struggled with). We then examined how well the items were placed into the categories by participants in order to make appropriate decisions about rewording or removing ambiguous items.

To analyze the results, we examined each category to determine the following: (1) the number of hits or correct item placements; (2) the number of underlying items in a category that were misplaced in other categories; (3) the number of errant items that the category received. Tables A2C and A2D (Appendix 2) show a summary of the analysis results for rounds 1 and 2, respectively. The analysis process resulted in three main types of actions: (1) modifying some item wordings to improve their clarity, comprehensibility, or consistency with construct definitions; (2) deleting some items if they were found to be redundant or ambiguous; (3) modifying some construct definitions to improve their precision. Appendix 2 shows the detailed analysis steps. At the end of the analysis, the overall hit ratio improved from 78% in round 1 to 83% in round 2.

---

1 It is to be noted in Tables A2C and A2D that there were additional constructs tested that are not part of this study.
**Pre-Testing and Pilot-Testing of the Measurement Instrument**

We tested the survey items and the overall survey with a representative sample from the target population while ensuring that the respondents covered diverse industries and areas of sales expertise. In all, 10 sales professionals participated mostly via a qualitative, face-to-face approach (except two professionals who participated by phone). Participants were requested to complete the survey and report any ambiguous or difficult items. Participants were also asked specific questions to test the items for whether their intended meaning is shared, the cognitive demand they require for response, and the level of interest and attention they receive (Converse & Presser 1986). We also checked for variability in item responses across participants (Converse & Presser 1986). In parallel with the pre-testing, we also pilot-tested the overall survey for flow, timing, and level of interest. Further refinements were made to the survey instrument based on the feedback from participants (see Appendix 3 for details). The rigorous steps used to test the structure of the survey and ensure that the items are clear, precise, interesting, and not difficult to answer, lend further support for the content validity of our survey instrument.

**Sampling & Data Collection**

Our target population represents North American business-to-business (B2B) salespersons selling products/services with a relatively quick turnaround. The unit of analysis was the individual salesperson. Data were collected from a double opt-in panel of respondents managed by a reputable data collection company specialized in B2B research. The panel list is actively managed by the third party company using quality measures that comply with the Marketing Research Association code (e.g., limits on the number of contacts; number of surveys
taken; flagging and removing professional survey takers). To ensure adequate representativeness, respondents were approached using a variety of methods including direct online opt-in into the panel, email invites, and mail/phone invites. The nature of this research and the commitments required were explained to all respondents. Respondents were also assured that participation in this research was entirely voluntary and that responses would be treated confidentially and reported only in aggregate form. To increase motivation to respond, respondents were offered a summary report of the results upon data analysis completion (intangible reward) as well as a tangible incentive (cash, gift certificate, or charitable donation). The latter set of rewards was suggested by most pre-test respondents as a way to increase response rate among sales professionals.

All respondents were screened for the following criteria: (1) frequency by which they are involved in sales activities; (2) segments to which they sell their products/services (B2B; B2C, etc.); (3) length of the sales cycle; (4) extent to which they use email in their sales activities. The survey responses were also checked against two quality control questions included in the survey to ensure that respondents were paying attention. Additionally, each response was manually checked for speeding (each question in the survey had a time stamp) and careless responding (e.g., straight-lining all answers). Finally, no duplication was allowed and controls were set to prevent the same respondents from completing the survey more than once.

The 365 responses in the final data set were obtained from a list of 2483 eligible (i.e., having met the screening criteria) respondents who were requested to participate, which is a response rate of 14.7%. We did not find evidence of nonresponse bias in the sample. This was assessed by verifying that there were no significant differences in the mean responses of early and late respondents with respect to demographic characteristics and the main constructs of the
study (Beaudry & Pinsonneault 2010; Pavlou & El Sawy 2006). The early respondents were those who responded during the first-wave of data collection, while late respondents were selected randomly from the pool of respondents who responded only upon being re-contacted during the second-wave of data collection. The two waves were separated by a period of six weeks.

**Survey Design**

A cross-sectional field study design using the survey technique was used to test the model. The survey was constructed using a web-based survey approach (computerized, self-administered survey accessed via Web browsers). Advantages of this design include cost savings, easier navigability, paperless design as well as easier management of the survey launch, data acquisition, and analysis (Simsek & Veiga 2001). Moreover, the self-administered nature of the survey provided respondents with the opportunity to reflect about their answers, especially to be able to better determine the patterns of their email interruptions. Although web-based surveys may introduce coverage errors – where all members of the survey population do not have an equal or nonzero chance of being sampled (Dillman 2000) – this was less of a concern in our study context because our population consisted of salespersons who use email in their selling activities and thus naturally had Internet access.

The questions in the survey were ordered in several sections based on topic (e.g., email-related behaviors; performance questions; demographic questions). Following Dillman’s (2000) recommendations, we ordered questions first by similarity of content and then by response scale similarity. This eases mental effort for switching between questions and encourages well-thought-out answers (Dillman 2000). We avoided randomizing the order of the questions due to
the cognitive demand this extols on respondents and since it could lead them to judge the questionnaire as meaningless (Babbie 1973; Dillman 2000). We also started the questionnaire with questions that are relevant, easy to answer, and less controversial (Dillman 2000); hence, we started with questions on perceived control rather than interruptions, subjective workload, or performance.

Screening questions were included in the survey (see Appendix 4) to enhance the quality of response and reduce sampling error (i.e., errors where the sample is not truly representative of the population due to chance). To further enhance response quality, we included reverse-worded items for most constructs as well as different quality control questions (e.g., a quality control question that requires respondents to select a particular answer to make sure they were paying attention; a knowledge-based question to ensure that the respondent is qualified and possesses required domain knowledge of a salesperson). To reduce ambiguity and context-related errors, we provided guidelines and definitions of the key terms (Hufnagel & Conca 1994). Finally, invisible timers were included in the survey pages to assess the time taken by respondents to complete every page and to make sure they were not speeding through the survey. Appendix 4 shows the final version of the survey.

Data Analysis

PLS as a Data Analysis Method

While the multivariate data we collected can best be analyzed using covariance-based structure equation modeling (CBSEM) techniques or partial least square (PLS) techniques (Gefen et al. 2000), we chose the latter method for five reasons. First, PLS has been deemed more appropriate than CBSEM for handling large and complex models (Chin et al. 2003; Ringle
et al. 2012). As Wold (1985) argues, “PLS comes to the fore in larger models, when the importance shifts from individual variables and parameters to packages of variables and aggregate parameters […] In large, complex models with latent variables PLS is virtually without competition” (p. 589-590). Chin (2010) added that CBSEM generally delivers poor model fit in models with many latent variables and more than 50 items. Our model involves 13 latent variables (when all interaction terms and higher-order constructs are included) and 49 indicators (before including the product indicators for interaction terms and the repeated indicators for the second-order constructs). These figures clearly reflect a large and complex model when compared to other models reviewed in both the CBSEM and PLS literatures (Ringle et al. 2012). Indeed, since email interruptions is a complex and little understood phenomenon, PLS allows us to model a larger slice of its theoretical domain and thus capture a more complete aspect of reality (Chin 2010).

Second, unlike PLS, CBSEM cannot readily model second-order formative (molar) models (Chin 2010; Pavlou & El Sawy 2006). The construct of perceived control represents one such variable in our model, which further justifies the use of PLS.

Third, adequate deployment of CBSEM requires strong theoretical background knowledge (Chin 2010), which does not sufficiently exist in the nascent area of email interruptions. Lacking such strong background, CBSEM models can be misspecified with minor modeling or item selection errors, which biases the entire model estimation process (Chin 2010). By contrast, PLS is deemed a more appropriate tool in less theoretically-developed areas (Chin 2010; Reinartz et al. 2009). This is especially because it is less sensitive to model misspecifications (estimates are based only on immediate structural connections), and since its
statistical power to detect effect sizes is always larger or equal to that of CBSEM (Chin 2010; Reinartz et al. 2009).

Fourth, PLS has been found to perform better than CBSEM when the data are not normally distributed (Cassel et al. 1999; Chin 2010; Hair et al. 2011; Ringle et al. 2012), a situation that is common with social science data (Wilson 2010). Specifically, CBSEM can be highly imprecise under such conditions (Hair et al. 2011). By contrast, PLS provides robust structural parameter estimates while imposing minimal restrictions on data distributions or relations among observations (Chin 2010). Indeed, inspection of our data distributions revealed deviations from multivariate normality, especially for the interruptions variables, which were positively skewed and leptokurtic (even after transformation). This further supports the choice of PLS for data analysis.

Finally, PLS requires much smaller sample sizes for adequate estimation than CBSEM (Chin 2010; Chin et al. 2003; Ringle et al. 2012). For example, with CBSEM we would have to collect at least 1,800 observations following Bentler and Chou’s (1987) rule of 10 observations per free parameter to be estimated. By contrast, PLS requires a minimum sample size of 220 observations based on the rule of ten times the largest number of predictors for a dependent variable (Chin 2010). Nevertheless, our actual sample size of 365 observations is much larger than the 220 observations required by the “rule of ten.” This increases statistical power and leverages the “consistency at large” principle of PLS (Chin 2010; Ringle et al. 2012), where estimate accuracy improves with a larger sample size and/or an increased number of indicators per construct (which we also respected wherever possible).
All PLS calculations were carried out using SmartPLS version 2 M3 software tool (http://www.smartpls.de). The model is interpreted below in two stages: (1) measurement model validation; (2) estimating the structural parameters of the model.

**Preliminary Data Analysis**

The preliminary data analysis involved analyzing the missing values in the data set and analyzing the descriptive statistics.

**Missing values.** Missing values were only found in three control variables and only in very small numbers: knowledge (3 cases, 1%); effort (3 cases, 1%); experience (3 cases, 1%). Due to such a small prevalence of missing values, it is not necessary (and in fact infeasible) to perform missing data randomness tests such as dichotomizing and correlating variables to determine the association between the missing data on each variable pair, or creating two groups of data with and without missing values and comparing the two groups on the other variables of interest (Hair et al. 2009; Wilson 2010). The missing values were handled using mean replacement (Wilson 2010), and a separate test using pairwise deletion found no significant differences.

**Outliers.** The data set was also analyzed for the presence of outliers. While moderate outliers do not present special problems, extreme outliers (with values +/- 2.5 standard deviations from the mean) need to be explicitly scrutinized to determine whether or not they should be excluded from the analysis (Hair et al. 2009). The main thing to consider when deciding how to treat outliers is to what extent they are representative of the population. Three types of outliers are most common (Hair et al. 2009): (1) outliers due to procedural (e.g., data entry) errors; (2) outliers due to extraordinary events; (3) extreme observations for which there is no known
Addas (Essay #2)  

Email Interruptions and Task Performance

explanation. First, procedural errors are less likely for questions using a Likert-type response scale and more likely when data are manually entered by respondents. This applies mostly to the interruptions and experience questions in our survey. However, the likelihood of procedural errors is reduced by the special validation steps we took in the survey design. More specifically, we cross-validated the accuracy of values entered by respondents to represent interruptions frequencies and durations by presenting them with a pop-up screen indicating the total interruption time and asking them to confirm it. Similarly, the accuracy of values entered for the experience questions were manually checked by ensuring that there are no inconsistencies between the reported values for total sales experience, experience at the current organization, and experience in the current sales position.

Second, we detected some outliers in responses to interruptions questions, which can be attributed to extraordinary events. More specifically, such outliers were found for respondents who indicated in a separate question that their past workweek of email activity was not typical of their usual activity. However, we decided that the outliers due to such extraordinary events should be retained in the analysis because weeks of extremely high or low activity levels are not uncommon and are representative of the B2B salespersons population. Hence, the decision to keep these outliers is consistent with Hair et al.’s (2009) recommendation to retain outliers unless there is “demonstrable proof that they are truly aberrant and not representative of any observations in the population” (p. 66).

Finally, a group of extreme outliers was detected in the interruptions questions for which there is no known explanation. These outliers were retained because respondents confirmed that their past workweek of email activity was typical and because such outliers were deemed valid observations in the population of B2B salespersons. Moreover, we also ran a separate analysis
with the extreme values on the interruptions variables omitted and found no significant differences in the results.

**Multivariate normality.** The analysis of the data distributions revealed that the variables were not normally distributed. In particular, the interruptions variables were positively skewed and leptokurtic. Although the PLS method has been found to be robust against deviations from multivariate normality (Cassel et al. 1999; Reinartz et al. 2009), it is still recommended to properly condition the data with respect to how they are distributed (to avoid inflated bootstrap standard errors in skewed data, for example) (Hair et al. 2011; Ringle et al. 2012). Hence, we transformed the data that exhibited the most deviation from normality. Specifically, we transformed the data representing interruptions frequencies and durations using the square root function, which is recommended for these kinds of data (Hair et al. 2009).

**Controlling for Common Method Bias**

To control for common method bias, we applied a number of procedures both at the design stage and at the analysis stage.

**Steps taken at the design stage.** First, common method bias is often an issue when the questions in a survey are conceptually related (e.g., presenting a question such as "Is the system useful?" and then asking "Do you intend to use it?"). However, our survey design was structured differently. As shown in Appendix 4, we asked questions about email patterns (number of emails; number and duration of suspensions due to email; suspensions due to primary and secondary emails) that were conceptually independent of the subsequent questions on behavioral outcomes occurring at the level of the sales activities.
Second, the survey questions were rated on different scales, which further mitigates common method bias (Wilson 2010). More specifically, the email interruptions questions were rated on a ratio scale (which was independently validated using different approaches as explained earlier), the questions on cognitive state (subjective workload and mindfulness) were rated on a Likert scale (strongly disagree-strongly agree), and the performance questions were rated on a comparative scale.

Third, guidelines were provided to respondents to alleviate cognitive and affective constraints that may induce common method bias (Campbell & Lee 1988). As an example of reducing cognitive constraints, we provided intrusions to respondents to report their sales performance relative to the current sales cycle (see Appendix 4). Similarly, several steps were taken to alleviate affective constraints such as assuring respondents of their anonymity, reminding them to answer as honestly as possible, and reiterating that responses would be used solely for research rather than for evaluation purposes.

**Steps taken at the data analysis stage.** In addition to the design measures used to control common method bias, three statistical tests were performed at the data analysis stage. First, we assessed common method bias using the Harman single-factor test (Podsakoff et al. 2003). Specifically, we ran a principal component factor analysis to verify whether a single factor accounts for most of the covariance among the constructs. The Harman test shows that eight factors are extracted with a total variance explained of 63%, with the highest factor contributing 22% (see Appendix 6). Hence, this can be considered evidence against common method bias (Pavlou & El Sawy 2006; Wilson 2010).

Second, further evidence is furnished by examining the latent variable correlation matrix (see Table 2). Common method variance is usually manifested through very high correlations
among the latent variables, typically in the range of 90% (Pavlou & El Sawy 2006). However, as shown in Table 2, the highest correlation in the matrix is 0.54 (between mindfulness and effort).

Finally, we used the more rigorous marker variable approach where the source of bias is used as a covariate in the model to partial out its effects on the other variables (Podsakoff et al. 2003; Rönkkö & Ylitalo 2011). To conduct this test, we followed Rönkkö & Yitalo’s (2011) procedure, which was specifically developed for PLS. In the first step, we developed a marker variable comprised of items that are theoretically unrelated and minimally correlated to – but subject to similar measurement scales as – the main constructs of interest. In the second step, the degree of common method variance in the data was diagnosed by calculating the mean correlation between the marker items and the study items. We found that the mean correlation is 0.056, which is very close to Rönkkö & Yitalo’s (2011) rule of thumb of 0.05. This indicates that less than 6% of the variance in the data is method variance. In step 3, we estimated the baseline model without controlling for the marker variable. In step 4, the marker variable was included in the model as an exogenous construct predicting all endogenous constructs. Similar to Liang et al. (2007), we modeled the formative constructs in the model as reflective when assessing common method bias to ensure interpretability of results. This was done after ensuring that no changes in the structural model results occurred (no paths gaining or losing significance and no significant paths changing signs) when modeling the formative constructs as reflective. In step 5, we compared the results between the two estimated models and found that no significant paths became non-significant and vice versa, which indicates lack of evidence of common method variance (Rönkkö & Ylitalo 2011). Together, the design measures and statistical tests conducted lead us to conclude that common method bias is not a not a serious threat in this study.
RESULTS

Sample Characteristics

The majority of respondents were from the retail (17%), computer hardware/software (16%), and finance, insurance and real estate (15%) industries. The least represented industries in the sample were legal services (4%), government (1%), and education (1%) industries, among others (see Appendix 5 for the full distribution of industries in the sample). Most of the respondents were sales managers (20%), account managers (13%), and sales representatives (13%). Sales assistants and sales engineers each represented only 3% of the sample (see Appendix 5). Moreover, most respondents were in their thirties (34%), forties (24%), and twenties (18%). Only one respondent was below 20 years old (see Appendix 5). Of those who identified their gender, 154 salespersons were female and 202 were male. Finally, approximately half of the sample respondents reported holding a bachelor’s degree (48%), while others mostly held a college/technical degree (22%) or a master’s degree (16%) (see Appendix 5).

Measurement Model Validation

Our measurement model validation procedure involved assessing the reliability and validity of all measures and their underlying reflective constructs. To achieve this goal, we removed some problematic items that did not perform well (five items were removed in total). In removing such items, however, we made sure that the entire content domains of the underlying reflective constructs were retained, and that there were some theoretical justifications for
removing the items.\textsuperscript{19} Formative constructs were validated separately using standard guidelines in the literature (Petter et al. 2007; Ringle et al. 2012).

**Measurement Model Reliability**

**Internal consistency reliability of reflective constructs.** As a first step in our measurement model validation, we assessed the reliability of the measures to ensure that the items reflected by an underlying construct separately move together and are low on measurement error (Straub & Boudreau 2004). First, following common practices in PLS analysis (Chin et al. 2003; Hair et al. 2011), we assessed internal consistency reliability using Dillon-Goldstein’s Rho coefficient (composite reliability). We used composite reliability rather than the more prominent Cronbach alpha coefficient to avoid the stringent tau-equivalency assumption associated with the latter (the assumption that all indicators are equally weighted). Indeed, Chin (2010, p. 671) argued that “while alpha tends to be a lower bound estimate of reliability, [composite reliability] is a closer approximation under the assumption that the parameter estimates are accurate.” Table 2 shows the summary statistics (means and standard deviations) of all constructs with reflective measurement models as well as the composite reliabilities, square root of average variance explained (on the diagonal) and construct correlations. As shown in Table 2, all composite reliability values are above the threshold value of 0.7, which indicates good construct reliability.

\textsuperscript{19} For example, item SW7 of the subjective workload construct (I feel that the pace required to do my activities is very slow) was removed because it correlated negatively with most other related items. That item had not performed well in the card-sorting analysis either and was sometimes confounded by participants with efficiency. Also, removing the item still retained the temporal dimension of subjective workload. Similarly, item Efr4 (see Appendix 1) was removed because it loaded poorly on its underlying construct and had very low correlations with other effort items. Indeed, we had modified that item (I tend to work without spending too much energy on planning) from its original version by Sujan et al. (1994), in which the item read: “I get to my work without spending too much time on planning.” While that decision had been because the original item was confounded with efficiency during the card-sorting analysis, a closer analysis of the item revealed that the modified item was still ambiguous. Two items from the mindfulness construct were also removed due to very low loadings. However, all four dimensions of mindfulness were retained after removing those items. Finally, an item from the multitasking self-efficacy scale was removed.
**Indicator reliability of reflective constructs.** Additionally, we assessed the indicator reliability of all reflective construct measures, which represents the percentage of indicator variance (squared loadings) that is explained by respective latent variable (Ringle et al. 2012). As shown in Table 3, most items have loadings higher than the more stringent threshold of 0.7 and four items have loadings above the 0.5-0.6 range, which is still considered appropriate since there are other items in the respective blocks (Chin 1998). Only a single item (SW5) has a considerably low loading of 0.3. However, we decided to keep that item for theoretical reasons since (1) it had been validated in the card-sorting analysis and the pre-tests, (2) removing it would result in losing the temporal/cognitive dimension of subjective workload, (3) it correlates significantly with all other subjective workload items, and (4) the subjective workload construct has a high composite reliability even with that item included.

**Measurement Model Validity**

**Convergent validity of reflective constructs.** The reflective constructs in our model were validated via tests of convergent and discriminant validity. Convergent validity reflects the degree to which items reflecting a construct converge (i.e., show significant correlations with one another), especially when compared to the convergence of items underlying other constructs (Straub & Boudreau 2004). It is assessed via the average variance extracted (AVE) in each reflective construct, with a threshold value of 0.50 indicating that more than half the variance of the construct is explained by its underlying items (Ringle et al. 2012). As shown in Table 2, all AVE values exceed 0.50 except for the social control dimension of perceived control, which has an AVE slightly below 0.50 (0.49). However, all standardized item loadings for that construct are greater than 0.5 and highly significant (p < .001), which indicates adequate convergent
validity (Chin 2010). Additional evidence of convergent validity of the reflective constructs was obtained by verifying that the range of item loadings on their respective constructs was low, which indicates that the items reflecting the construct are a homogenous set (Chin 2010).

**Discriminant validity of reflective constructs.** Discriminant validity establishes whether reflective items have a stronger connection with their focal construct than with other constructs in the model. If such connection is found, we can conclude that the reflective constructs are conceptually distinct and do not share measures. We assessed discriminant validity both at the construct level via the Fornell-Larcker criterion (Fornell & Larcker 1981), and the item level via the outer model loadings and cross-loadings (Chin 2010; Ringle et al. 2012). To apply the Fornell-Larcker approach, we compared the square root of the average variance extracted (AVE) with the correlations among constructs. As Table 2 shows, all constructs have higher AVE scores than their respective correlations with other constructs, which indicates discriminant validity. Moreover, the cross-loading matrix was examined and is shown in Table 3. Indeed, Table 3 illustrates that each block of indicators loads higher for its respective construct than indicators for other constructs (Pavlou & Gefen 2005). Hence, we conclude that the reflective constructs have discriminant validity.

**Validation of interruptions constructs.** The intrusion intensity and intervention intensity constructs represent a special kind of formative constructs in which the underlying dimensions were measured each by single ratio indicators. Because those constructs were a special case that relied on respondents recalling the frequency and duration of their email interruptions with respect to a recent time period, a separate approach was needed to validate those constructs while addressing the potential recall bias. In particular, we needed to address the possibility of the interruptions questions being too demanding and thus leading to poor estimates
Email Interruptions and Task Performance

(Dillman 2000). Indeed, this concern has been partially mitigated in prior research, which confirmed the reliability and validity of such frequency recall measures of salesperson activities (Brashear et al. 1997; Guenzi et al. 2007; Moncrief 1986). Nevertheless, we still decided to take a conservative approach by providing explicit validation for our recall measures. This was achieved via four steps (two steps at the survey design stage and two at the data analysis stage). First, we asked respondents in the survey to allocate their email interruption estimates over the two types of email (primary and secondary) and – for the frequency measures – over the set of primary selling activities they performed. This improves the accuracy of recall because it anchors the frequencies to be recalled against a set of specific selling activities that salespersons perform as a regular part of their selling behaviors. In essence, decomposing interruptions by interruption type and primary selling activities performed by the respondents provides cues that coincide with the natural categories used by the respondents to classify events, and helps them recall specific instances of interruptions. Indeed, Tourangeau et al. (2000) pointed out that frequencies are not directly stored in the respondent’s memory but rather, the facts of the events from which such frequencies are derived. Additionally, research in consumer behavior found that decomposing a frequency event and eliciting frequencies at the subcategory level reduce effort levels and yield more accurate frequency estimates (Menon 1997).

Second, we included a validation question in the survey in which the product of the estimated weekly frequency of interruptions and the estimated average duration per interruption was calculated and presented to respondents to find out whether their estimated total interruption time (in hours and minutes) over the past workweek reflected their true experience (see Appendix 4). If the response was negative, respondents were returned to the previous questions
where they were allowed to adjust the estimated frequencies and/or durations before reaching the validation screen again (this was repeated up to three times).

Third, we used the indicator weight significance test to provide additional validation of the formative interruption intensity constructs (Ringle et al. 2012). As shown in Figures 2a and 2b, all weights of the frequency and duration indicators on their respective interruption intensity constructs are highly significant (p < .001).

Finally, we tested for multicollinearity between the intervention intensity indicators as well as between the intrusion intensity indicators. As shown in Table 4, the values for the variance inflation factors (VIF) were 1.098 and 1.134, respectively, which are well below the 10.00 (Hair et al. 2009) and the even more stringent 3.33 (Cenfetelli & Bassellier 2009) thresholds. Together, the results of the different validation tests provide evidence of the reliability and validity of the interruption intensity constructs.

**Figure 2a: Indicator Weights of the Intrusion Construct**

Email intrusion intensity

- Intrusion frequency: 0.69***
- Intrusion duration: 0.53***

*** Significant at p < .001
Validation of the second-order perceived control construct. Since perceived control is an exogenous second-order formative construct with reflective first-order constructs (Type II), we followed standard practices in the literature for validating such types of constructs (Pavlou & El Sawy 2006; Ringle et al. 2012). First, we tested the construct validity using the repeated indicator approach (Pavlou & El Sawy 2006; Ringle et al. 2012). This approach uses all indicators of the first-order construct as indicators of the second-order construct to estimate the second-order construct. It then assesses the measurement model of the first-order reflective constructs and the path coefficients between the first-order and second-order formative construct. Therefore, we assessed the first-order constructs of personal control and social control via composite reliability, indicator reliability, and convergent/discriminant validity and indeed found evidence of reliability and validity, as we showed earlier (see Tables 2 and 3). We also estimated the loadings between the items and first-order constructs and the path coefficients between the first-order and second-order construct and found all values to be significant (see Figure 3).

Second, we examined the content specification of the formative portion of the construct as suggested by Diamantopoulos & Winklhofer (2001). Indeed, as we discussed earlier, the
dimensions of personal and social control have been widely suggested in the literature as adequately capturing the content domain of perceived control (Barley et al. 2011; Connell 1985; Greenberger et al. 1989). Additional evidence of adequate content specification was provided through the card-sorting analysis with the expert panel and the two phases of pilot testing with sales professionals.

Third, we examined the nomological validity of the construct (Diamantopoulos & Winklhofer 2001). Such validity is established when the formative construct is significantly related to at least one reflective construct in the structural model. Indeed, as we report in the structural model section, perceived control was significantly linked to two reflective constructs in the structural model: subjective workload and mindfulness.

Finally, the latent variable scores of the formative portion of the construct were tested for multicollinearity (Cenfetelli & Bassellier 2009). As shown in Table 4, the VIF value is 1.075, which – taken together with the other validation tests – provides evidence of reliability and validity for the perceived control construct.

![Figure 3: Loadings and Path Coefficients of the Perceived Control Construct](image-url)
Validation of the second-order salesperson performance construct. Since salesperson performance is a second-order formative construct with formative first-order constructs (Type IV), we followed standard practices for validating formative constructs while taking into account both the higher and lower order components of the construct. First, the content specification was assessed (Diamantopoulos & Winklhofer 2001; Petter et al. 2007). As previously argued, there is wide agreement in the literature that the efficiency and effectiveness dimensions adequately capture the content domain of salesperson performance (e.g., Behrman & Perreault 1984; Jaramillo & Mulki 2008; Johlke 2006; Sujan et al. 1994). This was also confirmed via the expert panel used in the card-sorting analysis and the two phases of pilot-testing with sales professionals.

Second, we assessed the indicator specification to ensure that the selected indicators fully capture the content of each dimension of performance (Diamantopoulos & Winklhofer 2001). Indeed, this was verified through our review of the sales literature in addition to the card-sorting analysis and pilot-testing. As shown in Appendix 1, the indicators for the efficiency and effectiveness dimensions cover the entire gamut of sales activities (prospecting; interacting with customers; preparing/making sales presentations; overcoming objections; closing the sale).

Third, we assessed the significance of the measurement model weight estimates. With the exception of one indicator (Efc1), all components have significant weights and most have highly significant weights (see Figure 4). The problematic component has a non-significant weight of 0.07. However, Cenfetelli and Basselier (2009) pointed out that an indicator may have a small relative contribution (weight) to the formed construct when the other indicators are controlled.
for, yet have an important absolute contribution if assessed independently from the other indicators. They recommended that if such absolute contribution was significant and “there is no theoretical overlap, the indicator should be kept in the remaining analyses and in subsequent studies” (p. 692). We thus estimated the zero-order bivariate correlation of the indicator with the construct of efficiency and found it to be highly significant ($r = 0.75, p < .001$). More importantly, the indicator captures a unique aspect of efficiency (timeliness in prospecting for potential customers), so if omitted, the construct would lose an important part of its content domain, which taps into the speed of the prospecting activity. Hence, we decided to keep that indicator because there is strong theoretical grounding to justify its inclusion and due to its absolute importance to the efficiency construct.

Finally, validity was also assessed by testing for multicollinearity between the indicators in a block as well as between the first-order factors. As shown in Table 4, VIF values ranged between 1.854-2.332 for the efficiency indicators and 1.762-2.460 for the effectiveness indicators. For the first-order constructs, VIF was 2.988. Hence, multicollinearity was not a concern at both the higher- and lower-order levels. Together, these tests establish the validity of the salesperson performance construct.
**Figure 4: Path Coefficients of the Salesperson Performance Construct**

*** Significant at p < .001  
** Significant at p < .01  
* Significant at p < .05
Table 2: Correlation Matrix and Composite Reliability Scores for Reflective Constructs

<table>
<thead>
<tr>
<th>Construct</th>
<th>Reliability</th>
<th>Average variance extracted (AVE)</th>
<th>Mean</th>
<th>STD</th>
<th>SW</th>
<th>Min</th>
<th>PerC</th>
<th>SocC</th>
<th>MSE</th>
<th>Efr</th>
<th>Exp</th>
<th>Knw</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjective workload (SW)</td>
<td>0.88</td>
<td>0.57</td>
<td>3.91</td>
<td>1.20</td>
<td>0.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mindfulness (Min)</td>
<td>0.87</td>
<td>0.54</td>
<td>5.58</td>
<td>0.85</td>
<td>-0.21**</td>
<td>0.73</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal control (PerC) +</td>
<td>0.72</td>
<td>0.59</td>
<td>4.55</td>
<td>1.30</td>
<td>-0.01</td>
<td>0.03</td>
<td>0.77</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social control (SocC) +</td>
<td>0.79</td>
<td>0.49</td>
<td>3.45</td>
<td>1.14</td>
<td>-0.17**</td>
<td>-0.24**</td>
<td>0.14**</td>
<td>0.70</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multi-tasking self-efficacy (MSE)</td>
<td>0.88</td>
<td>0.64</td>
<td>5.48</td>
<td>1.04</td>
<td>-0.38**</td>
<td>0.40**</td>
<td>0.04</td>
<td>0.05</td>
<td>0.80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effort (Efr)</td>
<td>0.78</td>
<td>0.55</td>
<td>5.58</td>
<td>0.95</td>
<td>-0.06</td>
<td>0.54**</td>
<td>0.00</td>
<td>-0.13*</td>
<td>0.33**</td>
<td>0.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experience (Exp)</td>
<td>0.84</td>
<td>0.64</td>
<td>9.81</td>
<td>7.14</td>
<td>-0.10</td>
<td>0.14**</td>
<td>-0.10*</td>
<td>0.05</td>
<td>0.17**</td>
<td>0.17**</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>Knowledge (Knw)</td>
<td>0.91</td>
<td>0.66</td>
<td>5.76</td>
<td>0.94</td>
<td>-0.22**</td>
<td>0.52**</td>
<td>0.03</td>
<td>-0.11*</td>
<td>0.48**</td>
<td>0.49**</td>
<td>0.16**</td>
<td>0.82</td>
</tr>
</tbody>
</table>

* The interruptions and salesperson performance constructs are not included in this Table because for formative measurement models it is not appropriate to estimate composite reliability, average variance extracted, and item-construct correlations.

** Significant at p < 0.01; * Significant at p < 0.05.

+ Personal control (PerC) and social control (SocC) are first-order reflective constructs that form the second-order construct of perceived control (PC).

Bold numbers on the diagonal show the square root of the AVE. Numbers below the diagonal represent construct correlations.
### Table 3: Outer Model Loadings and Cross-Loadings

<table>
<thead>
<tr>
<th>Construct</th>
<th>SW</th>
<th>Min</th>
<th>PerC</th>
<th>SocC</th>
<th>MSE</th>
<th>Efr</th>
<th>Exp</th>
<th>Knw</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW1</td>
<td>0.77</td>
<td>0.02</td>
<td>-0.04</td>
<td>0.94</td>
<td>-0.29</td>
<td>-0.04</td>
<td>0.09</td>
<td>-0.02</td>
</tr>
<tr>
<td>SW3</td>
<td>0.83</td>
<td>0.01</td>
<td>-0.10</td>
<td>0.36</td>
<td>-0.26</td>
<td>-0.03</td>
<td>-0.17</td>
<td>0.15</td>
</tr>
<tr>
<td>SW5</td>
<td>0.31</td>
<td>-0.09</td>
<td>-0.20</td>
<td>-0.03</td>
<td>-0.17</td>
<td>-0.02</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>SW6</td>
<td>0.82</td>
<td>-0.11</td>
<td>-0.19</td>
<td>-0.30</td>
<td>-0.01</td>
<td>-0.09</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>SW8</td>
<td>0.82</td>
<td>0.00</td>
<td>-0.15</td>
<td>-0.38</td>
<td>-0.11</td>
<td>-0.14</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>SW9</td>
<td>0.83</td>
<td>0.04</td>
<td>-0.19</td>
<td>-0.31</td>
<td>-0.10</td>
<td>-0.09</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>Min1</td>
<td>-0.13</td>
<td>0.75</td>
<td>-0.21</td>
<td>0.30</td>
<td>0.47</td>
<td>0.13</td>
<td>0.41</td>
<td></td>
</tr>
<tr>
<td>Min2</td>
<td>0.06</td>
<td>0.96</td>
<td>0.15</td>
<td>-0.04</td>
<td>-0.05</td>
<td>-0.16</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Min3</td>
<td>-0.22</td>
<td>0.80</td>
<td>0.01</td>
<td>-0.18</td>
<td>0.32</td>
<td>0.40</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>Min4</td>
<td>-0.13</td>
<td>0.72</td>
<td>0.03</td>
<td>-0.22</td>
<td>0.29</td>
<td>0.36</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>Min5</td>
<td>-0.14</td>
<td>0.71</td>
<td>0.03</td>
<td>-0.15</td>
<td>0.31</td>
<td>0.38</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>Min7</td>
<td>-0.26</td>
<td>0.58</td>
<td>0.03</td>
<td>-0.01</td>
<td>0.30</td>
<td>0.33</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>PC1</td>
<td>0.06</td>
<td>-0.05</td>
<td>0.96</td>
<td>0.15</td>
<td>-0.04</td>
<td>-0.05</td>
<td>-0.16</td>
<td>0.03</td>
</tr>
<tr>
<td>PC2</td>
<td>0.21</td>
<td>0.26</td>
<td>0.51</td>
<td>0.03</td>
<td>0.24</td>
<td>0.16</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>PC3</td>
<td>-0.23</td>
<td>-0.00</td>
<td>-0.12</td>
<td>0.59</td>
<td>0.23</td>
<td>0.10</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>PC4</td>
<td>-0.08</td>
<td>0.22</td>
<td>0.17</td>
<td>0.76</td>
<td>0.07</td>
<td>-0.24</td>
<td>-0.11</td>
<td></td>
</tr>
<tr>
<td>PC5</td>
<td>-0.04</td>
<td>-0.23</td>
<td>0.16</td>
<td>0.81</td>
<td>0.01</td>
<td>-0.07</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>PC6</td>
<td>-0.19</td>
<td>-0.17</td>
<td>0.13</td>
<td>0.62</td>
<td>0.03</td>
<td>-0.10</td>
<td>-0.01</td>
<td></td>
</tr>
<tr>
<td>MSE1</td>
<td>-0.26</td>
<td>0.29</td>
<td>0.06</td>
<td>-0.00</td>
<td>0.73</td>
<td>0.26</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>MSE3</td>
<td>-0.23</td>
<td>0.28</td>
<td>0.06</td>
<td>0.08</td>
<td>0.82</td>
<td>0.25</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>MSE4</td>
<td>-0.29</td>
<td>0.39</td>
<td>0.04</td>
<td>0.02</td>
<td>0.84</td>
<td>0.33</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>MSE5</td>
<td>-0.43</td>
<td>0.32</td>
<td>-0.02</td>
<td>0.06</td>
<td>0.81</td>
<td>0.23</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>Efr1</td>
<td>-0.03</td>
<td>0.41</td>
<td>-0.06</td>
<td>-0.13</td>
<td>0.24</td>
<td>0.80</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Efr2</td>
<td>-0.07</td>
<td>0.42</td>
<td>0.04</td>
<td>-0.08</td>
<td>0.20</td>
<td>0.71</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>Efr3</td>
<td>-0.04</td>
<td>0.38</td>
<td>0.04</td>
<td>-0.07</td>
<td>0.30</td>
<td>0.71</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>Exp1</td>
<td>-0.10</td>
<td>0.13</td>
<td>-0.10</td>
<td>0.04</td>
<td>0.17</td>
<td>0.17</td>
<td>0.92</td>
<td></td>
</tr>
<tr>
<td>Exp2</td>
<td>-0.06</td>
<td>0.08</td>
<td>-0.02</td>
<td>0.05</td>
<td>0.10</td>
<td>0.09</td>
<td>0.88</td>
<td></td>
</tr>
<tr>
<td>Exp3</td>
<td>-0.07</td>
<td>0.05</td>
<td>0.01</td>
<td>0.03</td>
<td>0.11</td>
<td>0.06</td>
<td>0.88</td>
<td></td>
</tr>
<tr>
<td>Knw1</td>
<td>-0.19</td>
<td>0.39</td>
<td>0.04</td>
<td>-0.03</td>
<td>0.40</td>
<td>0.38</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>Knw2</td>
<td>-0.19</td>
<td>0.34</td>
<td>0.07</td>
<td>-0.04</td>
<td>0.34</td>
<td>0.30</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Knw3</td>
<td>-0.16</td>
<td>0.45</td>
<td>-0.02</td>
<td>-0.17</td>
<td>0.38</td>
<td>0.42</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>Knw4</td>
<td>-0.16</td>
<td>0.48</td>
<td>0.03</td>
<td>-0.14</td>
<td>0.38</td>
<td>0.41</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>Knw5</td>
<td>-0.20</td>
<td>0.44</td>
<td>0.01</td>
<td>-0.05</td>
<td>0.43</td>
<td>0.44</td>
<td>0.22</td>
<td></td>
</tr>
</tbody>
</table>

* Reverse-coded item

### Table 4: Variance Inflation Factors for Formative Components

<table>
<thead>
<tr>
<th>Components</th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention frequency</td>
<td>1.098</td>
</tr>
<tr>
<td>Intervention duration</td>
<td></td>
</tr>
<tr>
<td>Intrusion frequency</td>
<td>1.134</td>
</tr>
<tr>
<td>Intrusion duration</td>
<td></td>
</tr>
<tr>
<td>PerC</td>
<td>1.075</td>
</tr>
<tr>
<td>SocC</td>
<td></td>
</tr>
<tr>
<td>Efr1</td>
<td>1.854</td>
</tr>
<tr>
<td>Efr2</td>
<td>2.332</td>
</tr>
</tbody>
</table>

216
Testing the Structural Model

The research model was tested using SmartPLS 2.0 M3, and significance levels were established via 300 bootstrapped iterations with subsample sizes of 365. Figure 5 shows the PLS path coefficients and variance explained (R² coefficient of determination) in the endogenous constructs. Since salesperson performance is an endogenous second-order formative construct with formative first-order constructs (Type IV), a special two-step approach is required to estimate the construct since almost all variance in the second-order construct is explained by the lower-order components (Ringle et al. 2012). In the first step, the second-order construct is modeled using the repeated indicator approach and the latent variable scores of the first-order constructs are obtained. In the second step, the scores become observed variables for the second-order construct (Ringle et al. 2012).

Testing the Direct Effects of Email Intrusions and Email Interventions

First, email intrusion intensity does not have a significant direct impact on salesperson performance (beta = 0.02; p = .62), which does not support H1. Second, email intrusion intensity has a significant direct impact in the positive direction on subjective workload (beta = 0.36, p <
.001), thereby providing strong support for H2a. Third, subjective workload has a significant negative impact on salesperson performance (beta = -0.10, p < .05), thus supporting H2b. Fourth, email intervention intensity has a significant direct impact in the positive direction on mindfulness (beta = 0.26, p < .001), thereby providing strong support for H3a. Finally, mindfulness has a significant positive impact on salesperson performance (beta = 0.15, p < .05), thus supporting H3b.

Testing the Indirect (Mediated) Effects of Email Intrusions and Email Interventions

To test the indirect (mediated) effects of email interruptions, we used the Baron and Kenny (1986) procedure: (1) test for significance in the direct model (without the mediator); (2) test for the effect of the predictor on the mediator in the mediated model; (3) test for the effect of
the mediator on the criterion variable, with the predictor variable controlled in the mediated model; (4) test whether the effect of the predictor on the criterion variable from Step 1 weakens (or disappears entirely) in the mediated model. Two mediators were formally hypothesized in the relationship between email interruption types and salesperson performance: subjective workload and mindfulness.

**Indirect effect of email intrusions on salesperson performance.** Subjective workload was formally hypothesized to be a mediator in the relationship between email intrusion intensity and salesperson performance. To test this effect, we first establish that email intrusion intensity significantly affects salesperson performance in the direct model shown in Figure 6 (beta = -0.18, p < .001). Second, we establish that email intrusion intensity significantly affects subjective workload in the mediated model shown in Figure 6 (beta = 0.44, p < .001). Third, we establish that subjective workload significantly affects salesperson performance, while email intrusion intensity is controlled for in the mediated model (beta = -0.25, p < .001). Finally, we establish that the effect of email intrusion intensity on salesperson performance diminishes to the point of becoming non-significant in the mediated model (beta = -0.07; p = .16), which indicates full mediation by subjective workload. Additionally, following Pavlou and El Sawy (2006), we show that the variance explained of salesperson performance is significantly increased in the mediation model over the direct model (from 3% to 8%).

We also performed two tests to assess the significance of the mediation effect: bootstrapping the indirect effect, and the variance accounted for (VAF) test (Preacher & Hayes 2008). First, we estimated the bootstrap t-statistic. The numerator for this term is obtained by

---

20 We also performed the more popular Sobel test and found the results to be significant (z = -3.27, p < .001), but we do not report the results here because the Sobel test has been criticized in the context of PLS for being a parametric test. 

---
multiplying the two original path coefficient estimates that comprise the indirect effect. The denominator is the standard deviation of the product terms from the bootstrap samples. We found the t-statistic to be strongly significant \( t = -3.53, p < .001 \).\(^{21}\) Second, we estimated the VAF and found it to be 0.61.\(^{22}\) This means that 61% of the total effect of email intrusion intensity on salesperson performance is accounted for by the indirect (mediating) effect of subjective workload. These results provide strong support for H2c, and we conclude that subjective workload fully mediates between email intrusion intensity and salesperson performance.

\[^{21}\] \( t = \frac{a \cdot b}{sd(a \cdot b)} = \frac{-0.44 \cdot 0.25}{0.0312} = -3.53 \ (p < .001) \).

\[^{22}\] \( VAF = \frac{ab}{ac'c'} = \frac{-0.44 \cdot 0.25}{(-0.44 \cdot 0.25) - 0.07} = 0.61. \)
and salesperson performance. To test this effect, we first establish that email intervention intensity significantly affects salesperson performance in the direct model shown in Figure 7 (beta = 0.16, p < .001). Second, we establish that email intervention intensity significantly affects mindfulness in the mediated model shown in Figure 7 (beta = 0.24, p < .001). Third, we establish that mindfulness significantly affects salesperson performance, while email intervention intensity is controlled for in the mediated model (beta = 0.44, p < .001). Finally, we establish that the effect of email intervention intensity on salesperson performance diminishes to the point of becoming non-significant in the mediated model (beta = 0.07; p = .14), which indicates full mediation by mindfulness. Additionally, following Pavlou and El Sawy (2006), we show the variance explained of salesperson performance is significantly increased in the mediation model over the direct model (from 3% to 21%).

We also performed the additional tests to assess the significance of the mediation effect. First, we tested for mediation by bootstrapping the indirect effect (Preacher & Hayes 2008) and found the t-statistic to be strongly significant (t = 4.14, p < .001). Second, the VAF value was estimated at 0.60, which means that 60% of the total effect of email intervention intensity on salesperson performance is accounted for by the indirect (mediating) effect of mindfulness. These results provide strong support for H3c, and we conclude that mindfulness fully mediates between email intervention intensity and salesperson performance.

\[ t = \frac{a \cdot b}{sd(a \cdot b)} = \frac{0.24 + 0.44}{0.0255} = 4.14 \quad (p < .001). \]

\[ \text{VAF} = \frac{ab}{ab + c} = \frac{0.24 + 0.44}{0.24 + 0.44 + 0.07} = 0.60. \]
**Testing the Compensating Effects of Perceived Control and Multitasking Self-Efficacy**

To test the moderating effects, we used the two-stage approach (Chin et al. 2003; Wilson 2010), since the exogenous factor (email intrusion intensity) is formative and at least one of the moderators is a second-order formative construct (perceived control). In the first step, the main effects model was run to obtain the latent variable scores. In the second step, these scores were used as indicators of the latent variables in the interaction model. The interaction terms were formed by cross-multiplying the latent variable scores of the exogenous variable(s) and moderator variable(s). The significance of each moderating effect was established via bootstrapped iterations of the beta coefficient of the interaction term, and the strength of the effect was determined via f-tests of the additional variance explained in the interaction model\(^{25}\) as well as by following Cohen’s (1988) guidelines for effect sizes (0.02 for weak, 0.15 for moderate, and 0.35 for strong).

\[^{25}\] \(f^2 = \frac{R^2_{interaction} - R^2_{main}}{1 - R^2_{interaction}}\)
Moderating effects of perceived control. We found no moderating effect of perceived control on subjective workload (beta = 0.00; p = .95) beyond the direct effect. Hence, H4a is not supported. However, we found that perceived control positively moderates the relationship between email intrusion intensity and salesperson performance (beta = 0.18; p < .001), providing support for H4b (see Figure 5). Finally, we found no moderating effect of perceived control on the link between email intervention intensity and mindfulness (beta = -0.02; p = .62), but the effect was direct and negative (beta = -0.24; p < .001). This does not lend support to H4c.

Following Chin et al. (2003), we separately examined the moderation effect that was found significant to determine the effect size and provide better interpretability. The main effects model and interaction model are shown in Figures 8 and 9, respectively. The f-test comparing the difference between the $R^2$ values of the main and interaction models was performed and an effect size of 0.03 was obtained. While this indicates a relatively small interaction effect (Cohen 1988), this does not mean that the effect is unimportant (Chin et al. 2003). Indeed, the interaction plot shown in Figure 10 indicates that the interaction effect is important because it results in meaningful changes in the beta coefficients. More specifically, Figure 10 shows that at a low level of perceived control, email intrusion intensity has a strong negative effect on performance. However, this negative effect is mitigated at a higher level of perceived control, such that increasing the intensity of email intrusions at that level of perceived control does not produce any noticeable effect on performance.

---

26 While Figures 8 and 9 show a significant direct effect of email intrusion intensity on salesperson performance, this relationship becomes non-significant when the mediating mechanism of subjective workload is included (Figure 5).

27 $f^2 = \frac{R^2_{interaction} - R^2_{main}}{1 - R^2_{main}} = \frac{0.072 - 0.042}{1 - 0.072} = 0.032$.

28 The interaction plots were created by varying perceived control at one standard deviation above and below its mean, and then plotting salesperson performance as a function of email intrusion intensity.
Email Interruptions and Task Performance

** Figure 8: Results of the Main Effects Model

** Figure 9: Results of the Interaction Model
Summary of Results

Overall, we found strong support for our main hypotheses that posit differential effects of the two email interruption types. On one hand, email intrusions exhibit a negative impact on salesperson performance through subjective workload. Conversely, email interventions have a positive effect on salesperson performance through mindfulness. While the compensating factors of perceived control and multitasking self-efficacy were not found to moderate the effects of email interruptions (with the exception of the moderating effect of perceived control on salesperson performance), they were instead found to exhibit direct compensating effects. Table 5 shows a summary of the results.
<table>
<thead>
<tr>
<th>Item</th>
<th>Hypothesis</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>Direct negative effect of email intrusion intensity on salesperson</td>
<td>Not supported (effect is fully mediated via subjective workload)</td>
</tr>
<tr>
<td></td>
<td>performance</td>
<td></td>
</tr>
<tr>
<td>H2a</td>
<td>Direct positive effect of email intrusion intensity on subjective</td>
<td>Supported</td>
</tr>
<tr>
<td></td>
<td>workload</td>
<td></td>
</tr>
<tr>
<td>H2b</td>
<td>Direct negative effect of subjective workload on salesperson performance</td>
<td>Supported</td>
</tr>
<tr>
<td>H2c</td>
<td>Subjective workload mediates between email intrusion intensity and salesperson performance</td>
<td>Supported</td>
</tr>
<tr>
<td>H3a</td>
<td>Direct positive effect of email intervention intensity on mindfulness</td>
<td>Supported</td>
</tr>
<tr>
<td>H3b</td>
<td>Direct positive effect of mindfulness on salesperson performance</td>
<td>Supported</td>
</tr>
<tr>
<td>H3c</td>
<td>Mindfulness mediates between email intervention intensity and salesperson performance</td>
<td>Supported</td>
</tr>
<tr>
<td>H4a</td>
<td>Negative moderating effect of perceived control on the link between email intrusion intensity and subjective workload</td>
<td>Not supported (effect is direct)</td>
</tr>
<tr>
<td>H4b</td>
<td>Positive moderating effect of perceived control on the link between email intrusion intensity and salesperson performance</td>
<td>Supported</td>
</tr>
<tr>
<td>H4c</td>
<td>Positive moderating effect of perceived control on the link between email intervention intensity and mindfulness</td>
<td>Not supported (effect is direct and in opposite direction)</td>
</tr>
<tr>
<td>H5a</td>
<td>Negative moderating effect of multitasking self-efficacy on the link between email intrusion intensity and subjective workload</td>
<td>Not supported (effect is direct)</td>
</tr>
<tr>
<td>H5b</td>
<td>Positive moderating effect of multitasking self-efficacy on the link between email intrusion intensity and salesperson performance</td>
<td>Not supported (effect is direct)</td>
</tr>
</tbody>
</table>

**Post-Hoc Analysis**

In addition to the hypotheses tests, we performed three types of post-hoc analyses to further explore the relationships between email interruptions and their important outcomes: (1) examining whether different properties of interruption intensity (frequency and duration) have different effects; (2) examining the effects of email interruptions separately for the two dimensions of performance (efficiency and effectiveness); (3) examining the separate effects of the two components of perceived control (personal and social control). Unpacking the separate dimensions in those constructs allows us to examine the impact of each dimension within the overall nomological network and compare the results with those obtained from the aggregate model.
Examining the Separate Effects of Interruption Frequency and Duration

All hypotheses tests were repeated but this time using frequency and duration as separate exogenous variables rather than being subsumed under a single interruption intensity variable. The results of the analyses suggest that the separate dimensions of the email interruption types exhibit different influences, and that different dimensions are salient for the two interruption types. More specifically, we found that for email intrusions, frequency has a significant impact on subjective workload (beta = 0.36; p < .001) while duration has no significant influence (beta = 0.03; p = .35). By contrast, we found that for email interventions, duration has a significant impact on mindfulness (beta = 0.26; p < .001), while the effect of frequency is non-significant (beta = 0.00; p = .90). No other paths gained or lost significance as compared to the original model. Together, these results show that different interruption properties are activated depending on the type of email interruption that takes place.

Examining the Effects of Interruptions on Performance Efficiency and Effectiveness

We repeated all hypotheses tests but this time replacing salesperson performance by its separate dimensions of efficiency and effectiveness. While most effects in this new model were similar to the original model, a notable exception was identified for subjective workload. Specifically, we found that subjective workload has a negative effect on salesperson performance effectiveness (beta = -0.11; p < .05), but a non-significant effect on performance efficiency (beta = -0.05; p = .28).
Examining the Separate Effects of Personal Control and Social Control

Again, all hypotheses tests were repeated but this time replacing perceived control by its separate components of personal and social control. Several interesting results were recorded. First, the moderating effect of perceived control on the relationship between email intrusion intensity and salesperson performance becomes non-significant when the two dimensions of perceived control are modeled separately. Indeed, the beta coefficient for the interacting term for personal control is 0.04 (p = .253) and for social control it is 0.07 (p = .066). This suggests that the mitigating effect on salesperson performance operates only when perceived control is considered as a whole.

Second, the results indicate that the two dimensions of control exhibit differential effects on mindfulness. Whereas personal control significantly enhances mindfulness (beta = 0.25; p < .001), social control exhibits a significant effect in the opposite direction (beta = -0.24; p < .001). Also, such disentanglement of the two dimensions leads to an increase in the R² value of mindfulness to 21%.

DISCUSSION & IMPLICATIONS

This study’s findings support our main hypotheses about the differential effects of the two email interruption types on performance, which are mediated by different attention-allocation mechanisms. Indeed, we found that the negative effect of email intrusions on performance is mediated by subjective workload with its temporal, cognitive, and emotional dimensions. This mechanism is consistent with cue utilization theory, which posits that intrusions elicit additional, competing task demands that overload salespersons’ attentional capacity and compel them to give up important cues required for task performance. Such
Attentional shrinkage diminishes salesperson performance. As our post hoc analyses indicate, the adverse effects come from the frequency, rather than duration, of the email intrusions. This is consistent with extant HCI research on IT-mediated interruptions, which found adverse effects of intrusion frequency (Cades et al. 2006; Eyrolle & Cellier 2000; Gievska et al. 2005; Ho & Intille 2005; Speier et al. 1997; Zijlstra et al. 1999), but that the effects of duration are non-significant (Gillie & Broadbent 1989; McDaniel et al. 2004) or level off at longer durations (Hodgetts & Jones 2007; Hodgetts & Jones 2006b; Monk et al. 2004b; Monk et al. 2008). While we had hypothesized that the adverse effects of email intrusions are partially mediated by subjective workload, we found a full mediation effect instead. Possible explanations for the absence of a direct impact of email intrusions on salesperson performance may be that individuals make up for the adverse structural effects by speeding up their interrupted work (Zijlstra et al. 1999), or by developing better work practices (McFarlane 2002; O'Leary et al. 2011).

On the other hand, we also found support for our hypotheses that email interventions produce a positive effect on salesperson performance, which is fully mediated by mindfulness. Specifically, interventions unearth a discrepancy between actual and desired performance, which redirects attention toward the source of the gap. Salespersons then begin to process their primary tasks activities in new and innovative ways that are consistent with mindfulness theory. Such expansion of attentional capacity leads to improvements in salesperson performance. As our post hoc analysis shows, such performance enhancements are based on the duration, rather than frequency, of the email interventions. It may be that the duration of email intervention is important because it represents the time individuals take to reflect and/or discuss important gaps in their task performance. The longer they handle such interventions, the more opportunities they have to process them in a conscious, mindful mode rather than rely on pre-conceived shortcuts.
and schemas. For example, research on interventions in a group setting found that an initial
switch to the intervention elicits a window of opportunity with a fixed time frame during which
group members actively and reflectively discuss important issues that impact positively on their
tasks (Okhuysen & Eisenhardt 2002; Tyre & Orlikowski 1994).

Additionally, we proposed two compensating factors that mitigate the adverse effects of
e-mail intrusions: perceived control and multitasking self-efficacy. Whereas we controlled for the
direct effect of perceived control on subjective workload and hypothesized moderating effects on
performance and subjective workload, we found support for all effects except for the latter.
While this latter result is surprising, it is consistent with findings in the job control literature,
which was our primary source for operationalizing perceived control. Indeed, prior research
found a direct negative effect of job control on workload but no interaction effect with job
demands (which can be considered a proxy for intrusions that operate by raising task demands;

Two explanations may account for the lack of significant moderating effect and the
presence of a direct effect instead. First, the perception of control may be operating as a
psychological mechanism that independently reduces workload regardless of whether or not the
control is exercised or the intrusion occurs (Aiello & Svec 1993; Glass & Singer 1972). For
example, in the only study from our literature review that directly assessed perceived control, 70
student subjects performing text editing tasks were exposed to intrusions (Carton & Aiello 2009).
Subsequently, only the groups that had the opportunity to control such intrusions (i.e., prevent
them from occurring) reported significantly lower stress levels. Remarkably, this occurred even
when subjects did not take advantage of that provided opportunity (Carton & Aiello 2009). This
suggests that it is the perception of control over interruptions, rather than the need for actual
Email Interruptions and Task Performance

execution of control, which matters for reducing workload. Indeed, this power of perceived – rather than actual – control as a psychological mechanism that reduces stress and workload has been substantiated in prior psychology research (Aiello & Svec 1993; Glass & Singer 1972).

Second, the lack of empirical support for a moderating effect may be due to the specific nature of the interaction. More specifically, since workload is reduced the most when there is a low level of task demand coupled with a high degree of perceived control, this may suggest more complex forms of interactions, such as discrepancy, proportional, or non-linear interactions (Edwards & Cooper 1990; Karasek 1979). For example, the discrepancy model associates changes in workload with task demand deviations from a given standard of perceived control (i.e., increases in perceived control would shift the line downward rather than affect its slope) (Edwards & Cooper 1990). While theoretically appealing, such an interaction is very difficult to model statistically since it requires commensurate measures that share a common zero point (both conditions are not met in this study). Also, it introduces problems such as perfect collinearity (a difference score is a linear combination of its components) and restriction of variance in the dependent variable (Edwards & Cooper 1990). This calls for further research that employs more advanced statistical techniques to uncover the true nature of the interaction.

Furthermore, the positive moderation effect of perceived control on mindfulness was not supported in this study, and instead, a surprising direct effect in the negative direction was found. Two explanations may account for this result. First, control research found that although perceived control is commonly associated with a mindful approach, individuals can process information in a mindless manner, especially when facing situations characterized by certainty (Brown & Langer 1990; Langer 1992). According to this perspective, the more individuals with high perceived control over interrupting their tasks via email are certain about the consequences
of their action, the more they would favor a mindless processing mode for their primary task activities. This may be because the absence of surprising or unexpected outcomes leads them to switch to an automatic mode with cognitive detachment from their ongoing tasks in order to conserve cognitive resources (Langer 1989). Similarly, it has been argued that regular social interactions such as meetings and discussions trigger mindless execution because they become formalized by individuals who have high subjective control over such interactions and can predict their consequences with relative certainty (Ashforth & Fried 1988). Essentially, such interactions become treated as structured behavioral episodes that are weaved into their day-to-day activities (Ashforth & Fried 1988).

Second, our post hoc analysis shows that the negative effect of perceived control on mindfulness comes from the social dimension of perceived control (see Table 2). The interpretation of this is that the less external means of control individuals believe they have over their email (i.e., the more they conform to peer pressures, social expectations, and/or job requirements about handling email), the more mindfully they perform their primary tasks. A possible explanation of this unusual finding may be found in Louis & Sutton’s (1991) theory of cognitive gear switching. More specifically, the theory posits that one of the primary conditions for switching from a mindless to a mindful mode of information processing is when there is a deliberate initiative as a response to internal or external requests for increased levels of conscious attention. In this case, the deliberate initiative is a result of the incoming email, which "explicitly questions" the recipient (Louis & Sutton 1991, p. 60), and which displays the sender's information and the subject line even before the recipient decides whether or not to interrupt his/her activity. Consequently, individuals with low levels of social control are more likely to
respond to such “explicit requests for attention” (Louis & Sutton 1991, p. 63) and may thus enter into a more mindful information processing mode.

With respect to *multitasking self-efficacy*, our moderation hypotheses were not supported. Instead, we found that the compensating mechanisms of multitasking self-efficacy work independently by directly reducing subjective workload and increasing performance. Some support for such direct relationships exist in the extant literature. For example, Basoglu’s (2009) study of individuals performing accounting tasks posited direct effects of multitasking self-efficacy on financial performance and moderated effects on cognitive load, but found the latter effects to be direct (Basoglu et al. 2009). Furthermore, Barley et al. (2011) studied different groups of technical and marketing professionals in a large IT company and found that by-and-large, those individuals who were good at multitasking with IT tools (e.g., doing email and teleconferencing at the same time) were less stressed and derived more positive emotional responses from such multitasking. Finally, a field study of executive recruiters found that better multitasking behaviors from using email increased individual productivity, unless it reached exceedingly high levels (Aral et al. 2006).

**Contributions to Research and Practice**

This paper makes four contributions to research. First, it focuses on email interruption types that are different in nature and that have different consequences. The paper thus extends the prior literature on IT-mediated interruptions, which has largely regarded interruptions as a monolithic, mostly negative phenomenon. This study shows empirically that interruptions are not necessarily bad and that different types of interruptions can affect cognitive and behavioral outcomes either positively or negatively. This has important implications for research to dig
deeper into the contents of various interruptions to segregate their disparate effects. For example, while we separate two types of email interruptions based on the extent to which the email is pertinent to the primary task, researchers could identify other classification types such as distinguishing between informational, communicational, and actionable email interruptions.

Second, the paper sheds light on the different paths through which email interruptions are related to salesperson performance. By elucidating those paths, we show that interruptions activate different attention allocation mechanisms that have distinct effects on performance. Drawing upon psychological theories of attention allocation, we show that one type of interruption contracts attention and adversely affects performance while the other type expands attention and subsequently enhances performance. This opens new avenues of research on attention as a scarce resource that shapes the way information technologies interrupt and generally interact with people in organizations.

Third, our paper provides insights into the compensating mechanisms that mitigate the adverse effects of intrusions. We identify two factors deriving from the asynchrony of email that exert direct and moderating limits on the cognitive and behavioral outcomes of email intrusions. This finding implies that researchers can look beyond the negative effects of IT-mediated intrusions toward understanding how such effects can be offset or cancelled.

Finally, this study has implication for IT value research. Specifically, IT value research focuses on the impacts of using IT in an environment characterized by continuity in performing the work tasks. Any disruption to such continuity would imply IT non-use, which is generally seen as a negative thing. This research presents a complementary view in which there are important positive and negative impacts to explicitly consider when the IT creates discontinuities in the tasks being performed.
For practitioners, we provide a potent message, which is that interruptions from email can have both positive and negative impacts depending on the nature of the interruption, the person being interrupted, and the way the interruption is managed. To manage the type of interruption, managers can develop best practices about how to channel emails that are directly related and unrelated to employees’ work tasks. With respect to the people factor, individuals with a high ability to multitask can be selected, especially if they are believed to occupy roles where they will frequently deal with email intrusions. Such pre-selection can be easily assisted via standard multitasking ability tests. Finally, one of the important design tools available for managers is the degree of perceived control they can give to employees. While such control is partly internally determined, it also contains a social dimension that depends on the social expectations and job norms related to handling email. This can be manipulated by managers in a way that awards individuals low or high levels of social control. However, in using this tool, managers need to be aware that perceived control can be a double-edged sword. On one hand, it may directly reduce subjective workload and help offset the adverse effects of email intrusions on performance. On the other hand, it may also reduce mindfulness by making individuals less attuned to their social environment, which can consequently reduce the positive effects of the email interventions.

**Limitations and Future Research**

This study has several limitations to be recognized. First, the self-reported, retrospective measures of email interruption intensity may be subject to recall bias. However, we expect this bias to be mitigated by our choice of salespersons as a context for this research. Specifically, since salespersons are largely commission-based, the continuity of their primary selling activities becomes very important to quickly turn around sales. Hence, interruptions to such activities are
more likely to be recalled in this context than in other contexts where the primary activities can be interrupted and juggled with other activities without major performance repercussions (e.g., academic work; office work; IT jobs). This is consistent with the widely known Zeigarnik effect, which posits that individuals are likely to remember interruptions to their tasks, especially when they have a high level of aspiration in the interrupted tasks (Zeigarnik 1927). Additionally, we took additional steps at the design and analysis stages to mitigate this recall bias, as explained earlier (the use of interruption type and primary selling activities as anchors, the survey validation questions, and the statistical tests to validate the interruption constructs). Future research may develop alternate methods for measuring interruption intensity such as via direct observation or archival data.

Second, the use of a single informant raises the likelihood of common method bias. However, we mitigated this bias by employing various techniques both at the study design stage (ex ante) and the data analysis stage (ex post). Additionally, common method bias would have systematically increased all path coefficients, but instead we found support for our hypotheses that different types of interruptions have differential impacts on performance, and that such effects are mediated by cognitive mechanisms.

Third, we did not use objective measures of salesperson performance. While we argued for the appropriateness of subjective measures in our context (e.g., better fit for reporting behavioral outcomes; proximity to interruption effects; better availability), objective measures could be used alongside subjective ones in future research and any differences closely examined.

Fourth, the cross-sectional design of this study makes it inherently difficult to confirm causation. We believe cross-sectional analysis is still appropriate to advance our currently limited understanding of email interruptions. However, future research can incorporate a
longitudinal approach which looks at the effects of email interruptions over time (e.g., over the course of a project) while controlling for the past (e.g., past performance).

Finally, the model proposed in this paper can be tested in different contexts and at different levels of analysis. Specific particularities arising in those different contexts should be carefully examined. For example, studying IT-mediated interruptions at the group level may give rise to spillover effects due to task-dependencies among group members.

CONCLUSION

At a time when individuals are facing myriad email interruptions in their work, it becomes critical to understand the different types of interruptions and their implications on cognition and work outcomes. Our research reveals that there are different types of email interruptions based on content, and that each type takes on a different path. Email intrusions increase subjective workload and subsequently debilitate individual performance. Conversely, email interventions enhance mindfulness, which is beneficial to task performance.

Overall, this study is an initial attempt to examine real interruptive events as they occur in their organizational setting, rather than manipulating artificial interruptive events that have no bearing on individuals’ real work environment. Also, the study integrates two psychological theories of attention allocation (cue utilization theory and mindfulness theory) that together help explain the disparate cognitive mechanisms that relate email interruptions to performance. We hope that the ideas developed and tested in this paper will encourage further research in this largely unexplored domain.
REFERENCES


Bailey, B. P., Konstan, J. A., and Carlis, J. V. "The Effects of Interruptions on Task Performance, Annoyance, and Anxiety in the User Interface," Proceedings of the 8th IFIP


Chin, W. W., Marcolin, B. L., and Newsted, P. R. "A partial least squares latent variable modeling approach for measuring interaction effects: Results from a Monte Carlo simulation study and an electronic-mail emotion / adoption study," Information Systems Research (14:2), 2003, pp 189-.


Ducheneaut, N., and Bellotti, V. "E-mail as habitat: an exploration of embedded personal information management," *interactions* (8:5), 2001, pp 30-38.


Addas (Essay #2)

Email Interruptions and Task Performance


Addas (Essay #2) Email Interruptions and Task Performance


Orlikowski, W. J., and Barley, S. "Technology and institutions: What can research on information technology and research on organizations learn from each other?," MIS Quarterly (25:2), 2001, pp 145-165.


### APPENDIX 1: MEASUREMENT ITEMS OF MAIN CONSTRUCTS

<table>
<thead>
<tr>
<th>Item</th>
<th>Question [Dimension]</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Email interruption intensity</strong></td>
<td>Over the past workweek, how many times did you temporarily suspend your primary selling activities to handle the incoming emails? By handling emails, we mean reading, responding to, or acting upon the incoming emails.</td>
<td>a</td>
</tr>
<tr>
<td></td>
<td>How many of the [number of interruptions piped from previous response] temporary suspensions were caused by primary emails vs. secondary emails? (Total must be [number of interruptions piped from previous response])</td>
<td></td>
</tr>
<tr>
<td>Interv-fq 1</td>
<td>Primary emails: Emails that are directly pertinent to performing your primary selling activities (e.g., information about prospective customer needs; feedback about your selling performance):</td>
<td></td>
</tr>
<tr>
<td>Intru-fq 2</td>
<td>Secondary emails: Emails that are related to secondary selling activities (e.g., servicing accounts; training/recruiting), or activities outside of the sales domain (e.g., general work; personal/social activities):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Over the past workweek, what has been the duration of a single typical suspension of your primary selling activities to handle primary emails vs. secondary emails?</td>
<td>a</td>
</tr>
<tr>
<td>Interv-dur 1</td>
<td>Duration of a typical suspension to handle primary emails: ____ (min)</td>
<td></td>
</tr>
<tr>
<td>Intru-dur 2</td>
<td>Duration of a typical suspension to handle primary emails: ____ (min)</td>
<td></td>
</tr>
<tr>
<td><strong>Subjective workload</strong></td>
<td>How do you feel about having to handle the suspensions from incoming emails in addition to performing your primary selling activities?</td>
<td>b</td>
</tr>
<tr>
<td>SW1</td>
<td>I feel annoyed. [Emotional]</td>
<td></td>
</tr>
<tr>
<td>SW2r</td>
<td>I feel relieved. [Emotional]</td>
<td></td>
</tr>
<tr>
<td>SW3</td>
<td>I feel frustrated. [Emotional]</td>
<td></td>
</tr>
<tr>
<td>SW4r</td>
<td>I feel energized. [Emotional]</td>
<td></td>
</tr>
<tr>
<td>SW5</td>
<td>I feel that my workload is substantial. [Cognitive]</td>
<td></td>
</tr>
<tr>
<td>SW6</td>
<td>I feel stressed. [Emotional]</td>
<td></td>
</tr>
<tr>
<td>SW7r</td>
<td>I feel that the pace required to do my activities is very slow. [Temporal]</td>
<td></td>
</tr>
<tr>
<td>SW8</td>
<td>I feel fatigued. [Emotional]</td>
<td></td>
</tr>
<tr>
<td>SW9</td>
<td>The rate at which my activities occur makes me feel pressured. [Temporal]</td>
<td></td>
</tr>
<tr>
<td>SW10r</td>
<td>I feel that my activities impose few mental demands. [Cognitive]</td>
<td></td>
</tr>
<tr>
<td><strong>Mindfulness</strong></td>
<td>The following statements evaluate your state of mind after handling the primary emails and secondary emails that temporarily suspend your primary selling activities.</td>
<td>b</td>
</tr>
<tr>
<td>Min1</td>
<td>... I tend to investigate new issues that emerge in my primary selling activities.</td>
<td></td>
</tr>
<tr>
<td>Min2</td>
<td>... I try to think of new ways of doing my primary selling activities.</td>
<td></td>
</tr>
<tr>
<td>Min3</td>
<td>... I become open to new ways of doing my primary selling activities.</td>
<td></td>
</tr>
<tr>
<td>Min4</td>
<td>... I develop an open mind about the issues I face, even things that challenge my core beliefs.</td>
<td></td>
</tr>
<tr>
<td>Min5</td>
<td>... I find myself very curious about issues that I face.</td>
<td></td>
</tr>
<tr>
<td>Min6r</td>
<td>... I find myself generating few novel ideas.</td>
<td></td>
</tr>
<tr>
<td>Min7r</td>
<td>... I rarely attend to new developments in my primary selling activities.</td>
<td></td>
</tr>
<tr>
<td>Min8r</td>
<td>... I do my primary selling activities automatically, without being aware of what I’m doing.</td>
<td></td>
</tr>
<tr>
<td><strong>Salesperson Performance</strong></td>
<td>Please evaluate how well you perform on each of the following criteria compared to an average salesperson in similar selling situations.</td>
<td></td>
</tr>
<tr>
<td>Notes:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

252
Consider your current sales cycle when answering.

Take into account the temporary suspensions to your activities from primary & secondary emails.

| Efc1  | Timeliness in prospecting for potential customers. [Efficiency] | c |
| Efc2  | Efficiency in delivering sales presentations or materials. [Efficiency] | d |
| Efc3  | Managing time well across the primary selling activities. [Efficiency] | e |
| Efc4  | Timeliness in providing information to prospect customers. [Efficiency] | c |
| Efc5  | Speed of identifying and solving prospect customer issues. [Efficiency] | c |
| Efc6  | Speed of generating sales from prospect customers. [Efficiency] | c |
| Ef1   | Interacting effectively with prospect customers. [Effectiveness] | e |
| Ef2   | Avoiding mistakes in sales presentations or materials. [Effectiveness] | e |
| Ef3   | Communicating my sales presentations clearly and concisely. [Effectiveness] | e |
| Ef4   | Solving prospect customers' problems or objections. [Effectiveness] | e |
| Ef5   | Developing new customers from established contacts. [Effectiveness] | e |
| Ef6   | Accuracy in matching prospect customer requirements with available product offerings. [Effectiveness] | d |

### Perceived Control

The statements below tap into your perceptions about handling (reading, responding to, and/or acting upon) incoming email. Please rate your level of agreement/disagreement with each statement.

| PC1   | I find it easy to ignore my incoming email messages if I choose to do so. [Personal] | b |
| PC2   | I feel that I have personal control over when to deal with my incoming email messages. [Personal] | b |
| PC3'  | I conform to peer pressures in accepting or declining to handle my incoming email messages. [Social] | b |
| PC4'  | The fears of falling behind or missing something important compel me to deal with my incoming email messages right away. [Social] | b |
| PC5'  | I conform to social expectations of addressing my incoming email messages right away. [Social] | b |
| PC6'  | Due to the nature of my job, I often have no choice but to suspend my tasks to handle incoming email messages. [Social] | b |

### Multitasking Self-Efficacy

Please rate your level of agreement/disagreement with each of the following statements about juggling activities.

| MSE1 | I believe I can succeed in a job where I constantly shift from one task to another. | b |
| MSE2' | I have to finish one task completely before being able to focus on anything else. | b |
| MSE3 | When doing a number of assignments, I have the ability to switch back and forth between them without losing the flow. | b |
| MSE4 | I believe I have the ability to reengage in the task quickly after being interrupted by another event. | b |
| MSE5' | In general, I think I perform poorly when I have to shift my attention between multiple tasks. | b |

### Effort

Please rate your level of agreement/disagreement with each of the following statements.

| Efr1 | I work untiringly at selling the product/service to customers. | b |
| Efr2 | Even when I encounter a customer who is difficult to sell, I do not spare any sweat. | b |
| Efr3 | I vary my selling approach from situation to situation. | b |
| Efr4' | I tend to work without spending too much energy on planning. | b |

### Knowledge

Please rate your level of agreement/disagreement with each of the following statements about your level of expertise.

| Knw1 | I know all the specifications and applications of our products. | b |
| Knw2 | I can be considered an expert on my company’s technical procedures. | b |
| Knw3 | I am an excellent resource of competitive information. | b |
| Knw4 | I have a lot of information on industry trends. | b |
| Knw5 | I have rich knowledge of strategies for handling different customer types. | b |

### Demographic questions

Exp1 | Years and months of total sales experience (incl. current and previous organizations): _____ | a [Experience] |
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exp2</td>
<td>Years and months spent at the current organization: _____ [Experience]</td>
<td>a</td>
</tr>
<tr>
<td>Exp3</td>
<td>Years and months spent in current sales position at the organization: _____ [Experience]</td>
<td>a</td>
</tr>
<tr>
<td>Age</td>
<td>Please select your age group: [Age]</td>
<td>f</td>
</tr>
<tr>
<td>Gen</td>
<td>What is your gender? _____ [Gender]</td>
<td>a</td>
</tr>
<tr>
<td>Edu</td>
<td>What is the highest degree you earned? [Education]</td>
<td>f</td>
</tr>
<tr>
<td>Job</td>
<td>What is your job title? [Job title]</td>
<td>f</td>
</tr>
<tr>
<td>Size</td>
<td>About how many employees are there in your company? _____ [Size]</td>
<td>a</td>
</tr>
<tr>
<td>Ind</td>
<td>Select your company's primary industry: [Industry]</td>
<td>f</td>
</tr>
</tbody>
</table>

**Notes**
*(italics) Item dropped from final measurement scale after testing of measurement properties.*
*(f) Reverse-coded item.*

**Scale**
- **a** Ratio scale
- **b** 7-point Likert scale (1. Strongly disagree – 7. Strongly agree)
- **c** 7-point Likert scale (1. Much slower – 7. Much faster)
- **d** 7-point Likert scale (1. Much lower – 7. Much higher)
- **e** 7-point Likert scale (1. Much worse – 7. Much better)
- **f** Multiple choice question with pre-defined response categories
APPENDIX 2: CARD-SORTING ANALYSIS

The instructions for the card-sorting analysis, which were provided to the academic experts in round 1 and round 2, are shown in Tables A2A and A2B, respectively. Tables A2C and A2D show a summary of the analysis results for the first and second rounds, respectively. As shown in Tables A2C and A2D, the summarized results include the hits or correct item placements (shown in the shaded diagonals), the theoretical total placements (TTP), the hit ratio (hits divided by TTP), and actual total placements (ATP). Taking the category of multitasking self-efficacy (MSE), for example, we see in Table A2C that from the 50 theoretical total placements (5 items times 10 judges) for this category, there are 48 hits. Hence, MSE has a very high hit ratio of 96%, with only two item misplacements in other categories. Additionally, looking vertically at the MSE column (column labeled 7), we see that this category received 66 actual total placements (ATP). This means that the percentage of correct item placements for this category is 73%.

Looking at the overall results for all categories in round 1, we see in the bottom of Table A2C that from the theoretical maximum of 960 item placements, a total of 744 hits were achieved for an overall hit ratio of 78%. We can also look at the individual placements in the off-diagonal cells by rows and columns to identify ambiguous items and constructs. An analysis by rows reveals the placement pattern of a category’s items into the intended and unintended categories. Erroneous placements in unintended categories may indicate that the items of the focal category are not sufficiently differentiated from the items of the unintended categories (Moore & Benbasat 1991). On the other hand, an analysis by columns shows the pattern of accepting items from all categories into the focal category. Erroneous placements in this case
may indicate problems with the focal categories, such as ambiguous construct definitions (Moore & Benbasat 1991).

**Round 1 Analysis by Rows**

The analysis by rows in Table A2C indicates that most categories have hit ratios above 70% with the exception of the effort construct and the two dimensions of salesperson performance (efficiency and effectiveness). Since the items of those three categories were frequently misplaced in other categories, this indicates that those items may not be sufficiently differentiated from the items of the other categories in which they were wrongly placed (Moore & Benbasat 1991). For example, the effort items were frequently misplaced under mindfulness (six placements) and salesperson performance effectiveness (four placements). Examining the individual effort items, we found that one item was especially problematic: “I think about strategies I will fall back on if I encounter problems in a sales interaction.” This item alone was placed under effort only twice and caused five wrong misplacements under mindfulness among other misplacements. Since the wording of the item reflects a cognitive state rather than a behavior, it has some overlap with items from mindfulness. This item was thus deleted from the subsequent analysis. Deleting the item retained the content domain of the effort construct, which still captured aspects of “working hard” and “working smart.”

Additionally, two other effort items refer to behaviors that seem to have been confused with performance effectiveness behaviors (they caused four misplacements under the latter category). We found that this situation was due to the conceptual definition of performance effectiveness. Hence, this is addressed as part of the column analysis that is reported next. Similarly, we found that the low hit ratios of the two dimensions of performance were likely due
to conceptual issues that are addressed in the column analysis. Finally, items underlying one performance dimension were often misplaced in the other dimension (see Table A2C). This was found to be caused by some ambiguous items that were later removed without affecting the content domain of performance.

**Round 1 Analysis by Columns**

The column analysis indicates that some categories have a lower percentage of correct placements: effort, performance efficiency/effectiveness, and knowledge. Effort was especially problematic with only 29% correct item placements, which suggests that it is an ambiguous construct that erroneously catches items from many other categories (see Table A2C). Particularly, effort caught 17 erroneous placements from the performance effectiveness category (almost as many as the number of hits for effort). We argue that this is because the conceptual definition of performance effectiveness is not sufficiently precise to distinguish behaviors related to performance from behaviors related to effort. More specifically, we found that the original definition of performance effectiveness (“the perceived ability of a salesperson to close sales and build profitable relationships with customers”) did not sufficiently highlight the fact that performance is a behavior that is evaluated relative to its contribution to sales goals (Campbell et al. 1973; Hunter & Goebel 2008). Hence, the definition of performance effectiveness was modified to reflect this fact (see Table A2B). We then reviewed the wording of all performance effectiveness items (especially the problematic ones) to make sure they stayed true to this constrained definition of performance as evaluated behaviors that are conducive to achieving sales objectives.
Furthermore, there seemed to be some confounding of effort and efficiency, which likely resulted from the original definition of effort as “the amount of time and energy that an individual allocates to his or her primary task” (see Table A2A). More specifically, the time component in this definition seems to overlap inversely with the definition of efficiency as "the perceived ability of a salesperson to perform his or her primary selling activities in a timely manner." To better distinguish between those two concepts, we first replaced the term "perform" with "accomplish" in the original definition of performance efficiency. This is important because when an individual performs his/her task in a short time-period, this may be an indication of the amount of effort assigned to performing the task (low degree of effort), but it is not really an indication of efficiency (i.e., accomplishing the task in that short time period).

Then, we also changed the definition of effort by removing the “time” component (see Table A2B). Constraining the definition of effort to the amount of energy expended is consistent with the formal definition of effort in the Merriam Webster Online Dictionary (“the conscious exertion of power”29), the Oxford Online Dictionary (“strenuous physical or mental exertion”30), as well as some prior effort research (Rangarajan et al. 2005). To be consistent with this definition, some problematic effort items were modified.

The category of knowledge also caught many item placements from other categories (37% erroneous placements). We argue that this likely resulted from the ambiguity surrounding the original definition of knowledge as “the salesperson’s understanding about their product or service and basic market trends.” This definition does not clearly identify the property represented by the construct’s conceptual domain (MacKenzie et al. 2011). Consequently, such ambiguity likely resulted in the construct capturing some behavioral items from the performance

effectiveness category (12 erroneous item placements) as well as some cognitive state items from mindfulness (six erroneous item placements). We therefore redefined knowledge and clearly identified the property of its conceptual domain as “information held by salesperson on facts and procedures relating to the product/service and market” (see Table A2B).

Finally, we found that several items from the "novelty creation" dimension of mindfulness overlap conceptually with items under salesperson effectiveness. To avoid such overlap, some items were deleted and others reworded, without violating the conceptual domain of mindfulness.

Table A2A: Intrusions for Card-Sorting Analysis (Round 1)

<table>
<thead>
<tr>
<th>SECTION 1: INTRODUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am conducting research that will help us gain a better understanding of email interruptions. To be able to do this exercise, think of your role as a salesperson who is performing various primary selling activities that are related to the generation of new sales. Consider that while you are working on your primary selling activities, you may temporarily suspend some activities to handle (read, respond to and/or act upon) incoming email that may or may not be related to those activities.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SECTION 2: GENERAL INSTRUCTIONS FOR EACH SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructions for Section 3: In Section 3 you will see the definitions for 14 categories (constructs). Please read the definitions carefully before proceeding to Section 4 to place the items.</td>
</tr>
</tbody>
</table>

Instructions for Section 4: In Section 4 you will see a list of all the items on the left and boxes representing the 14 categories on the right. Click on each item to drag it onto the appropriate category. Repeat with the remaining items, grouping items that belong together (don’t worry about the rankings). When going through the items, please do not guess the corresponding category and it is recommended that you go back to the category definitions in order to make sure you are placing the item correctly. If you are not certain where the item belongs, please choose the category that seems to fit best, and then make sure to explain why you were not sure about this item, by writing a comment next to the respective item in Section 5. You can also use the general comments area in Section 6 for reporting any comments or ambiguities relating to the wording or the meaning of the items, or any general comments about this exercise. |

Instructions for Section 5: In Section 5 you will see again the list of all items, and there is a text entry field which allows you to enter any comments you have about a respective item (e.g., why it was hard to place; ambiguities in wording or meaning; etc.) |

Instructions for Section 6: In Section 6 there is a general comments area where you can enter any comments about the items, constructs, or this exercise. |

When you are finished placing all items and writing comments, please have one final look under each category to make sure you did not misplace any item (e.g., as a result of dragging it to the wrong category).
SECTION 3: CATEGORY DEFINITIONS

**Frequency of email interruptions:** The perceived rate at which an individual temporarily suspends his or her primary task activities to handle (read, respond to and/or act upon) different types of incoming email messages.

**Duration of email interruptions:** The average duration of time spent by an individual each time he or she suspends the primary task activities to handle (read, respond to and/or act upon) different types of incoming email messages.

**Clusteredness of email interruptions:** The degree to which an individual perceives interruptions from incoming email messages to follow each other in close temporal proximity.

**Subjective workload:** The extent to which an individual feels his or her task execution is demanding emotionally, temporally, and mentally.

**Mindfulness:** A state of cognitive functioning through which an individual performing his or her primary tasks exhibits alertness to distinction, openness to novelty, orientation in the present, and implicit, if not explicit, awareness of multiple perspectives.

**Perceived control over email:** The perceived latitude of an individual over whether and when to handle potential interruptions from incoming email.

**Task activation:** Individual practices used to keep retrospective or prospective details about interrupted tasks active in memory, both by rehearsing the task details and linking them to cues in the environment.

**Salesperson performance efficiency:** The perceived ability of a salesperson to perform his or her primary selling activities in a timely manner.

**Salesperson performance effectiveness:** The perceived ability of a salesperson to close sales and build profitable relationships with customers.

**Multitasking self-efficacy:** The individual’s belief in his or her ability to effectively shift attention among ongoing tasks.

**Work/role experience:** The degree of exposure that an individual accumulates in relation to performing the requirements of his or her work roles.

**Task complexity:** The extent to which ongoing tasks have (1) a large number of components, (2) little overlap among demands imposed by such components, (3) components that require tight coordination, and (4) components that are dynamic.

**Knowledge:** The salesperson’s understanding about their product or service and basic market trends.

**Effort:** The amount of time and energy that an individual allocates to his or her primary selling tasks.

---

**Table A2B: Intrusions for Card-Sorting Analysis (Round 2)**

**SECTION 1: INTRODUCTION**

I am conducting research that will help us gain a better understanding of email interruptions. To be able to do this exercise, think of your role as a salesperson who is performing various primary selling activities that are related to the generation of new sales. Consider that while you are working on your primary selling activities, you may temporarily suspend some activities to handle (read, respond to and/or act upon) incoming email that may or may not be related to those activities.

---

**SECTION 2: GENERAL INSTRUCTIONS FOR EACH SECTION**

Instructions for Section 5: In Section 3 you will see the definitions for 14 categories (constructs). Please read the definitions carefully before proceeding to Section 4 to place the items.

Instructions for Section 4: In Section 4 you will see a list of all the items on the left and boxes representing the 14 categories on the right. Click on each item to drag it onto the appropriate category. Repeat with the remaining items, grouping items that belong together (don’t worry about the rankings). When going through the items, please do not guess the corresponding category and it is recommended that you go back to the category definitions in order to make sure you are placing the item correctly. If you are not certain where the item belongs, please choose the category that seems to fit best, and then make sure to explain why you were not sure about this item, by writing a comment next to the respective item in Section 5. You can also use the general comments area in Section 6 for reporting any comments or ambiguities relating to the wording or the meaning of the items, or any general comments about this exercise.

Instructions for Section 5: In Section 5 you will see again the list of all items, and there is a text entry field which allows you to enter any comments you have about a respective item (e.g., why it was hard to place; ambiguities in wording or meanings; etc.)

Instructions for Section 6: In Section 6 there is a general comments area where you can enter any comments about the items, constructs, or this exercise.

When you are finished placing all items and writing comments, please have one final look under each category to make sure you did not misplace any item (e.g., as a result of dragging it to the wrong category).
### Table A2C: Summary of Card-Sorting Analysis (Round 1)

<table>
<thead>
<tr>
<th>Target Category</th>
<th>Actual Categories</th>
<th>TTP</th>
<th>% Hits</th>
<th>% Received</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Frequency of email interruptions</td>
<td>(1) 20</td>
<td>20</td>
<td>100</td>
<td>87</td>
</tr>
<tr>
<td>(2) Duration of email interruptions</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3) Clusteredness of email interruptions</td>
<td>21 23 1 2</td>
<td>1 30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4) Subjective workload</td>
<td>100 2 2 6 8</td>
<td>2 120</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td>(5) Mindfulness</td>
<td>3 117 4 4 6 11 3 5</td>
<td>160</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>(6) Perceived control</td>
<td>3 1 83 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(7) Multitasking self-efficacy</td>
<td>1 48 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8) Salesperson performance efficiency</td>
<td>1 2 55 11 12 17 2</td>
<td>140</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>(9) Salesperson performance effectiveness</td>
<td>6 11 92</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(10) Work/role experience</td>
<td>1 29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(11) Knowledge</td>
<td>1 1 1 36 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(12) Effort</td>
<td>1 6 2 4 22 3 2</td>
<td>40 55</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>(13) Task activation</td>
<td>3 1 8 1</td>
<td>7 60</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>(14) Task complexity</td>
<td>3 3 1 1 39 50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual Totals Placements (ATP)</td>
<td>23 21 23 112 138 89 66 79 123 31 57 77 71 50</td>
<td>40</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>% Received</td>
<td>87 95 100 89 85 93 73 70 75 94 63 29 85 78</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Item Placements: 960  
Total Hits: 744  
Overall Hit Ratio: 78%
TTP is the number of theoretical total placements that can be made within a construct (calculated as the number of judges times the number of items).

ATP is the number of actual total placements that are made within a construct.

% Hits = % of correct placements of category items in their respective category.

% Received = % correct item placements received by a category.

### Table A2D: Summary of Card-Sorting Analysis (Round 2)

<table>
<thead>
<tr>
<th>Target Category</th>
<th>Actual Categories</th>
<th>TTP(^1)</th>
<th>% Hits(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Frequency of email interruptions</td>
<td>19</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>(2) Duration of email interruptions</td>
<td>1</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>(3) Clusteredness of email interruptions</td>
<td>4</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>(4) Subjective workload</td>
<td>67</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>(5) Mindfulness</td>
<td>2</td>
<td>67</td>
<td>2</td>
</tr>
<tr>
<td>(6) Perceived control</td>
<td>2</td>
<td>1</td>
<td>71</td>
</tr>
<tr>
<td>(7) Multitasking self-efficacy</td>
<td></td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>(8) Salesperson performance efficiency</td>
<td>2</td>
<td>1</td>
<td>55</td>
</tr>
<tr>
<td>(9) Salesperson performance effectiveness</td>
<td>3</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>(10) Work/role experience</td>
<td></td>
<td>29</td>
<td>1</td>
</tr>
<tr>
<td>(11) Knowledge</td>
<td></td>
<td>1</td>
<td>39</td>
</tr>
<tr>
<td>(12) Effort</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(13) Task activation</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>(14) Task complexity</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Actual Totals Placements (ATP)*</td>
<td>27</td>
<td>19</td>
<td>25</td>
</tr>
<tr>
<td>% Received*</td>
<td>70</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Total Item Placements: 740  
Total Hits: 612  
Overall Hit Ratio: 83%

1 TTP is the number of theoretical total placements that can be made within a construct (calculated as the number of judges times the number of items).

2 ATP is the number of actual total placements that are made within a construct.

3 % Hits = % of correct placements of category items in their respective category.

4 % Received = % correct item placements received by a category.

### Round 2 Analysis by Rows

As can be seen in Table A2D, the % hits figures improved from the previous round and are mostly above 70%. The only exception is the category of effort, which – despite some improvement from the previous round – still has 43% misplacements of its own items. One item was particularly problematic, causing seven of the 13 erroneous effort item placements: “I do not give up easily when I encounter a customer who is difficult to sell.” This item was placed seven times under performance effectiveness and only twice under effort. In post hoc conversations with some experts, they indeed confirmed that the “not giving up” aspect is ambiguous and
seems to indicate an evaluative element. To be more consistent with the intended meaning of the effort construct as a behavior reflecting the exertion of energy, the item was subsequently reworded to “Even when I encounter a customer who is difficult to sell, I do not spare any sweat.”

Additionally, there were 26% erroneous misplacements for the mindfulness items. Two items were responsible for 15 out of 23 such misplacements: “When performing my primary selling activities, I find myself ‘getting involved’ in almost everything I do” and “I feel that I avoid unconventional conversations about my primary selling activities.” Indeed, the terms “getting involved” and “unconventional conversations” do not precisely indicate the meaning of the items. Participants also confirmed in their comments that they found those items too ambiguous. Also, the former item did not perform well in prior research (Haigh et al. 2010). Those items were subsequently removed, without affecting the dimensionality of the mindfulness construct.

Finally, the % hits figures improved significantly for the two performance dimensions over the previous round. However, one item in the efficiency category performed poorly in both rounds albeit improving in the second round from 70% misplacement under effort to 30% misplacement. This item was vaguely worded as “Proportion of time spent in direct contact with prospect customers.” It was modified to “Proportion of sales time spent in direct contact with prospect customers.”

**Round 2 Analysis by Columns**

As shown in Table 2D, the % received figures also improved from the previous round and are mostly above 70%. However, the category of effort – while now accepting less erroneous
item placements (e.g., 11 misplacements from mindfulness and performance items as opposed to 39 in the first round) – still has 65% erroneous item placements from other categories. Over half of such misplacements (in fact 17) come from items in the subjective workload category alone. Indeed, some experts wrote in their comments that they often had a hard time deciding whether to place some items under effort or subjective workload. Two subjective workload items were particularly confusing to participants, having caused 10 misplacements under effort: “I feel that much mental activity is required to perform my activities (e.g., thinking; deciding; remembering; searching)” and “I feel that I have to work frantically to keep up.” Although the conceptual definition of subjective workload taps into the amount of energy that an individual feels is required to perform a task while effort reflects the amount of energy actually allocated to the task, this distinction seems to have been overlooked for those two items. We thus dropped those two items from the subsequent analysis.

However, this left the subjective workload scale with a single item for the “temporal demand” dimension. To avoid this, another item that had been removed from the first round came back, but after modification. The old item (“I feel that the pace of my activities is very slow”) had been removed because its wording seemed to capture the perception about the efficiency of performing the task itself (indeed, it had 50% misplacement under efficiency). Hence, it was reworded to “I feel that the pace required to do my activities is very slow” in order to capture the perception of the temporal demand of the task.

Overall, the hit ratio improved in round 2 to 83% from 78% in the first round.
APPENDIX 3: PRE-TESTING AND PILOT-TESTING THE SURVEY INTRUMENT

The pre-testing and pilot-testing analyses resulted in several changes to the survey items, guidelines, and flow (see Table A3A for an illustration of the old and revised formats). Below is a bullet-point summary of the major changes that were made.

Email Interruption Frequency

- The time anchor was changed from “a typical day” to “the past workweek” since (1) not all sales activities are done homogeneously on a typical day, and (2) setting a specific reference period improves the accuracy of recall (see Table A3A).

- Response scale was changed from Likert-type to ratio scale to allow a more precise response and avoid over-estimation. The new scale allows a mathematical validation of the response (frequency x duration) so that respondents can go back and adjust their answers.

- The new data entry format for the various interruption estimates reduces cognitive demand because in the old format respondents had to recall and enter 14 interruption estimates into a single frequency Table (7 activities x 2 types of email). In the revised format, they only have to make entries based on the actual activities they reported over the past week, which are piped from their previous answers (hence, a maximum of seven entries if they performed all activities over the past workweek + two entries for interruption types).

- In the old format, some respondents were confused about the categories of the primary selling activities listed in the frequency Table, thinking that these items referred to the content of the interrupting email rather than the primary selling activity that is interrupted by email. This is avoided in the revised format since there is a separate question that asks about...
the primary selling activities performed over the previous week, and answers are piped into the interruptions questions.

- In the old format, respondents seemed not to differentiate between interruptions from Type 1 and Type 2 emails (they just copied their answers into both sides of the frequency Table). The new format forces respondents to explicitly distinguish between the two types. It first defines the two types clearly and then asks respondents to allocate their total estimated interruption time (reported earlier) between the two email types.

- In the old format, several respondents wrongly reported their number of emails handled rather than the number of email interruptions (this despite the question guidelines that seem to have been overlooked). The qualitative interviews revealed that they automatically thought about the number of emails, and that the distinction should be made more explicit. In the new format, respondents are forced to explicitly differentiate between the two since they are first asked about the number of emails received, and then this is followed up directly with a question about the number of email interruptions.

- Overall, the new format is more readable and flows better.

**Email Interruption Duration**

- The question in the old format was confusing and too long (this was echoed by both some card-sorting judges and sales professionals in the pre-test). In the new format, the question is clearer and more concise (see Table A3A).

- Similar to the interruption frequency question, the scale for the interruption duration questions was changed to a ratio scale in the revised format.
In the old format, respondents seemed not to differentiate between interruptions from Type 1 and Type 2 emails (they just copied their answers into both sides of the frequency Table). The new format forces respondents to explicitly distinguish between the two types by asking whether or not the duration is similar for the two types (if No is selected, a new question pops up requesting respondents to make two separate entries for the duration).

**Screening Questions**

In the old format (see Table A3A), one of the screening questions asked whether or not respondents had any sales responsibilities. However, it was pointed out during the pre-test that some individuals may have very few sales responsibilities as part of their overall responsibilities. Hence, the question was made more precise by asking “Within your current job role(s), how often are you involved in sales activities?” (1. Never – 5. Quite often).

**Salesperson Performance**

The guidelines for this question were perceived as complex by participants. We simplified them by asking directly what was required from respondents. Then, in the brackets they were given pointers to consider when answering the question (see Table A3A).

The item “Managing time in my primary selling activities” caused confusion for participants (this item was also a bit problematic in the card-sorting analysis, with 40% misplacement in round 2). It was changed to “Managing time well across my different primary selling activities” to make it more precise and reflect the evaluative component.

Several participants were confused with the order of the performance questions. They suggested that to make better sense, they should be ordered with respect to the primary
selling activities performed (i.e., first present questions related to prospecting, then questions on interacting with prospects, etc.). This was taken into account in the new format.

**Perceived Control**

- Several respondents found the term “job conditions” ambiguous in “Due to my job conditions, I often have no choice but to suspend my tasks to handle incoming email messages.” This was changed to: “Due to the nature of my job, I often have no choice but to suspend my tasks to handle incoming email messages.”
Email Interruptions and Task Performance

Table A3A: Changes Resulting from Pre-Testing Analysis

<table>
<thead>
<tr>
<th>Email interruption frequency</th>
<th>Revised format</th>
</tr>
</thead>
<tbody>
<tr>
<td>On a typical day, how many times – on average – do you suspend your primary selling activities (shown below in rows) in order to handle (read, respond to, and/or act upon) the following types of incoming emails (shown below in columns)? Do not report the number of emails.</td>
<td>Email interruption frequency For the next set of questions, think of your past workweek. We will ask about the temporary suspensions to your primary selling activities caused by incoming emails. By primary selling activities, we mean all activities relating to the generation of new sales.</td>
</tr>
<tr>
<td>Primary selling activity:</td>
<td>Old format</td>
</tr>
<tr>
<td>Number of times per day you temporarily suspend the activity to handle incoming emails containing information, feedback, questions, discussions, or calls for action that are…</td>
<td>Email interruption frequency Please indicate which of the following primary selling activities you performed over the past workweek (Choose all that apply).</td>
</tr>
<tr>
<td>…directly pertinent to performing your primary selling activities</td>
<td>☐ Prospecting customers</td>
</tr>
<tr>
<td>…related to other selling activities (e.g., servicing accounts; working on orders), or activities outside of the sales domain (e.g., general work; personal/social activities)</td>
<td>☐ Interacting with prospect customers</td>
</tr>
<tr>
<td>Prospecting customers</td>
<td>☐ Preparing sales presentations and materials</td>
</tr>
<tr>
<td>Interacting with prospect customers</td>
<td>☐ Delivering sales presentations and materials</td>
</tr>
<tr>
<td>Preparing sales presentations and materials</td>
<td></td>
</tr>
<tr>
<td>Making sales presentations</td>
<td></td>
</tr>
<tr>
<td>Overcoming prospect customer obstacles</td>
<td></td>
</tr>
<tr>
<td>Closing the sale</td>
<td></td>
</tr>
<tr>
<td>Other activities related to generating new sales</td>
<td></td>
</tr>
</tbody>
</table>

| How many emails did you receive over the past workweek? Please consider all incoming emails containing information, feedback, questions, discussions, or calls for action. | |
| How many times did you temporarily suspend your primary selling activities to handle the incoming emails? By handling emails, we mean reading, responding to, or acting upon the incoming emails. | |
| From the 54 suspensions of your primary selling activities, how many times was each activity below suspended? (Total must be 54) | |
| Prospecting customers | 0 suspensions |
| Interacting with prospect customers | 0 suspensions |
| Preparing sales presentations and materials | 0 suspensions |
| Total | suspensions |

| How many of the 54 temporary suspensions were caused by primary emails vs. secondary emails? (Total must be 54) | |
| 1) Primary emails: Emails that are directly pertinent to performing your primary selling activities (e.g., information about prospect customer needs; | |
| | 0 suspensions |
Email Interruptions and Task Performance

**Email interruption duration**

For the primary selling activities listed above:

How many minutes is a given activity suspended each time to handle incoming emails?

<table>
<thead>
<tr>
<th>… directly pertinent to performing your primary selling activities</th>
<th>… related to other selling activities (e.g., servicing accounts; working on orders), or activities outside of the sales domain (e.g., general work; personal/social activities)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1-2</td>
</tr>
<tr>
<td>3-4</td>
<td>5-6</td>
</tr>
<tr>
<td>7-8</td>
<td>9-10</td>
</tr>
<tr>
<td>11+</td>
<td>0</td>
</tr>
<tr>
<td>1-2</td>
<td>3-4</td>
</tr>
<tr>
<td>5-6</td>
<td>7-8</td>
</tr>
<tr>
<td>9-10</td>
<td>11+</td>
</tr>
</tbody>
</table>

How many minutes are spent each time you suspend a given activity to handle incoming emails containing information, feedback, questions, discussions, or calls for action that are…

**Email interruption duration**

Over the past workweek, what has been the average duration of a single typical suspension of your primary selling activities so as to handle incoming emails?

________ minutes (per suspension)

You previously indicated that over the past workweek the average duration of a typical suspension of your primary selling activities has been 6 minutes. Has the duration been similar for handling primary emails vs. secondary emails?

☐ Yes - similar suspension durations for handling primary vs. secondary emails

☐ No - different suspension durations for handling primary vs. secondary emails

[If previous question was answered with No]

**What has been the duration of a typical suspension** of your primary selling activities to handle primary emails vs. secondary emails?

Duration of a typical suspension to handle primary emails: __________ minutes

Duration of a typical suspension to handle secondary emails: __________ minutes

**Screening question**

Within your current job role(s), do you currently have any sales responsibilities? (Yes/No)

**Salesperson performance (guidelines)**

The questions below refer to your performance in your primary selling activities in the current sales cycle. Please rate your current level of performance on the following items by evaluating how well you perform in that area compared with an average salesperson in similar selling situations.

**Salesperson performance (guidelines)**

Please evaluate how well you perform on each of the following criteria compared to an average salesperson in similar selling situations. (Consider your current sales cycle when answering. Take into account that your activities are subject to temporary suspensions from primary emails and secondary emails).

**Salesperson performance (Efficiency)**

Managing time in my primary selling activities

**Perceived control**

Due to my job conditions, I often have no choice but to suspend my tasks to handle incoming email messages.

**Screening question**

Within your current job role(s), how often are you involved in sales activities? (1. Never – 5. Quite often)

**Salesperson performance (Efficiency)**

Managing time well across my different primary selling activities

**Perceived control**

Due to the nature of my job, I often have no choice but to suspend my tasks to handle incoming email messages.
APPENDIX 4: THE WEB-BASED SURVEY

Dear Participant,

Thank you for your interest in this survey. You are about to take part in an academic research project on the use of email by sales professionals.

To ensure that your profile fits with our target sample, please answer the following questions:

(1) Within your current job role(s), how often are you involved in sales activities?

- Never
- Rarely
- Sometimes
- Quite Often
- Very Often

next >>
(2) To which of the following segments do you sell your products/services? (Please select all that apply)

- Business entities (B2B)
- Consumers (non-business - B2C)
- Government, Education, Non-profits
- Other (Please specify)

(3) Approximately how long is the time between generating a lead and closing the sale for the products/services you sell?

Note: By closing the sale, we mean that the prospect customer has agreed to purchase the product/service.

- Less than 1 month
- Between 1 and 2 months
- Between 2 and 3 months
- Between 3 and 6 months
- Between 6 and 12 months
- More than 12 months
(4) In which of the following sales activities do you use email? (Please select all that apply)

- [ ] Prospecting customers
- [ ] Overcoming prospect customer objections/obstacles
- [ ] Interacting with prospect customers
- [ ] Closing the sale
- [ ] Preparing sales presentations and materials
- [ ] None of the above
- [ ] Delivering sales presentations and materials

You are about to begin a 15-minute survey on the use of email by sales professionals and the impacts of incoming emails on selling activities and outcomes. Taking the survey is entirely voluntary and you may exit it at any time. Your answers are completely confidential.

Click here for more information on this research (optional).

Our sincere thanks for your valuable participation!

By clicking "next", I certify that I have read this message and volunteer to participate in this survey.
### Part I: Perceptions and Behaviors relating to Email Use

In this section, you will be asked questions that relate to how you use email as a sales professional in your organization.

---

The statements below tap into your perceptions about handling (reading, responding to, and/or acting upon) incoming email. Please rate your level of agreement/disagreement with each statement:

<table>
<thead>
<tr>
<th>Perception</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Somewhat Agree nor Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I find it easy to ignore my incoming email messages if I choose to do so.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I feel that I have personal control over when to deal with my incoming email messages.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I conform to peer pressures in accepting or declining to handle my incoming email messages.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The fears of falling behind or missing something important compel me to deal with my incoming email messages right away.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I conform to social expectations of addressing my incoming email messages right away.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Due to the nature of my job, I often have no choice but to suspend my tasks to handle incoming email messages.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
For the next set of questions, think of your past workweek. We will ask about the temporary suspensions to your primary selling activities caused by incoming emails. By primary selling activities, we mean all activities relating to the generation of new sales.

First, how many hours did you work over the past workweek?

___ hours

Now indicate which of the following primary selling activities you performed over the past workweek (Choose all that apply).

- [ ] Prospecting customers
- [ ] Interacting with prospect customers
- [ ] Overcoming prospect customer objections/ obstacles
- [ ] Closing the sale
- [ ] Preparing sales presentations and materials
- [ ] Delivering sales presentations and materials
- [ ] Other (please specify): __________

How many emails did you receive over the past workweek? Please consider all incoming emails containing information, feedback, questions, discussions, or calls for action.

___ emails

Over the past workweek, how many times did you temporarily suspend your primary selling activities to handle the incoming emails? By handling emails, we mean reading, responding, or acting upon the incoming emails.

___ suspensions

Over the past workweek, what has been the average duration of a single typical suspension of your primary selling activities so as to handle incoming emails?

___ minutes (per suspension)
Based on your estimates, the total duration of suspending your primary selling activities to handle incoming emails has been 192 minutes (3.2 hours) over the past workweek. Does this seem about right? If you click No, you will have the opportunity to adjust the values in the previous questions.

- Yes
- No

<table>
<thead>
<tr>
<th>Activity</th>
<th>Suspensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prospecting customers</td>
<td>0</td>
</tr>
<tr>
<td>Preparing sales presentations and materials</td>
<td>0</td>
</tr>
<tr>
<td>Overcoming prospect customer objections/obstacles</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

From the 32 suspensions of your primary selling activities, how many times was each activity below suspended? (Total must be 32)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Suspensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prospecting customers</td>
<td>0</td>
</tr>
<tr>
<td>Preparing sales presentations and materials</td>
<td>0</td>
</tr>
<tr>
<td>Overcoming prospect customer objections/obstacles</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

How many of the 32 temporary suspensions were caused by primary emails vs. secondary emails? (Total must be 32)

1) **Primary emails**: Emails that are directly pertinent to performing your primary selling activities (e.g., information about prospect customer needs; feedback about your selling performance).

2) **Secondary emails**: Emails that are related to secondary selling activities (e.g., servicing accounts; training/recruiting), or activities outside of the sales domain (e.g., general work; personal/social activities).

<table>
<thead>
<tr>
<th>Activity</th>
<th>Suspensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary emails</td>
<td>0</td>
</tr>
<tr>
<td>Secondary emails</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>
You previously indicated that over the past workweek the **average duration of a typical suspension** of your primary selling activities has been **6 minutes**. Has the duration been similar for handling primary emails vs. secondary emails?

- Yes - **similar** suspension durations for handling primary vs. secondary emails
- No - **different** suspension durations for handling primary vs. secondary emails

---

**What has been the duration of a typical suspension** of your primary selling activities to handle primary emails vs. secondary emails?

**Duration of a typical suspension to handle primary emails:** __________ minutes

**Duration of a typical suspension to handle secondary emails:** __________ minutes

Do you consider your past workweek to be typical of the number of hours you usually work in a week, the number of emails you receive, and the frequency and duration of suspensions from incoming emails?

- Yes
- No
Thinking of your past workweek, please select the pattern which you feel best describes how your task suspensions were distributed throughout the day.

<table>
<thead>
<tr>
<th>pattern</th>
<th>distributed evenly throughout the day</th>
<th>to occur at any time in the day (scattered randomly)</th>
<th>scattered throughout the day with some concentrations at particular periods</th>
<th>concentrated in a few blocks of time in the day</th>
<th>concentrated in one block of time in the day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspensions from primary emails seemed...</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Suspensions from secondary emails seemed...</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

Given the number of times you suspended your primary selling activities over the past workweek, please indicate your perception of the time elapsed between one suspension and the next.

<table>
<thead>
<tr>
<th>perception of the time elapsed between one suspension and the next</th>
<th>... very short</th>
<th>... short</th>
<th>... of average length</th>
<th>... long</th>
<th>... very long</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel that the time elapsed between suspensions from primary emails has typically been...</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>I feel that the time elapsed between suspensions from secondary emails has typically been...</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
Email Interruptions and Task Performance

Now we focus on some practices you might do prior to suspending your primary selling activities, and/or while the activities are suspended. How frequently do you do the following?

<table>
<thead>
<tr>
<th>Practice</th>
<th>Never</th>
<th>Almost Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Frequently</th>
<th>Almost Always</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>I review the content of my current or intended task activity before I suspend it.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I use tools that remind me of what I was doing or about to do (e.g., use CRM; take notes).</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I glance back at the content of my suspended task.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I take a mental snapshot of my task environment before I suspend the task.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For computer-based tasks, I keep my task window open during its suspension.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Part II: Outcomes relating to Primary Selling Activities

In this section, you will be asked questions that relate to the outcomes of your primary selling activities. Remember, the responses you provide are strictly confidential and will be used only for research purposes.
Please evaluate **how well you perform** on each of the following criteria compared to an average salesperson in similar selling situations.

**Notes:**
- Consider your current sales cycle when answering.
- Take into account that your activities are subject to temporary suspensions from primary emails and secondary emails.

<table>
<thead>
<tr>
<th>Timeliness in prospecting for potential customers.</th>
<th>Much Slower</th>
<th>Slower</th>
<th>Somewhat Slower</th>
<th>About the Same</th>
<th>Somewhat Faster</th>
<th>Faster</th>
<th>Much Faster</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency in delivering sales presentations or materials.</td>
<td>Much Lower</td>
<td>Lower</td>
<td>Somewhat Lower</td>
<td>About the Same</td>
<td>Somewhat Higher</td>
<td>Higher</td>
<td>Much Higher</td>
</tr>
<tr>
<td>Managing time well across the primary selling activities.</td>
<td>Much Worse</td>
<td>Worse</td>
<td>Somewhat Worse</td>
<td>About the Same</td>
<td>Somewhat Better</td>
<td>Better</td>
<td>Much Better</td>
</tr>
<tr>
<td>Timeliness in providing information to prospect customers.</td>
<td>Much Slower</td>
<td>Slower</td>
<td>Somewhat Slower</td>
<td>About the Same</td>
<td>Somewhat Faster</td>
<td>Faster</td>
<td>Much Faster</td>
</tr>
<tr>
<td>Speed of identifying and solving prospect customer issues.</td>
<td>Much Slower</td>
<td>Slower</td>
<td>Somewhat Slower</td>
<td>About the Same</td>
<td>Somewhat Faster</td>
<td>Faster</td>
<td>Much Faster</td>
</tr>
<tr>
<td>Speed of generating sales from prospect customers.</td>
<td>Much Slower</td>
<td>Slower</td>
<td>Somewhat Slower</td>
<td>About the Same</td>
<td>Somewhat Faster</td>
<td>Faster</td>
<td>Much Faster</td>
</tr>
</tbody>
</table>
Please evaluate **how well you perform** on each of the following criteria compared to an average salesperson in similar selling situations.

**Notes:**
- Consider your current sales cycle when answering.
- Take into account that your activities are subject to temporary suspensions from *primary emails* and *secondary emails*.

<table>
<thead>
<tr>
<th>Listening attentively to prospect customer needs or issues.</th>
<th>Much Worse</th>
<th>Worse</th>
<th>Somewhat Worse</th>
<th>About the Same</th>
<th>Somewhat Better</th>
<th>Better</th>
<th>Much Better</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identifying and understanding the real concerns of prospect customers.</td>
<td>Much Worse</td>
<td>Worse</td>
<td>Somewhat Worse</td>
<td>About the Same</td>
<td>Somewhat Better</td>
<td>Better</td>
<td>Much Better</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interacting effectively with prospect customers.</td>
<td>Much Worse</td>
<td>Worse</td>
<td>Somewhat Worse</td>
<td>About the Same</td>
<td>Somewhat Better</td>
<td>Better</td>
<td>Much Better</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avoiding mistakes in sales presentations or materials.</td>
<td>Much Worse</td>
<td>Worse</td>
<td>Somewhat Worse</td>
<td>About the Same</td>
<td>Somewhat Better</td>
<td>Better</td>
<td>Much Better</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communicating my sales presentations clearly and concisely.</td>
<td>Much Worse</td>
<td>Worse</td>
<td>Somewhat Worse</td>
<td>About the Same</td>
<td>Somewhat Better</td>
<td>Better</td>
<td>Much Better</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solving prospect customers’ problems or objections.</td>
<td>Much Worse</td>
<td>Worse</td>
<td>Somewhat Worse</td>
<td>About the Same</td>
<td>Somewhat Better</td>
<td>Better</td>
<td>Much Better</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accuracy in matching prospect customer requirements with available product offerings.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Accuracy in matching prospect customer requirements with available product offerings.

<table>
<thead>
<tr>
<th>Much Lower</th>
<th>Lower</th>
<th>Somewhat Lower</th>
<th>About the Same</th>
<th>Somewhat Higher</th>
<th>Higher</th>
<th>Much Higher</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Circle" /></td>
<td><img src="image2" alt="Circle" /></td>
<td><img src="image3" alt="Circle" /></td>
<td><img src="image4" alt="Circle" /></td>
<td><img src="image5" alt="Circle" /></td>
<td><img src="image6" alt="Circle" /></td>
<td><img src="image7" alt="Circle" /></td>
</tr>
</tbody>
</table>

### Developing new customers from established contacts.

<table>
<thead>
<tr>
<th>Much Worse</th>
<th>Worse</th>
<th>Somewhat Worse</th>
<th>About the Same</th>
<th>Somewhat Better</th>
<th>Better</th>
<th>Much Better</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image8" alt="Circle" /></td>
<td><img src="image9" alt="Circle" /></td>
<td><img src="image10" alt="Circle" /></td>
<td><img src="image11" alt="Circle" /></td>
<td><img src="image12" alt="Circle" /></td>
<td><img src="image13" alt="Circle" /></td>
<td><img src="image14" alt="Circle" /></td>
</tr>
</tbody>
</table>

### Remembering significant details about the primary selling activities.

<table>
<thead>
<tr>
<th>Much Worse</th>
<th>Worse</th>
<th>Somewhat Worse</th>
<th>About the Same</th>
<th>Somewhat Better</th>
<th>Better</th>
<th>Much Better</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image15" alt="Circle" /></td>
<td><img src="image16" alt="Circle" /></td>
<td><img src="image17" alt="Circle" /></td>
<td><img src="image18" alt="Circle" /></td>
<td><img src="image19" alt="Circle" /></td>
<td><img src="image20" alt="Circle" /></td>
<td><img src="image21" alt="Circle" /></td>
</tr>
</tbody>
</table>

### Distractedness from performing the primary selling activities.

<table>
<thead>
<tr>
<th>Much Lower</th>
<th>Lower</th>
<th>Somewhat Lower</th>
<th>About the Same</th>
<th>Somewhat Higher</th>
<th>Higher</th>
<th>Much Higher</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image22" alt="Circle" /></td>
<td><img src="image23" alt="Circle" /></td>
<td><img src="image24" alt="Circle" /></td>
<td><img src="image25" alt="Circle" /></td>
<td><img src="image26" alt="Circle" /></td>
<td><img src="image27" alt="Circle" /></td>
<td><img src="image28" alt="Circle" /></td>
</tr>
</tbody>
</table>
From your total dollar sales in the current sales cycle, what is the percentage of sales from new accounts?

<table>
<thead>
<tr>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

% of sales from new accounts

What is your prospect conversion rate in the current sales cycle?

<table>
<thead>
<tr>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

Prospect conversion rate

What proportion of your sales time do you spend in direct contact with prospect customers (e.g., face-to-face; phone; email; etc.)?

<table>
<thead>
<tr>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

Proportion of sales time spent in direct contact with prospect customers
Part III: Behaviors relating to Primary Selling Activities

In this section, you will be asked questions that relate to your behaviors in the primary selling activities.

Please rate your level of agreement/disagreement with each of the following statements.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Agree nor Somewhat Disagree</th>
<th>Somewhat Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I work unstiringly at selling the product/service to customers.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Even when I encounter a customer who is difficult to sell, I do not spare any sweat.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>I vary my selling approach from situation to situation.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>I tend to work without spending too much energy on planning.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
Part IV: Feeling, Thoughts & Perceptions relating to Primary Selling Activities

In this section, you will be asked questions that relate to your feelings, thoughts, and perceptions about your primary selling activities.
The following statements evaluate your state of mind after handling the primary emails and secondary emails that temporarily suspend your primary selling activities.

After handling the incoming emails that temporarily suspend my activities...

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Somewhat Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>...I tend to investigate new issues that emerge in my primary selling activities.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>...I try to think of new ways of doing my primary selling activities.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>...I become open to new ways of doing my primary selling activities.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>...I develop an open-mind about the issues I face, even things that challenge my core beliefs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>...I find myself very curious about issues that I face.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>...I find myself generating few novel ideas.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>...I rarely attend to new developments in my primary selling activities.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>...I do my primary selling activities automatically, without being aware of what I'm doing.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
How do you feel about having to handle the suspensions from incoming emails in addition to performing your primary sales activities?

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Somewhat Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel annoyed.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I feel relieved.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I feel frustrated.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I feel energized.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I feel that my workload is substantial.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I feel stressed.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I feel that the pace required to do my activities is very slow.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I feel fatigued.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>The rate at which my activities occur makes me feel pressured.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I feel that my activities impose few mental demands.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

For quality control purposes, please select answer C below.

- ○ A) Never
- ○ B) Sometimes
- ○ C) Please select this option
- ○ D) Always
Please rate your level of agreement/disagreement with each of the following statements about juggling activities.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Somewhat Agree</th>
<th>Neither Agree nor Disagree</th>
<th>Somewhat Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I believe I can succeed in a job where I constantly shift from one task to another.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have to finish one task completely before being able to focus on anything else.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>When doing a number of assignments, I have the ability to switch back and forth between them without losing the flow.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I believe I have the ability to reengage in the task quickly after being interrupted by another event.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In general, I think I perform <em>poorly</em> when I have to shift my attention between multiple tasks.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Please rate your level of agreement/disagreement with each of the following statements about juggling activities.*

<table>
<thead>
<tr>
<th>Rating</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Somewhat Agree</th>
<th>Neither Agree nor Disagree</th>
<th>Somewhat Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Please rate your level of agreement/disagreement with each of the following statements about your level of expertise.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Somewhat Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I know all the specifications and applications of our products.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I can be considered an expert on my company’s technical procedures.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I am an excellent resource of competitive information.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I have a lot of information on industry trends.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I have rich knowledge of strategies for handling different customer types.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

next >>
Please rate your level of agreement/disagreement with each of the following statements about the nature of your primary selling activities.

When performing my primary selling activities...

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Somewhat Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>...a large number of methods and procedures is required.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>...there is a great extent of variety with respect to one or more of the</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>following: (1) situations, (2) people, or (3) tasks.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>...there is an identifiable sequence of steps that can be followed.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>...the required rules and procedures are rarely subject to change.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Part V: Demographic Questions

We would like you to answer the following demographic questions. Your answers will help us provide a context within which we can interpret the different survey responses.

### What is your sales experience?

<table>
<thead>
<tr>
<th>Whole years</th>
<th>Additional months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Years and months of total sales experience (incl. current and previous organizations):

- Years and months spent at the current organization:

- Years and months spent in current sales position at the organization:

### Please select your age group:

- ☐ <20
- ☐ 20-29
- ☐ 30-39
- ☐ 40-49
- ☐ 50-59
- ☐ 60+

### What is your gender?

- ☐ Female
- ☐ Male

### What is the highest degree you earned?

- ☐ High School Degree
- ☐ Collegial/ Technical Degree
- ☐ Bachelor Degree
- ☐ Master Degree
- ☐ PhD Degree
Concluding Questions

Please answer these final questions if you would like to receive a copy of the research results.

Would you like to obtain a copy of the research results after the data analysis is completed?

- Yes
- No

Optional: General comments about this survey / this research:

Submit
APPENDIX 5: SAMPLE CHARACTERISTICS

Figure 5A: Sample Distribution by Industry
Addas (Essay #2)

Email Interruptions and Task Performance

Figure 5B: Sample Distribution by Job Type

Figure 5C: Sample Distribution by Age
Figure 5D: Sample Distribution by Gender

Figure 5E: Sample Distribution by Education
### APPENDIX 6: HARMAN’S SINGLE-FACTOR TEST

**Extracted Factors in Harman’s One-Factor Test**

<table>
<thead>
<tr>
<th>Component</th>
<th>Initial Eigenvalues</th>
<th>Extraction Sums of Squared Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Variance Explained</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% of Variance</td>
<td>Cumulative %</td>
</tr>
<tr>
<td>2</td>
<td>3,649</td>
<td>11,057</td>
</tr>
<tr>
<td>3</td>
<td>2,485</td>
<td>7,530</td>
</tr>
<tr>
<td>4</td>
<td>1,997</td>
<td>6,052</td>
</tr>
<tr>
<td>5</td>
<td>1,557</td>
<td>4,719</td>
</tr>
<tr>
<td>6</td>
<td>1,468</td>
<td>4,448</td>
</tr>
<tr>
<td>7</td>
<td>1,326</td>
<td>4,018</td>
</tr>
<tr>
<td>8</td>
<td>1,022</td>
<td>3,096</td>
</tr>
<tr>
<td>9</td>
<td>.935</td>
<td>2,833</td>
</tr>
<tr>
<td>10</td>
<td>.879</td>
<td>2,664</td>
</tr>
<tr>
<td>11</td>
<td>.815</td>
<td>2,470</td>
</tr>
<tr>
<td>12</td>
<td>.765</td>
<td>2,317</td>
</tr>
<tr>
<td>13</td>
<td>.733</td>
<td>2,220</td>
</tr>
<tr>
<td>14</td>
<td>.676</td>
<td>2,048</td>
</tr>
<tr>
<td>15</td>
<td>.631</td>
<td>1,913</td>
</tr>
<tr>
<td>16</td>
<td>.603</td>
<td>1,828</td>
</tr>
<tr>
<td>17</td>
<td>.575</td>
<td>1,742</td>
</tr>
<tr>
<td>18</td>
<td>.521</td>
<td>1,577</td>
</tr>
<tr>
<td>19</td>
<td>.501</td>
<td>1,519</td>
</tr>
<tr>
<td>20</td>
<td>.494</td>
<td>1,498</td>
</tr>
<tr>
<td>21</td>
<td>.451</td>
<td>1,367</td>
</tr>
<tr>
<td>22</td>
<td>.417</td>
<td>1,265</td>
</tr>
<tr>
<td>23</td>
<td>.409</td>
<td>1,240</td>
</tr>
<tr>
<td>24</td>
<td>.404</td>
<td>1,224</td>
</tr>
<tr>
<td>25</td>
<td>.376</td>
<td>1,140</td>
</tr>
<tr>
<td>26</td>
<td>.342</td>
<td>1,037</td>
</tr>
<tr>
<td>27</td>
<td>.328</td>
<td>.994</td>
</tr>
<tr>
<td>28</td>
<td>.296</td>
<td>.896</td>
</tr>
<tr>
<td>29</td>
<td>.268</td>
<td>.813</td>
</tr>
<tr>
<td>30</td>
<td>.255</td>
<td>.772</td>
</tr>
<tr>
<td>31</td>
<td>.194</td>
<td>.587</td>
</tr>
<tr>
<td>32</td>
<td>.188</td>
<td>.568</td>
</tr>
<tr>
<td>33</td>
<td>.079</td>
<td>.239</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis.
CHAPTER IV (ESSAY #3). IT INTERRUPTIONS AND COORDINATION EFFECTIVENESS IN SOFTWARE DEVELOPMENT GROUPS: A CONCEPTUAL, MULTILEVEL MODEL

ABSTRACT

Research is abundant on how the processes of interdependent groups such as software development groups are enhanced by using information technology (IT). However, the unintended effects of interruptions triggered by such IT on group processes and outcomes are rarely examined. In particular, the research on IT interruptions has remained almost exclusively at the individual level. This paper develops a conceptual, multilevel model that focuses on these under-examined paths linking individually experienced IT interruptions to group coordination outcomes. Drawing upon coordination theory and the literature on work interruptions, we propose that different types of IT interruptions (intrusions and interventions) exhibit different effects. On one hand, IT intrusions create resource constraints that emerge to the group level via interdependencies and debilitate group coordination effectiveness. To mitigate such detrimental effects, the group engages in coordination by task organization. On the other hand, IT interventions facilitate coordination by group problem solving (a cross-level effect), which enhances group coordination effectiveness. These effects are moderated by perceived quality and perceived intervention level. This research extends the IT interruptions literature by focusing on the multilevel effects of such interruptions. Moreover, it extends the IT impacts literature by unearthing the unintended positive and negative effects of IT via interruptions of group members’ work.

INTRODUCTION & MOTIVATION

Software development issues continue to capture the attention of scholars and practitioners. According to the 2011 Chaos Report by the Standish Group,³¹ about two thirds of software development projects in the past decade were either downright failures or were at best challenged; i.e., with schedule or cost overruns, or shortfalls in the requested functionality. In a $630 billion industry such as the software development industry (Guevara et al. 2011), it becomes pivotal to understand the factors that enhance and inhibit software development performance.

To explain this high failure rate, several approaches have been used in the information systems (IS) literature. Extant research has focused on different factors driving software development performance including psychological states such as user involvement (Hartwick & Barki 1994; Hunton & Beeler 1997), technical factors such as innovative tools and methodologies (Henderson & Clark 1990; Nambisan & Wilemon 2000), and contextual factors such as risk management (Barki et al. 1993; Barki et al. 2001). One very important approach – inspired from group theory (Marks et al. 2001; Mathieu et al. 2008) – is the focus on team processes such as the process of coordinating the software team’s resources and activities (Crowston 1997; Faraj & Sproull 2000). The main premise of this approach is that team processes such as coordination enhance performance by transforming inputs into group outcomes (LePine et al. 2008; Marks et al. 2001). Indeed, coordination has been identified as one of the most important team processes for improving group performance (LePine et al. 2008; Marks et al. 2001), especially when tasks are highly interdependent (Mathieu et al. 2008), such as in software development. In this particular context of software development, enhanced group performance is also strongly tied to the performance of the overall software project in terms of efficiency (e.g., adherence to costs and schedules) and effectiveness (e.g., product quality) (Faraj & Sproull 2000; Pattit & Wilemon 2005; Sawyer 2001). Hence, group coordination may be key to explaining software development group performance.

To enhance the software team’s coordination outcomes, group members use a variety of information technology (IT) tools to communicate, collaborate, and manage their task activities (Faraj & Sproull 2000; Patnayakuni et al. 2007; Pavlou & El Sawy 2006). While such IT tools have indeed been shown to improve coordination effectiveness (e.g., Malhorta et al. 2001; Malone & Crowston 1994; Pavlou & El Sawy 2006; Yassine et al. 2004), a flip-side effect is that
such IT may also be responsible for interrupting the work of group members (Dabbish et al. 2007; Rennecker & Godwin 2005). Indeed, extant interruptions research indicates that software development groups are subject to frequent interruptions (Chong & Siino 2006; Perlow 1999). But despite these widespread interruptions caused by IT, very little knowledge exists about their effects at the group level. The overwhelming majority of research examines the effects of isolated interruptions at the individual level (e.g., Adamczyk & Bailey 2004; Avrahami et al. 2007; Cutrell et al. 2000; Speier et al. 1997). The empirical results in this line of research indicate that the impacts of such interruptions may vary from negative (e.g., Kapitsa & Blinnikova 2003; McFarlane 2002; Speier et al. 1997) to positive (e.g., Ang et al. 1993; Gluck et al. 2007; Robertson et al. 2004) depending on the type – and specifically the content relevancy – of the interruption. However, little is known about the group-level effects of such interruptions on the group’s coordination outcomes when tasks are interdependent and nested within larger projects (such as in software development).

In this paper, we ask the following question: What are the effects of IT interruptions on the software development group’s coordination effectiveness? Drawing upon coordination theory (Crowston 1997; Malone & Crowston 1994) and the literature on work interruptions (Jett & George 2003), we develop a conceptual, multilevel model of IT interruptions. Specifically, we propose that the effects of IT interruptions are experienced at the individual level but due to interdependencies between software group member activities, spill over to the group level (Ren et al. 2008). Such effects may be positive or negative, depending on the type of interruption. On one hand, some interruption types (directly related interventions such as feedback on task performance) may exhibit cross-level effects by leveraging opportunities for using coordination mechanisms that enhance the group’s communication and problem solving (Okhuysen &
Eisenhardt 2002; Zellmer-Bruhn 2003), which is beneficial for coordination effectiveness. On the other hand, some other interruption types (intrusions unrelated to the primary task activities) may create individual-level resource constraints (Crowston 1997; Ren et al. 2008) that emerge to the group level as a result of task interdependencies. Additional activities (coordination mechanisms) must then be performed to mitigate the negative effects of the intrusions on coordination effectiveness. In short, our theoretical propositions suggest that IT interruptions exhibit differential multilevel effects on group coordination effectiveness depending on the type of interruption and the coordination mechanism they leverage.

We chose to focus on group coordination effectiveness rather than overall group performance for two reasons. First, this allows us to focus the theoretical model around a limited set of concepts that are close to the concept of interruptions. Second, much of the software development literature has already examined the factors that lead to group performance (e.g., Andres & Zmud 2002; Faraj & Sproull 2000; Nidumolu 1995). In particular, it has been shown that group coordination effectiveness leads to improved group performance in software development (Andres & Zmud 2002; Espinosa et al. 2004; Kiesler et al. 2001; Kraut & Steeler 1995; Nidumolu 1995) and product development contexts (Ancona & Caldwell 1992; Chen 2007; Clark & Fujimoto 1991; Iansiti & Clark 1995; Montoya-Weiss & Calantone 1994; Sivadas & Dwyer 2000). Instead, we focus on the important group coordination processes and outcomes that are antecedent to group performance. This allows us to open the black box of the “mediating processes that explain why certain inputs affect team effectiveness” (Ilgen et al. 2005, p. 519).

The contributions of this research are threefold. First, the paper provides a complementary perspective to the literature on the impacts of IT on group coordination by focusing on the unintended IT impacts via interruptions to the group’s work. Second, this research informs
coordination theory by examining the coordination problems and solutions taking place in a context when the group’s work faces IT interruptions. The paper suggests that one type of interruption enhances coordination effectiveness by leveraging coordination mechanisms based on group problem solving. Conversely, a second type of interruption is detrimental to coordination effectiveness but its effect can be mitigated by employing coordination mechanisms based on task organization. Finally, while most extant research on interruptions has focused on individual (Beefink et al. 2008; France et al. 2005; Gong 2006; Madjar & Shalley 2008; Speier et al. 1997; Zijlstra et al. 1999) or dyadic outcomes (Dabbish & Kraut 2004; McFarlane 2002; Rennecker & Godwin 2005), this research is – to the author’s knowledge – the first to examine the multilevel impacts of IT interruptions on group coordination outcomes.

The remainder of this paper is structured as follows. The next section develops the notion of IT interruptions in a group context with help from the literature on IT interruptions. The following section provides an overview of coordination theory, which is subsequently used to explain the relationships between IT interruptions and coordination effectiveness. Then, the conceptual, multilevel model is presented and propositions are developed that relate IT interruptions to the coordination effectiveness of software groups. The paper concludes with the discussion and implications for future research.

**IT INTERRUPTIONS IN GROUPS**

**Conceptualization of IT Interruptions**

IT Interruptions are defined in this paper as *perceived, IT-based external events with a range of content that captures cognitive attention and breaks the continuity of an individual’s*
primary task activities (Addas & Pinsonneault 2010; Jett & George 2003). Primary activities are ongoing tasks that individuals perform as their primary responsibility when working on a given project. By IT-based, we mean that the interruptions are affected by IT in one of three ways: (1) induced by the lack of availability of the system’s resources; (2) delivered via communicational IT media; (3) triggered by the information produced by the IT. Hence, IT interruptions can be instigated by the system’s behavior or by human activity. First, interruptions may occur as a direct effect of the absence of IT resources such as system or network failures (e.g., France et al. 2005; Johansson & Aronsson 1984).

Second, communication and collaboration tools used by software development team members provide a platform that facilitates interruptive practices. For example, many of the interruptions facing software developers are caused by email (Iqbal & Horvitz 2007; van Solingen et al. 1998). Software developers typically interrupt their primary task activities and switch to processing such incoming email in as little as two seconds after arrival (Iqbal & Horvitz 2007).

Finally, interruptions may be triggered by the informational output created and disseminated by the technology. For example, software development group members produce, store, process, and share a huge amount of information when working on their projects (Lyytinen & Robey 1999). Examples of such information include data libraries, software bug tracking, status reports, product prototypes and documentation, project information and best practices, and collaborative discussions. Because of limited attentional resources, this triggers interruptions as individuals muddle through, make sense of, share, and extract value from this monumental pool of information (Eppler & Mengis 2004; Schultze & Vandenbosch 1998; Speier et al. 1999).
Types of IT Interruptions

We draw upon Jett and George’s (2003) taxonomy of work interruptions to define two main types of IT interruptions: intrusions and interventions. Intrusions refer to interruptions in which an individual working on the primary project’s activities is compelled to temporarily turn his or her attention away from such primary activities. This can occur when the content of the interruption is related to any activities in other projects, secondary activities in the current project (e.g., non-development activities in the case of intrusions directed at developers), general work (non-project) activities, personal/social issues, or when the interruption causes an idle state of work. As an example of intrusions, an individual whose primary task is to design a software module may have the task interrupted by an online meeting request to discuss corporate policy.

Alternately, interventions refer to interruptions in which an individual working on his or her primary activities within a project is targeted with events that are directly related to those primary activities. Such interventions fragment the individual’s ongoing work and motivate behavioral changes as a result of perceived discrepancies in task performance (Jett & George 2003). The interruptive aspect of interventions is that the perceived discrepancy leads to suspending the existing way of information processing and switching to a more reflective mode focusing on the source of the discrepancy (Jett & George 2003; Zellmer-Bruhn 2003). Unlike intrusions, interventions do not involve switching attention away from the primary activities. Rather, they redirect attention to the source of the problems within the primary activities. An email providing feedback to a software developer on his or her performance in the project is an example of such interventions. Such an email received by the individual may trigger discussions about the content of the feedback, areas of discrepancy, and how to close such performance gaps.
Hence, interventions may contain information that is "critical to the quality or completion of the [primary activities]" (Jett & George 2003). 32

**IT Interruptions for Individuals Working in Groups**

Traditionally, the extant literature on work interruptions (whether IT-based or not) has focused on single interruptive events for individual actors working on microscopic, isolated tasks of brief durations (e.g., Adamczyk & Bailey 2004; Avrahami et al. 2007; Cutrell et al. 2000; Speier et al. 1997). The empirical results in this line of research indicate that the impacts of such interruptions may depend on the type – and specifically the content relevancy – of the interruption. On one hand, non-relevant intrusions elicit negative emotional reactions (e.g., Bailey et al. 2001; Gievska et al. 2005), lead to losses in efficiency of both resuming and completing the interrupted tasks (e.g., Arroyo & Selker 2003; Bailey et al. 2000; Monk et al. 2004b), and debilitate performance effectiveness as a result of increased errors (e.g., Kapitsa & Blinnikova 2003; McFarlane 2002; Speier et al. 1997) and a reduced ability to remember interrupted task details (McDaniel et al. 2004; Oulasvirta & Saariluoma 2004). On the other hand, relevant interventions are generally beneficial for task performance (Ang et al. 1993; Robertson et al. 2004), despite incurring some cognitive and emotional costs such as stress (Szalma et al. 2006) and annoyance (Gluck et al. 2007).

32 Note that individuals can face interruptions that are related to other projects within their overall program or portfolio. These interruptions - while they may be considered related interventions at a program level - are considered intrusions from the point of view of the current project. By fixing the level of analysis to the current project, we can better examine the effects of interruptions on coordination effectiveness since the software development unit’s outcomes are typically tied to a given project (Espinosa et al. 2004; Faraj & Sproull 2000; Patnayakuni et al. 2007).
While these studies advance our understanding of the psychological and behavioral outcomes of interruptions at the individual level, they shed little light on the broader impacts that result when individuals work on interdependent tasks that are nested within larger projects. To conceptualize interruptions within this wider social context, it is necessary to consider aggregates of individual interruptive instances. Consistent with the notion that individual acts derive their meaning in groups when they are aggregated and situated in their contexts (McGrath 1991), we suggest that interruptions become meaningful for group members mostly in aggregate form. Single instances of interruptions are mostly ephemeral by nature and unlikely to be visible enough in a web of interrelated group interactions (Okhuysen & Eisenhardt 2002). Indeed, prior group research found that group members perceive interruptions as combinations and sequences of events rather than isolated instances of events (Okhuysen 2001; Okhuysen & Eisenhardt 2002). It is also important to note that since interruptions are considered here as events experienced by individuals, they may be interpreted differently when individuals work in a group context depending on the nature of the interruption target. However, we do not focus here on the divergent interpretations of different members in a group, but rather on the effects of such individual-level interruptions that propagate to the wider group context (multilevel effects).

We thus scanned the literature for studies where different types of interruptions are administered to individuals working in group contexts. The results are summarized in Table 1, which summarizes studies by the following criteria: authors, research objectives, interruption type (intrusion vs. intervention), methodology, level of relationship (single-level vs. cross-level), and main findings. Three key implications – discussed separately below – are drawn from the results:

33 For example, interrupting a developer with a task that is mostly relevant to the testing unit is considered an intrusion for the developer, but interrupting a testing specialist with the same task would be considered an intervention for the testing specialist.
(1) the outcomes of interruptions at the group level seem to depend on the type of interruptions; 
(2) there is a need to explicitly examine the multilevel nature of the effects of IT interruptions; (3) 
it is important to identify the task interdependencies to understand how the effects of individual-
level interruptions spill over to higher levels.

**Group-level Outcomes Depend on the Type of Interruptions**

The first implication is that, consistent with the results at the individual level, there also 
seem to be divergent outcomes of interruptions at the group level, depending on the type of 
interruption (intrusion vs. intervention). Intrusions seem to exhibit overall negative effects 
(Dabbish et al. 2007; Dabbish & Kraut 2004; Dabbish & Kraut 2008; Harr & Kaptelinin 2007). 
Harr & Kaptelinin (2007) presented – via hypothetical examples – four mechanisms by which 
such negative effects spill over from the individual level to the group level: location; 
communication; collaboration; interpersonal relation. Dabbish and colleagues focused on the 
optimal use of awareness systems as a coordination mechanism to administer the intrusions at 
opportune moments, which was found to increase response likelihood and speed (Dabbish et al. 
2007), and mitigate the adverse performance effects in the team condition (Dabbish et al. 2007; 
Dabbish & Kraut 2004; Dabbish & Kraut 2008).

Conversely, interventions are predominantly positive at the group level (Hazlehurst 2003; 
Matsui et al. 1987; Okhuysen & Eisenhardt 2002). As shown in Table 1, results from various 
group contexts – such as cockpit crews (Hazlehurst 2003), electronic brainstorming groups 
(Jessup & Connolly 1993), and experimental groups assigned problem-solving tasks (Matsui et al. 
1987; Okhuysen & Eisenhardt 2002) – indicate that interventions bring group members closer
together to discuss and resolve areas of discrepancy about the task and/or its execution. Consequently, this has resulted in enhanced group performance outcomes such as enhanced flexibility and error detection (Hazlehurst 2003), parallel execution (Hazlehurst 2003), better idea generation (albeit at a cognitive cost) (Jessup & Connolly 1993), improved problem solving (Matsui et al. 1987), and enhanced knowledge integration (Okhuysen & Eisenhardt 2002).

The divergent effects of interruptions can also be discerned across some studies that did not explicitly distinguish between interruption types. For example, interruptions were found to trigger group coordination breakdowns (Ren et al. 2008), but also to enhance knowledge transfer effort and knowledge acquisition among group members (Zellmer-Bruhn 2003).

Need to Examine the Multilevel Nature of IT Interruption Outcomes

The second implication concerns explicit theorizing about multilevel phenomena. While the extant literature indicates evidence of different types of multilevel models (see the level of relationship column in Table 1), such evidence is only implicit and the explicit nature of the multilevel relationships is not taken into account (e.g., issues such as how individual-level constructs emerge to higher levels; comparing the content and meaning of constructs at the individual and group levels). Kozlowski & Klein (2000) suggest that there are three different types of multilevel models specifying the predicted relationships: single individual-level relationships, single unit-level relationships, and cross-level relationships. The first type denotes relationships where both the independent variable (the interruption) and dependent variable (the outcomes of the interruption) are at the individual level (see the level of relationship column in Table 1). Two studies reflect this type of relationship (Miller 2002; Perlow 1999). Although these
studies examined individuals who were executing their tasks within a team context, both the interruption and its effects were analyzed at the individual level. Thus, these studies are similar in that regard to the traditional individual-level studies in the interruptions literature.

The second type involves relationships where both the interruptions and their outcomes are at the unit (dyad or group) level. Some studies in Table 1 reflect these single unit-level relationships where all variables are assessed either at the dyadic (Matsui et al. 1987) or group levels (Okhuysen 2001; Okhuysen & Eisenhardt 2002; Zellmer-Bruhn 2003). However, these studies do not show how these group-level variables may be tied to micro-level aspects.

Most studies in Table 1 depict the third type, cross-level relationships, where interruptions are administered at the individual level and the effects assessed at the dyadic (Dabbish et al. 2007; Dabbish & Kraut 2004; Dabbish & Kraut 2008; Matsui et al. 1987) or group level (Harr & Kaptelinin 2007; Hazlehurst 2003; Jessup & Connolly 1993; Ren et al. 2008; Weisband et al. 2007). However, to specify a cross-level relationship between individual interruptions and group-level outcomes, the dependent variable should be explicitly conceptualized as either a global construct (e.g., group coordination outcomes), a shared construct (e.g., group climate), or a configural construct (e.g., group performance) (Kozlowski & Klein 2000). In the research summarized in Table 1, such multilevel theorizing is absent. For example, group performance in the studies by Dabbish and colleagues is not explicitly conceptualized as a global, shared, or configural construct. It may appear as a configural construct because it was assessed by aggregating the outcomes of two distinct tasks performed by the interruption source and target (Dabbish et al. 2007; Dabbish & Kraut 2004; Dabbish & Kraut 2008). However, specifying group performance as a configural construct requires that the tasks performed by the individual team
members are interdependent (Kozlowski & Klein 2000), a condition that is not met in those studies. Hence, we cannot conclude that these models represent multilevel models.

One study that would qualify as a multilevel study – although not presented as such – is Weisband et al. (2007), who conducted an ethnography and a simulation study to examine the implications of interruptions for group members’ coordination across roles in the hospital operating room. In that study, the cross-level relationship is between an individual-level interruptions construct (electronic notifications for operating room staff) and a global construct (coordinated group outcomes). The authors did not find a direct effect of interruption on group performance and concluded – consistent with our approach of linking interruptions to group coordination outcomes – that “the data suggests that interruptions affect performance through players’ work trajectories” (p. 9). As examples of coordination outcome measures, they identified different aspects such as starting the surgery on time (a measure of temporal coordination effectiveness), and starting with the proper resources in place (process coordination effectiveness), among others.

Need to Identify Task Interdependencies

As a third implication, we highlight the importance of explicitly recognizing group members’ interdependencies. Even though all studies summarized in Table 1 involve individuals working in group contexts, tensions are still evident between individual and collective pressures that influence how the effects of interruptions are played out. Indeed, several studies exhibit such tensions by conceiving of interruptions as events that are likely to benefit the interruption source

34 Although the interruption source’s task depended on obtaining information from the interruption target, the latter’s task was completely independent from that of the former.
but harm the interruption target (Dabbish et al. 2007; Dabbish & Kraut 2004; Dabbish & Kraut 2008; Perlow 1999; Rennecker & Godwin 2005). We argue that such misalignments in perspectives on interruption may occur when there is a lack of task or outcome interdependence, and that such tensions can limit the ability to examine whether the effects of individually-administered interruptions spill over to the group level. For example, outcome interdependence was explicitly manipulated in research by Dabbish and colleagues to ensure that subjects felt they were part of a team (Dabbish et al. 2007; Dabbish & Kraut 2004; Dabbish & Kraut 2008). This mitigated the adverse effects of intrusions on the interruption targets. But there was no task interdependence to allow us to see whether the effects of the individual-level interruptions propagate through the collective system. While the interruption source’s task depended on obtaining information from the interruption target, the latter was rewarded solely based on performance in a separate task that was independent from the task performed by the interruption source. Joint performance was then assessed by simply aggregating performance in the two separate tasks. Hence, the tasks were not interdependent in the direction where the interruption flowed. Stated differently, the task of the person being interrupted – and for which the person was rewarded – was completely independent and not tied to anyone else’s tasks. Also, the interruption source and target never met and had no previous history or expectations for future transactions.

Conversely, Perlow’s (1999) field study of a software engineering team exhibits task interdependence in the sense that the different activities of software development are tied together within a nested hierarchy and are strongly contingent on information sharing across team members. But because the software engineers were rewarded for “individual heroics” rather than interactive activity (no outcome interdependence), there were inconsistencies between the way
interruptions affected the productivity of individual engineers and the way such effects were shared by other members in the team.

Summary

By way of summary, the prior literature on interruptions in group contexts has made important strides toward elucidating some of the individual and group effects, and ways to mitigate the adverse effects of interruptions. However, we lack a theoretical basis that explains the multilevel relationships between IT interruptions and group-level outcomes such as coordination effectiveness when tasks and outcomes are tightly interlinked (e.g., as in the case of software development groups). In using coordination theory, which focuses on the interdependencies among the group's activities, we provide such a theoretical framework. In the following, we draw upon coordination theory to develop a multilevel model of IT interruptions where the individual-level effects spill over to the group level, thereby creating coordination problems and opportunities that affect the software group’s coordination outcomes.
Table 1: Summary of Literature on Interruptions in Group Contexts

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Research objectives</th>
<th>Type of interruption</th>
<th>Method</th>
<th>Level of relationship</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chong &amp; Siino (2006)</td>
<td>Examines differences in interruption patterns between paired versus solo programmers</td>
<td>Intrusions; interventions</td>
<td>Case study of two software development teams in a mid-sized Californian company (ethnographic observations)</td>
<td>N/a</td>
<td>Paired programmers initiate interruptions that are more functional and of shorter durations, respond faster to interruptions, possess situational awareness to determine importance of interruptions, monitor each other’s work during interruptions, are more flexible in ending interruptions, rely on each other as cues for interrupted tasks, and use resource sharing to recover more quickly.</td>
</tr>
<tr>
<td>Dabbish &amp; Kraut, (2004)</td>
<td>Examines the impact of using awareness display systems on regulating interruptions and influencing performance outcomes of interruption source and target</td>
<td>Intrusions</td>
<td>Experiment with students working on a problem-solving task; n = 36 dyads</td>
<td>X, ( \rightarrow ) Y_\text{g} (group performance aggregate of individual performance)</td>
<td>Use of awareness system by interruptor as coordination mechanism mitigates interruption effects and improves performance, especially in team condition. But too much information in the system overloads interruptor’s attention.</td>
</tr>
<tr>
<td>Dabbish et al. (2007)</td>
<td>Examines the impacts of control over interruption timing, displaying interruption urgency, and common team identity on response strategy and performance of interruption source and target</td>
<td>Intrusions</td>
<td>Two experiments with students working on a problem-solving task; n = 12 dyads; n = 9 dyads</td>
<td>X, ( \rightarrow ) Y_\text{g} (group performance aggregate of individual performance)</td>
<td>Interruptee’s response likelihood and speed is increased by interruptor control over interruption timing, display of interruption urgency, and common team identity. Interruptor control over interruption timing also increases interruptor’s performance.</td>
</tr>
<tr>
<td>Dabbish &amp; Kraut (2008)</td>
<td>Examines the impact of using awareness display systems on regulating interruptions and influencing performance outcomes of interruption source and target</td>
<td>Intrusions</td>
<td>Two experiments with students working on a problem-solving task; n = 36 dyads; n = 33 dyads</td>
<td>( X, \rightarrow ) Y_\text{g}</td>
<td>In team condition (common social identity and outcome interdependence), awareness display leads to interruptions at moments with lower interruptee workload, improving interruptee performance. Too much information in display harms interruptor’s task performance.</td>
</tr>
<tr>
<td>Gong (2006)</td>
<td>Examines the impacts of interruptions at the individual and group levels</td>
<td>Not specified</td>
<td>Conceptual (empirical part only on individual-level interruptions)</td>
<td>N/a</td>
<td>Interruptions trigger knowledge sharing and exchange among group members, and stimulate resource allocation.</td>
</tr>
<tr>
<td>Harr &amp; Kaptelinin (2007)</td>
<td>Examines the ripple effects of interruptions on the social context</td>
<td>Intrusions</td>
<td>Conceptual</td>
<td>( X, \rightarrow ) Y_\text{g}</td>
<td>Four aspects of the social ripple effects of interruptions are identified: location, communication, collaboration, interpersonal relation.</td>
</tr>
<tr>
<td>Hazlehurst (2003)</td>
<td>Describes crew coordination patterns in an aircraft cockpit to understand drivers of group performance (knowledge sharing, crew coordination, workload distribution)</td>
<td>Intervention</td>
<td>Case study of a cockpit crew executing a checklist task (video analysis)</td>
<td>( X, \rightarrow ) Y_\text{g}</td>
<td>Crew members enact both task-driven and interrupt-driven processing. The latter is critical for pointing out discrepancies beyond the immediate routine task, which enables flexibility, parallel execution and error detection.</td>
</tr>
<tr>
<td>Jessup &amp; Connolly (1993)</td>
<td>Examines the effects of interruption frequency on group productivity and satisfaction</td>
<td>Intervention</td>
<td>Experiment with students working on an idea-generation task in</td>
<td>( X, \rightarrow ) Y_\text{g}</td>
<td>Frequently interrupted groups outperform infrequently interrupted ones and nominal groups but this comes at a cognitive cost (feeling interrupted, less able to</td>
</tr>
<tr>
<td>Addas (Essay #3)</td>
<td>IT Interruptions and Group Coordination Effectiveness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Matsui et al. (1987)</strong></td>
<td>Examines the impact of individual and group feedback interventions on individual and group performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intervention</td>
<td>Experiment with students working on a perceptual problem-solving task; n = 54 individuals in 14 groups</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$X_i \rightarrow Y_g$</td>
<td>Individual and group feedback interventions increase performance for groups below target.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Miller (2002)</strong></td>
<td>Examines the impact of interruptions on decision making in a team setting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid interruption (intervention for future task, intrusion for current task)</td>
<td>Experiment with students working on a team decision-making task; n = 24 individuals in simulated groups</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$X_i \rightarrow Y_i$</td>
<td>Interruptions lengthen decision time, especially when goal rehearsal instructions are given. No effect on accuracy.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Okhuysen (2001)</strong></td>
<td>Examines the impacts of interruptions in the form of formal interventions on attention switches and group performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intrusions; interventions</td>
<td>Experiment with students working on a problem-solving task; n = 168 individuals in 40 groups</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$X_g \rightarrow Y_g$</td>
<td>Interventions motivate flexible structures that reorient the group’s activities and enhance group performance.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Okhuysen &amp; Eisenhardt (2002)</strong></td>
<td>Examines the impacts of interruptions in the form of formal interventions on attention switches and knowledge integration</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interventions</td>
<td>Experiment with students working on a problem-solving task; n = 168 individuals in 40 groups</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$X_g \rightarrow Y_g$</td>
<td>Interventions trigger windows of opportunity that allow group members to reorient their activities and better coordinate their knowledge.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Perlow (1999)</strong></td>
<td>Examines the antecedents and impacts of interruptions on the work patterns of a software engineering team</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not specified</td>
<td>Case study of a Fortune 500 software engineering team</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$X_i \rightarrow Y_i$</td>
<td>Team members’ work reflects an interruptive sequence of individual and interactive activities. This is caused by a crisis mentality and rewards for individual heroics. To mitigate interruption effects, a “quiet time” strategy was implemented, which enhanced productivity but had short-lived effects.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ren et al. (2008)</strong></td>
<td>Examines the antecedents and consequences of group coordination breakdowns, coping mechanisms and the role of IT support</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intrusions; interventions (not distinguished)</td>
<td>Case study of multiple groups working in the operating rooms of an urban U.S. hospital</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$X_i \rightarrow Y_g$</td>
<td>Internal interruptions (from patients, surgeons, and nurses), external interruptions, and interruptions across groups are sources of coordination breakdowns. Coping mechanisms include constant communication, joint problem solving, and role switching. Consequences of the interruptions at the collective level include group conflicts and organizational losses. Three critical factors to cope with interruptions and promote coordination: trajectory awareness; IS integration; information pooling &amp; organizational learning.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Weisband et al. (2007)</strong></td>
<td>Examines the impact of interruption notifications on performance in critical work environments</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intrusions: interventions</td>
<td>Experiment with students working on a simulated operating room scheduling task; n = 39 individuals in</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$X_i \rightarrow Y_g$</td>
<td>Interruption modality (silent delivery to messaging board rather than screen pop-up) increases task switching, which in turn enhances individual and group performance.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zellmer-Bruhn (2003)</td>
<td>Examines the impacts of team interruptions on knowledge transfer</td>
<td>Interruption types not distinguishable as intrusions/interventions</td>
<td>Survey of operational teams from three pharmaceutical firms; n = 90</td>
<td>X \rightarrow Y_g</td>
<td>Interruptions increase the team’s knowledge transfer efforts and acquisition of new knowledge beyond the existing routines. Interruptions rated as disruptive reduce knowledge acquisition.</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------------------------------------------------------</td>
<td>---------------------------------------------------------------</td>
<td>---------------------------------------------------------------</td>
<td>-----------------</td>
<td>------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>X_i \rightarrow Y_i</td>
<td>Single individual-level relationship</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X_g \rightarrow Y_g</td>
<td>Single unit-level relationship</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X_c \rightarrow Y_g</td>
<td>Cross-level relationship</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
COORDINATION THEORY

In this section, we present the basic tenets of coordination theory, which is subsequently used to explain the multilevel relationships between IT interruptions and group coordination effectiveness. Coordination theory adopts a system dynamics approach (Forrester 1958), which focuses on interactions between a system’s components and the impacts of changes in one part of the system on other parts. When the system’s components are interdependent, problems arise because such interdependencies may constrain the functioning of some parts (e.g., when one part requires input from the other(s) to function). Hence, such interdependencies need to be effectively managed (i.e., coordinated).

Coordination Problems

In organization theory, early coordination studies view coordination as an information processing mechanism used to manage the flow of information within and across organizational units. The goal of such coordination is to reduce uncertainty and achieve optimal performance through matching between the demands of a task and its corresponding information processing structures (Galbraith 1973; March & Simon 1958; Thompson 1967; Tushman & Nadler 1978). The focus in these studies is on examining the best means to coordinate such as using personal or impersonal mechanisms (van De Ven et al. 1976), programming or feedback (March & Simon 1958), and standardization, plans, or mutual adjustment (Thompson 1967).

Crowston and colleagues (Crowston 1997; Crowston & Kammerer 1998; Malone & Crowston 1994; Malone et al. 1999) provide a more nuanced process perspective, which examines the types of coordination problems and solutions that are faced by organizations in
different situations in terms of the nature of dependencies between systems’ components. Within this perspective, the focus is on the process, which is viewed as a possible configuration of activities. While two organizations may perform the same set of activities, the processes comprising those activities may differ with respect to how they are coordinated (e.g., how tasks are assigned; who performs them) (Crowston 1997). Any given process involves actors (individuals or collectives) who perform interdependent activities to achieve goals. The activities are part of an overall task that actors are required to do. Activities may require or create various resources including time, effort, skill, knowledge, and other artifacts (e.g., information reports) (Crowston 1991). Two important properties of resources are shareability (i.e., fit for simultaneous use by multiple activities) and reusability (i.e., fit for use at different points in time). Resources may be shareable and reusable (e.g., information), non-shareable and reusable (e.g., production tools), or non-shareable and non-reusable (e.g., raw materials) (Crowston 1991).

Because of bounded rationality and other obvious resource constraints (e.g., time, effort, and cost), no single individual can perform all activities included in the organization’s task environment. Organizations thus resort to a division of activities and allocation of resources (often based on actor specialization). Since most activities performed by actors are part of an overall task or goal that needs to be accomplished, this gives rise to various dependencies that may constrain the execution of those activities and thus lead to coordination problems (Crowston 1997; Malone & Crowston 1994). Coordination problems can result from three types of dependencies in which resources are related to multiple activities: (1) sharing dependencies; (2) fit dependencies; (3) flow dependencies. Sharing dependencies arise when multiple activities use the same resource. In fit dependencies, multiple activities together produce a single resource.
Flow dependencies occur when one activity produces a resource that is used by another activity (Malone et al. 1999).

Coordination Mechanisms

To resolve the coordination problems, additional coordination activities must be performed that focus on overcoming the constraints and effectively managing the dependencies. Performing such coordination activities is referred to simply as “coordination,” which is formally defined as managing dependencies among activities (Crowston 1991; Malone & Crowston 1994). Coordination activities may be recursive, meaning that they themselves may require coordination.

Coordination literature has identified two broad types of coordination mechanisms that allow a collective (e.g., a group) to coordinate or manage dependencies: (1) task organization; (2) group problem solving. Coordination via task organization, also referred to as programming (March & Simon 1958), coordination by plan (Thompson 1967), and impersonal coordination (van De Ven et al. 1976), is a structural arrangement used to manipulate various aspects of the task and the resources employed in the task. Group members using this mode implement practices (e.g., assigning tasks; allocating resources; integrating outputs) that are designed or codified into programs of action (Gittell 2002; van De Ven et al. 1976). While these practices are often predefined (March & Simon 1958), they may also arise in direct response to different types of coordination problems (Crowston 1997; Malone & Crowston 1994; Wittenbaum et al. 2002). For example, an ambiguous software specification can be managed by involving users (flow dependency), and a re-occurring software bug issue can be addressed by reusing a previous bug-fixing solution (fit dependency).
Traditionally, organization theory recommends the use of task organization as a coordination method when the task is more routine and repetitive (March & Simon 1958; Thompson 1967; van De Ven et al. 1976). However, recent research points out that this coordination mode can also be used in less stable situations, as long as the dependencies between tasks and activities can be somewhat predicted (Crowston 1997; Espinosa et al. 2004; Malone & Crowston 1994). For example, a software development unit that is frequently interrupted by email, instant messaging, and other communication tools may use predefined mechanisms to cope with interruptions such as including extra developers with similar skills in the group to compensate for the interruptions facing some group members. In this case, the group’s work is not stable since it is punctuated by interruptions. However, the dependencies are somewhat predictable and thus amenable to coordination via task organization.

Coordination via group problem solving is the second basic type of coordination mechanism, previously described using various terms such as communication (Espinosa et al. 2004; March & Simon 1958), mutual adjustment (Thompson 1967), coordination by feedback (van De Ven et al. 1976), and group problem solving and decision making (Grant 1996; Malone & Crowston 1994). Rather than involving a mechanistic, structural program, this coordination mode reflects an organic process of intense interaction among group members to resolve a problem situation. Faced by a novel or discrepant task situation (i.e., unpredictable dependency), group members enact “frequent, timely, accurate problem-solving communication” (Gittell 2002, p. 1410), in which they share knowledge to ameliorate the situation (Gittell 2002; Okhuysen & Eisenhardt 2002). While communication among group members may certainly also be present in the coordination by task organization mode, the primary goal there is to design mechanisms that reduce the need for continuous communication (Grant 1996; van De Ven et al. 1976). By contrast,
the communication in group problem-solving coordination is more intense, more personal, less standardized, and deliberately sought to resolve problem situations (Grant 1996; van De Ven et al. 1976). Group problem-solving discussions may be formal or informal (Espinosa et al. 2004), written or verbal (Rico et al. 2008), and scheduled or unscheduled (van De Ven et al. 1976).

Group problem-solving coordination is best used in emergent situations when dependencies cannot be fully predicted (Crowston 1991; Espinosa et al. 2004; Grant 1996). For example, a software development group member may receive feedback from the customer revealing that a critical software functionality does not work as desired. In this case, a flow (usability) dependency (Malone & Crowston 1994) is affected in which the product cannot proceed to the next iteration unless resolved. To resolve that unpredicted dependency problem, the software development group typically engages in discussions that involve intra-team members and customers in order to find a solution for such a discrepancy.

While the two types of coordination mechanisms may be more salient in different types of tasks, research shows that the same tasks could also elicit different coordination mechanisms. For example, Wholey et al. (1996) found that groups use group problem-solving as a coordination mechanism early on in the task, whereas task organization becomes more effective later on. This suggests that different situational factors may trigger different types of coordination mechanisms.

Coordination Effectiveness

Coordination effectiveness – defined as the extent to which dependencies have been effectively managed – has been introduced as a construct that reflects the outcomes produced by the act of coordinating (Espinosa et al. 2004). This construct includes three dimensions: technical,
temporal, and process. The technical dimension assesses how well technically-oriented dependencies are managed. In the software development context, technical coordination effectiveness is high when the multiple software components in a given project are well integrated and work well together (Espinosa et al. 2004). Conversely, it is low when technical coordination problems are not resolved, resulting in issues such as redundant code, incompatible interfaces, and integration problems (Espinosa et al. 2007).

The temporal dimension reflects the extent to which interdependent tasks are completed on schedule. Thus, for a software development project, temporal coordination effectiveness is high when software parts and software development activities (and sub-activities) are completed according to schedule. It is low when there are slippages in the schedule of some parts in the system, which in some cases could push the whole project behind (Espinosa et al. 2007).

Finally, the process dimension assesses the effectiveness in managing process dependencies. In a software project, this reflects the extent to which in a given project activities are performed and resources are used according to an established software process. This measure is high when group members adhere to the agreed-upon procedures. It is low when process coordination issues are not resolved, which leads to various problems such as feature churn, priority conflicts, and blocking issues affecting software functionality (Espinosa et al. 2007).

**A MULTILIVAL MODEL OF IT INTERRUPTIONS**

The conceptual, multilevel model is shown in Figure 1. As shown in the model, IT intrusions are proposed to trigger various individual-level resource constraints that emerge to the group level and debilitate group coordination effectiveness. In multilevel theory language, this
relationship can be described as a mixed unit-level relationship with one global construct (coordination effectiveness) and one shared construct (group-level resource constraints) (Kozlowski & Klein 2000). The model also proposes that task organization coordination mitigates this negative influence on coordination effectiveness via moderation and partial mediation effects. On the other hand, IT interventions elicit a group problem-solving coordination mode (a cross-level relationship in the language of multilevel theory; cf. Kozlowski & Klein 2000), which subsequently enhances group coordination effectiveness. This cross-level effect is moderated by two factors: perceived quality of the intervention and intervention level (individual vs. group intervention). Below, we provide theoretical justifications for each proposed link in the model.

Figure 1: Conceptual Model
IT Intrusions, Group-Level Resource Constraints, and Group Coordination

Effectiveness

At the individual level, intrusions typically introduce secondary activities that interfere with the individual’s primary activities and compete over limited attentional resources (Speier et al. 1997). Such interferences may include capacity interference and cognitive interference. Capacity interference occurs when the additional cues required to process the intrusion exceed the individual’s available attentional capacity (Kahneman 1973). This limitation is further complicated by the switching back and forth between the demanding intrusions and primary task, which requires reordering of task priorities and suppressing/activating cues associated with those tasks. Also, cognitive interference may occur when the primary task and intrusion draw on similar resources in a way that confuses attentional allocation (e.g., if both activities are visual in nature, or if both use similar IT tools) (Wickens et al. 2005). As a result of the above interferences, intrusions produce resource constraints that manifest in various negative outcomes such as increased time pressure and workload (France et al. 2005; Hopp et al. 2005; Trafton et al. 2003), longer task resumption and completion times (Bailey et al. 2001; Burmistrov & Leonova 1996; Cutrell et al. 2001; Iqbal & Horvitz 2007; McFarlane 2002; Speier et al. 1997), and increased error rates (Bailey et al. 2001; Basoglu et al. 2009; McFarlane 2002; Monk et al. 2002).

While these effects originate at the individual level, they emerge to the group level through the software development group’s interactions on interdependent activities. For some resource constraints (time pressure; time delays; work product errors), such emergence is in the form of composition, meaning that the higher-level construct is composed of similar or shared lower-level elements (Kozlowski & Klein 2000). For other constraints (cognitive workload) it is in the form of compilation, meaning that it is a combination of individual cognitions (Kozlowski
Addas (Essay #3)

IT Interruptions and Group Coordination Effectiveness

& Klein 2000). Hence, the effects of intrusions at the group level can be better understood by examining the ways by which they ripple through the system via interdependencies and constrain how such dependencies are managed.

The individual effects of intrusions (inefficiencies and errors) can ripple though in various ways. Consider the hypothetical model – shown in Appendix 1 – of group members interacting on the component tasks of the software development process. There are at least three ways for intrusions to spill over to higher levels. First, an intrusion (e.g., system breakdown) for a single group member performing a given task can spill over and affect that same person on another interdependent task (sharing dependency; see Scenario A in Appendix 1). From a multilevel perspective, this type of emergence is due to the workflow design in the software development process, which patterns interactions among group members and their activities (Kozlowski & Klein 2000). Perlow (1999) described this ripple effect as a vicious work-time cycle. She found that the tasks of software engineers would be interrupted due to a crisis, but that such interrupted tasks themselves became crises later on that pushed some of their other work behind.

Second, interrupting a group member on a given task (e.g., via an information request) may affect other group members working concurrently on the same task (see Scenario B in Appendix 1). Harr & Kaptelinin (2007) described this as a “collateral disruption.” They provided the example of a phone ringing in the theater, which interrupts not only the call receiver but also other attendees sharing the same space.

Finally, intrusions may also exhibit ripple effects directly across interdependent tasks (see Scenario C in Appendix 1). For example, interrupting a coding task may cause testing and validation to be delayed until the former task is completed (flow dependency). This type of ripple
effect has been described as a “communication freeze” when interruption to a part of the system spills over to another interdependent part that waits for input from the first part (Harr & Kaptelinin 2007).

Proposition 1: Because of interdependencies among software development group members’ activities, the individual-level resource constraints triggered by IT intrusions ripple through to the group level and debilitate group-coordination effectiveness.

We now discuss in more detail how the different types of interdependencies trigger ripple effects of the intrusions and constrain task execution in a way that diminishes group coordination effectiveness. Appendix 2 summarizes the main dependencies and coordination mechanisms outlined in coordination theory (Crowston 1997; Malone et al. 1999). The multilevel effects of IT intrusions arise mostly because of sharing dependencies and flow dependencies.

IT Intrusion Effects via Time Resource Constraints (Sharing Dependencies)

Sharing dependencies facilitate the emergence of IT intrusion effects when such intrusions constrain the use of a resource shared by multiple tasks. One of the most pertinent of these resources is time. As noted earlier, intrusions increase perceptions of time pressure for individuals as they juggle their attention between the competing demands of their primary

---

35 Time pressure has been studied both as a separate construct in the extant literature (Adamczyk & Bailey 2004) and as a dimension of subjective workload (Hart & Staveland 1988).
activities and intrusions and go through a series of cue activation/suppression (France et al. 2005; Gong 2006; Hopp et al. 2005; McFarlane 2002; O’Conaill & Frohlich 1995; Oulasvirta & Saariluoma 2006; Trafton et al. 2003). Adamczyk et al. (2004) reported an increase of perceived time pressure of 55% for intrusions introduced at the worst timings and 37% for intrusions introduced randomly.

According to group research, such individual perceptions of time pressure propagate quickly through the group and are shared at the group level (Karau & Kelly 1992), especially when the group works on interdependent tasks for extended periods (Chong et al. 2011). Gersick’s (1989) study of eight simulated product development groups – working interdependently under a common deadline – found that individual comments about time concerns subsequently led to a shared time pressure perception by the group and the development of time pacing behaviors to speed up the work during the remaining period. Another study of 48 project groups found that time pressures initially perceived by individual group members led to the formation of overall temporal awareness by the group (Janicik & Bartel 2003). Chong et al.’s (2011) study of 81 product development teams attributed the emergence of time pressure perceptions from the individual to the group level to emotional contagion in highly interdependent teams. Software development teams are prone to such emergence of individual-level time pressures to the group level. Since software team members are highly interdependent, share the same resources, and are subject to the same time constraints, perceived time pressures from intrusions are likely to manifest at the group level. Indeed, Perlow’s (1999) field study of a software development group showed that individually administered intrusions trigger an overall perception of time pressure among the group.
According to Karau & Kelly’s (1992) attentional focus model, groups experiencing time pressure in their tasks narrow their attention to focus on task completion rather than group interactions and coordinative activities (Chong et al. 2011; Karau & Kelly 1992; Kelly & McGrath 1985; McGrath 1991). Stated differently, time-pressured group members working on interdependent tasks attend less to coordinating their resources and outputs, and more to achieving “quick fix efficiencies” (Kelly & McGrath 1985) and taking shortcuts (Alvero et al. 2001) to meet task demands. Hence, while temporal coordination effectiveness may not be affected as a result of such reactive acceleration of task performance (Abdel-Hamid et al. 1999), technical and process coordination outcomes are likely to be debilitated. Specifically, group members may tend to devote less time for ensuring adequate integration of their components and adherence to established development processes. Indeed, time-pressured software development groups were found to reduce promised functionality (Costello et al. 2009; Pries-Heje et al. 2005), allow less customer involvement (Pries-Heje et al. 2005), allow little time for system testing (Brooks 1979), and ignore maintenance issues (Pries-Heje et al. 2005). Rakitin (1999) suggested that time-pressured software team members typically react by:

[… abandoning] whatever process the team was following. The focus shifts to paring down features and cranking up coding. Activities such as regression testing, design reviews, and code inspections are eliminated. The amount of time the software quality assurance group needs for validation testing is drastically cut since it is always the last activity on the schedule. No design reviews, no code inspections, less testing, and more hurrying add up to a poor quality product (p. 55).

Chong et al.’s (2011) study of 81 product development groups also found that narrowing of attention under time pressure led group members to absorb less informational and social cues necessary for coordination, which weakened group coordination effectiveness.
Proposition 1a: IT intrusions increase time pressure among software group members, which aggregates to the group level because of sharing dependencies. This hinders effective task execution and diminishes group-coordination effectiveness (technical and process dimensions).

IT Intrusion Effects via Cognitive Load Constraints (Sharing Dependencies)

Cognitive effort is another shared resource that can be constrained by intrusions in a group environment. Effort can be represented by the relative amount of attentional resources required to complete a task. When the cognitive effort required exceeds available capacity, this results in high cognitive workload for an individual\(^{36}\) (Bowers et al. 1997; Urban & Hauser 1993). Intrusions increase cognitive workload because of the additional effort that must be allocated and shared between the primary and intrusion activities. Effort can be exhausted not only because of the additional work required to handle the intrusion, but also because such work impinges on the original demands of the primary activities, which requires constant activation, suppression, and reactivation of cues as attention is juggled between the primary activities and intrusions. Indeed, interruptions literature found empirical support for the link between intrusions and cognitive load (Basoglu et al. 2009; Carroll & Kay 1988; Gievska et al. 2005).

The detrimental effects of intrusions on cognitive workload are expected to emerge to the group level because of the software development group’s sharing interdependencies. Team members have a finite pool from which to expend effort toward managing their frequently interrupted tasks (task work), but also toward communicating and coordinating such tasks across

\(^{36}\) Cognitive workload is a dimension of subjective workload. Broader conceptualizations of subjective workload also exist including one that includes physical and mental demand, time pressure, effort, and stress (Hart & Staveland 1988).
the group (teamwork). Additionally, they have to expend effort for timesharing between task work and teamwork (Bowers et al. 1997; Funke et al. 2012). Even without intrusions, such constant fragmentation of the cognitive effort of group members among different types of activities – known as the dual-task paradigm – imposes significant team workload, especially when tasks are highly interdependent (Bowers et al. 1997; Funke et al. 2012; Gopher et al. 1984).

Because the group-level concept of workload includes more components than its individual-level counterpart (e.g., teamwork and timesharing), the two may not be structurally equivalent (Kozlowski & Klein 2000). Stated differently, the two constructs may manifest themselves differently at different levels (Morgeson & Hofmann 1999). However, they are still functionally equivalent (Morgeson & Hofmann 1999), with the common function being a depletion of effort beyond available capacity. With respect to the emergence of this construct, Bowers et al. (1997) suggest that team workload is an emergent property of the team that is greater than the sum of its individual components. An alternative perspective, which we follow in this paper, is that team workload is a linear combination of the individual components (Funke et al. 2012). More specifically, Funke et al. (2012) proposed an additive conceptualization of team workload, which regards the elemental contributions as comprising each team member’s contribution toward task work, teamwork, and time sharing between the two. Because team members differ with respect to the type and amount of their elemental contributions (e.g., differences in endowed resource capacities; polychronicity), the emergence of team workload is one of compilation (Kozlowski & Klein 2000). That is, team members have an unequal distribution of individual workload amounts, which aggregates to form overall team workload.

Increased cognitive workload for the group is likely to debilitate group coordination and performance (Bowers et al. 1997; DeJoode et al. 2004). Indeed, research on group workload
found that increased cognitive workload diminishes coordination activities (Urban et al. 1996) and triggers coordination breakdowns as a result of shifting effort toward task work rather than teamwork (Serfaty & Kleinman 1990). Bearman et al.’s (2010) study of cockpit teams showed that self-reported team workload leads to coordination breakdowns such as non-adherence to established procedures (lower process-coordination effectiveness). In a longitudinal study of a software development team, team workload was found to decrease delivery performance, meaning that the team had to reschedule many uncompleted development tasks to later iterations (lower temporal coordination effectiveness) (Cataldo & Ehrlich 2012). Also, it increased the number of component defects reported in each iteration (lower technical coordination effectiveness).

Intrusions introduce additional complications to the situation as a result of further increasing workload and fragmenting the scarce cognitive effort of group members. Hence, we expect them to be detrimental to coordination effectiveness and this can be manifested in similar ways, as we proposed for the effects of time pressures (e.g., reduced functionality; decreased involvement; cutting corners on important steps in the development process).

**Proposition 1b: IT intrusions increase cognitive workload among software group members, which aggregates to the group level because of sharing dependencies. This fragments effort and diminishes group coordination effectiveness (technical, temporal, and process dimensions).**
IT Intrusion Effects via Time Resource Constraints (Flow Dependencies)

The effects of IT intrusions can also be shaped by flow dependencies when intrusions constrain the use of a common resource created by one activity and used by another. Time can be seen as one such resource (Crowston 1997). It is widely established in the interruptions literature that intrusions create task resumption and completion delays at the individual level (Bailey et al. 2000; Bailey et al. 2001; Burmistrov & Leonova 1996; Cades et al. 2006; Cutrell et al. 2001; Eyrolle & Cellier 2000; Gillie & Broadbent 1989; Hodgetts & Jones 2006b; Kapista & Blinnikova 2003; McFarlane 2002; Monk et al. 2004b; Nagata 2006; Ratwani et al. 2007; Speier et al. 1997; Trafton et al. 2005). This has also been substantiated in the context of software development, albeit also at the individual level (Iqbal & Horvitz 2007; Mark et al. 2005; Perlow 1999). At the group level, such individual delays can ripple through the group’s lifecycle activities and push the whole project behind, especially if some delayed activities reside on the project’s critical path. Indeed, Brooks (1979) argued that disastrous overall schedule slippage for software teams is usually due to “termites, not tornadoes” (p. 154). That is, day-to-day slippage that occurs as a result of unexpected individual events (e.g., an absent employee; machine breakdowns; meetings) can accumulate and ripple through the system (Brooks 1979), thereby debilitating the group’s temporal coordination effectiveness. The reasons for this ripple effect are twofold. First, some software development activities have sequential constraints between them so delays in one activity (e.g., coding) almost inevitably cause delays in the subsequent activity (e.g., testing). This has been referred to as the phase-to-phase knock-on effect (Reichelt & Lyneis 1999). Second, interdependent software components and modules call upon each other so that a delay in one module hinders performance on the other module (Williams 1999). Hence, the emergence of time delays from an individual-level to a group-level resource constraint is due to
the nature of software team’s work flow as sequentially patterned interactions (Kozlowski & Klein 2000).

For sharing dependencies, we argued that time-pressured group members could guard against diminishing temporal coordination effectiveness by incurring quality and process tradeoffs (lower technical and process coordination effectiveness). However, for flow dependencies, the ripple effect of time delays is more difficult to offset due to the sequential constraints. Also, trying to offset the slippage by throwing more resources at the tasks may be more tricky because of the added communication and coordination costs (Brooks 1979) in addition to introducing quality and productivity problems (Reichelt & Lyneis 1999). As Brooks (1979, p. 25) contended, “adding manpower to a late software project makes it later.” Consequently, intrusions are expected to debilitate temporal coordination effectiveness under flow dependencies.

*Proposition 1c: IT intrusions increase time delays among software group members, which ripples to the group level because of flow dependencies. This diminishes group coordination effectiveness (temporal dimension).*

**IT Intrusion Effects via Work Product Error Constraints (Flow Dependencies)**

A second way by which the effects of IT intrusions are shaped by flow dependencies is through the ripple effect of errors in the created work products. As discussed earlier, intrusions incur cognitive costs as a result of switching attention back and forth between the primary and
intrusion activities. One of the main negative outcomes identified in the literature is an increase in the error rates committed (Burmistrov & Leonova 2003; Cutrell et al. 2001; Eyrolle & Cellier 2000; Nagata 2003; Speier et al. 1997). This adverse effect of intrusions on error rate has also been observed in the context of software development, which is a complex, error-prone process requiring intense concentration (Ko & Myers 2005; Ko et al. 2006; Robertson et al. 2004; Smallwood et al. 2004). For example, Ko & Myers (2005) identified external intrusions as a primary cause of attention breakdowns (e.g., failing to complete a routine upon task resumption), which invites software errors in the code.

Because of flow dependencies in software development where the output of one task is used as the input of another (Crowston 1997), errors in any software work product (e.g., requirements specification; user interface design; code; test plan) can ripple through the entire lifecycle and affect the group’s overall technical coordination effectiveness. For example, Wohlin & Korner (1990) showed that a single undetected error can cause four errors in the subsequent phase and up to 250 errors four phases after the phase where the error was introduced. Another study focused on a software team developing an engine control system for Rolls Royce under a very time-pressured environment (Powell 2001). The study found that errors committed early on in the project multiplied and propagated through a bow-wave effect. In a case study of a software team developing a large commercial legacy system, Li (2010) also found errors that were especially persistent in propagating across development phases and product releases. These errors also diffused across modules that depended on (i.e., called on, were called by, or shared data with) the module in which the error was introduced, leading to overall architectural degeneration. While those multi-module errors comprised only 8% of the total errors, they required over 50% of the change effort as a result of changing multiple modules each time (Li 2010). Hence, intrusions are
likely to diminish technical coordination effectiveness because of the spread in errors, which constrains the way different work product components work together.

Proposition 1d: IT intrusions increase work product errors among software group members, which ripples to the group level because of flow dependencies. This diminishes group coordination effectiveness (technical dimension).

IT Intrusions and Task Organization Coordination

While the IT intrusions disrupt the work processes of group members and produce negative effects, task organization coordination is designed to restore the proper functioning of such processes and alleviate such negative effects. These structural coordination mechanisms are designed to help the group efficiently manage the coordination problems created by intrusions while reducing the need for intense communication. Indeed, organization theory and IS literature posit that task organization coordination is very likely to be activated in response to events that are repetitive (March & Simon 1958; Thompson 1967; van De Ven et al. 1976), and for which dependencies are relatively predictable (Crowston 1997; Espinosa et al. 2004; Malone & Crowston 1994).

As noted earlier, task organization coordination mechanisms may be either pre-defined (Gittell 2002; March & Simon 1958; van De Ven et al. 1976) or applied to deal with emergent situations such as intrusions (Faraj & Sproull 2000; Malone & Crowston 1994; Wittenbaum et al. 2002). However, since intrusions are dynamic events that occur during the performance of task processes, we focus here on coordination practices that are implemented in direct response to such
intrusions rather than independently planned. Two coordination mechanisms – based on manipulating resources or tasks – can be used to effectively cope with the disruptive effects of intrusions: (1) role switching (manipulating people resources); (2) temporal task management (manipulating tasks and time resources).

Role Switching as a Coordination Response to IT Intrusions

When group members face frequent and intense intrusions, they can better cope with their disruptive effects by introducing role switching in the group. For this type of coordination to work, group members must share a given level of expertise and skills so that they can become relatively interchangeable on some tasks (Chong & Siino 2006; Crowston 1997; Faraj & Xiao 2006). Hence, role switching relies on sharing dependencies among group members (Crowston 1991; Crowston 1997). Software development teams – especially those using agile methodologies – implement role switching to streamline their tasks and account for any process disruptions (Strode et al. 2012). In particular, software team members can replace their interrupted teammates and generally compensate for the time and effort diverted into interruptive activities. For instance, Faraj & Xiao (2006) observed a “plug-and-play” coordination mechanism in a medical trauma center group where group members replaced each other or split up into more subgroups to deal with emergent interruptions and situations. Coordination via role switching as a response to disruptive situations has been observed in different group contexts including software development groups (Chong & Siino 2006; Crowston 1997; Strode et al. 2012), healthcare provision groups (Faraj & Xiao 2006; Ren et al. 2008), film production crews (Bechky & Okhuysen 2011), and police SWAT groups (Bechky & Okhuysen 2011).
Proposition 2a: Because of sharing dependencies among software group members’ activities, structural disruptions triggered by IT intrusions lead to the use of role switching as a task organization coordination mode.

Temporal Coordination as a Coordination Response to IT Intrusions

Temporal coordination is another structural coordination mechanism that can be used by group members to cope with intrusions. It is loosely conceptualized as a process of “complex matching of bundles of activities to particular periods of time” (McGrath 1991, p. 163). Temporal coordination may contain various activities such as scheduling and deadlines, sequencing, prioritization, and synchronization (McGrath 1991). Because of flow interdependencies among group member activities, temporal coordination can be used in response to emergent situations to streamline tasks and put them back on track (McGrath 1991; Waller 1999).

Indeed, group research found that one of the pivotal responses to disruptions faced by group members is temporal coordination (Bechky & Okhuysen 2011; Gersick 1988; Waller 1999). This has been substantiated, for instance, in situations where group members face scarcity in time resources (a situation that is activated by intrusions, as we argued earlier) (McGrath 1991; Montoya-Weiss et al. 2001). Temporal coordination is also one of the key mechanisms used by software development teams to deal with emergent situations (Espinosa et al. 2007; Espinosa et al. 2004; Massey et al. 2003). For example, Sarker & Sahay (2004) found that virtual software development teams reacted to losses in time by implementing temporal coordination structures to “reclaim” the lost time (Sarker & Sahay 2004). We propose the following:
Proposition 2b: Because of flow dependencies among software group members’ activities, structural disruptions triggered by IT intrusions lead to the use of temporal coordination as a task organization coordination mode.

Task Organization Coordination & Group Coordination Effectiveness

The Moderating Effect of Role Switching on Group Coordination Effectiveness

Role switching can affect group coordination effectiveness by overcoming some of the additional constraints placed on task execution by IT intrusions. First, role switching can ease the effects of time pressures experienced by group members facing intrusions under sharing dependencies. This can result from introducing additional members (or existing members with shared skills) who can replace their interrupted teammates, keep the task activities on track, and restore attention to coordination activities. Indeed, Gong (2006) suggested that while intrusions increase time pressures, groups are more resistant to such pressures than individuals because of flexible structures that allow them to work more effectively on segmented task activities. In another study of a hospital operating team, role switching was used as a strategy to mitigate the significant time pressures the team experienced from interruptions, which helped team members cope and recover from coordination breakdowns (Ren et al. 2008).

Second, role switching can offset the effort fragmentation that group members experience under sharing dependencies, and which debilitates coordination effectiveness. This is consistent with a widely accepted view in the organization science literature that using slack resources helps
buffer the technical core from the discontinuities presented by environmental demands (Bourgeois & Singh 1983; Galbraith 1973; Thompson 1967). In particular, Galbraith (1973) argued that the availability of slack resources “reduces the amount of information that must be processed during task execution and prevents the overloading of the hierarchical channels” (Galbraith 1973, p. 15). Hence, we expect that role switching will help smooth effort allocation among the interrupted group members and maintain balanced attention between task work and coordination activities.

Third, role switching can help guard against error propagation due to frequent intrusions in flow dependencies. More specifically, groups employing role switching can better verify one another’s output to ensure conformity before proceeding to the next task (Crowston 1997). This eases the constraints placed by the flow (usability) dependency where errors ripple through the entire lifecycle. For example, a study of software development groups working in pair programming mode found that programmers replaced each other when interrupted and monitored each other’s work in order to cope with adverse consequences (Chong & Siino 2006). Similarly, a study of a film production crew reported a role switching effect when a newly hired assistant director was aided in scheduling scenes by a location manager with the requisite skills in order to avoid error propagation (Bechky & Okhuysen 2011).

Finally, role switching can mitigate the effects of task performance delays that are created by intrusions in flow dependencies and that ripple across the group’s activities. Specifically, group members can curb such task delays by re-allocating free actors or assigning more actors to the task. For example, Chong & Siino’s (2006) study of software development teams found that role switching – achieved by pairing programmers with similar skills – helped provide more task continuity and cued the attention of interrupted group members, which accelerated their interruption recovery time. The authors noted that “pair work seemed to allow the pair
programmers to reduce somewhat the derogatory effects of interruptions by dulling potential losses in productivity” (Chong & Siino 2006, p. 36). Similarly, another case study of a small software development team found that developers with redundant skills performed each other’s work, which enabled them to maintain time schedules and improve coordination by reducing workflow bottlenecks (Funke et al. 2012). As another example, Faraj & Xiao’s (2006) plug-and-play teaming strategy was found to provide the medical trauma center team with the necessary flexibility to meet external contingencies and better address time-critical task demands. However, as we noted earlier, there are limits to the mitigation effect of role switching on flow dependencies as a result of possible sequential constraints. Together, the above arguments allow us to propose the following:

**Proposition 3a:** Because it allows software group members to compensate for each other in response to IT intrusions, role switching helps overcome the additional constraints placed by intrusions on task execution (time pressure; cognitive workload; work product errors; task performance delays). This will result in a negative moderation effect on group coordination effectiveness.

**The Direct Effect of Temporal Coordination on Group Coordination Effectiveness**

Like role switching, temporal coordination is expected to be beneficial for group coordination effectiveness. However, this effect is expected to be direct rather than moderated. First, setting clear schedules and deadlines for activities may act as a common leverage that reminds group members to return quickly to their primary activities and break out of the “chain of
diversions” (Iqbal & Horvitz 2007) that is typically elicited by intrusions. This accelerating effect of deadlines has been substantiated in group research. For example, Gersick (1988) conducted a seminal field study of eight naturally occurring groups performing interdependent tasks that were part of a project. The study revealed that deadlines afford natural milestones to group members, during which their awareness of time heightens significantly. This motivates them to pay great attention to accelerating their pace and leads to dramatic improvements in efficiency. Similarly, group research on entrainment showed that group members accelerate their pace to match external deadlines and that such behavior is sticky (Kelly & McGrath 1985).

Second, group members may cope with intrusions by sequencing and prioritizing their activities (Crowston 1997; Malone & Crowston 1994). For example, Waller’s (1999) research on professional airline flight crews examined how the crew reacted to interruptions to their flight simulation activities (e.g., steering problems; hydraulic system failures; intrusions by air traffic control). The study found that timely application of task reprioritization and redistribution after interruptions significantly enhanced the group’s performance. Similarly, Bechky & Okhuysen’s (2011) investigation of police SWAT groups and film crews identified reassembling the work as a coordination mechanism to deal with interruptions. They observed, for example, that the film crew changed the sequence of the shooting events to deal with the unexpected absence of an actor. Specifically, they decided to shoot a scene that was scheduled for later in the same location and which did not require the missing actor’s presence. This allowed the crew to save time and avoid having to return to that location.

Third, synchronizing activities by aligning the pace of effort across group members (McGrath 1991) can also reduce the detrimental temporal effects of intrusions. This is achieved chiefly by overlapping activities and information processing (Blackburn et al. 1996; Hauptman &
Hirji 1999). Overlapping can be done across projects (e.g., by reusing code), within a project (e.g., by performing some design and development activities concurrently), and/or within a particular project task (e.g., by coding several modules concurrently or concurrently coding the same module by several programmers). Two mechanisms that support synchronizing activities and information are front-loading and flying start (Blackburn et al. 1996). With front-loading, group members in the upstream activities (e.g., requirements analysis) involve downstream members (e.g., design) by sharing information. This provides early warning of issues and avoids costly delays later on, which is especially important in requirements definition because requirement volatility is one of the major causes of project delay (Blackburn et al. 1996). Flying start involves transferring partial information from upstream to downstream activities to allow work to be done concurrently. An example of this is the “synchronize and stabilize” approach used by Microsoft and others where requirements specification, development, and testing are carried out concurrently before being stabilized ahead of the subsequent iteration (Boehm 2011). Consequently, even if the requirements phase is delayed as a result of intrusions, the downstream entities such as design have a head start and do not wait idly for input.

The acceleration effect of synchronization has been supported at a general level by empirical research (Blackburn et al. 1996). For example, a study of 140 completed product development projects in the electronics industry found significant time gains from overlapping development activities (Terwiesch & Loch 1999). This effect was especially strong when there was fast resolution of uncertainties in project parameters, since such uncertainties may trigger rework offsetting the time gains. In a mathematical model of a global software development team, Espinosa & Carmel (2003) showed that synchronizing activities significantly reduces coordination costs, which includes input and communication delays. In the group interruptions
literature, Ren et al. (2008) observed that to cope with interruptions, the hospital operating team synchronized their activities via joint problem solving, which included upstream (e.g., preoperative holding; anesthesia team) and downstream sub-groups (e.g., post-anesthesia care; care nurses). This coordination mechanism helped resolve coordination breakdowns and delays (e.g., putting operating rooms on hold; keeping patients and/or staff waiting). Based on the preceding analysis, we propose the following:

**Proposition 3b**: Because it allows software group members to put their interrupted activities back on track, temporal coordination (scheduling and deadlines; sequencing and prioritizing; synchronizing) will have a beneficial direct impact on group coordination effectiveness (temporal dimension).

**IT Interventions and Group Problem-Solving Coordination**

A central thesis of this paper is that the effects of IT interruptions on group coordination effectiveness are likely to vary with respect to the type of interruption. While we have argued in the previous section that IT intrusions are detrimental to group coordination outcomes and need to be mitigated, we now examine the effects of the other type of interruptions, namely interventions. Interventions – also referred to as discrepancy interruptions (Jett & George 2003) – produce a perceived inconsistency between an individual’s knowledge or expectations and actual observations about the primary activities (Jett & George 2003). Hence, interventions can be understood as providing feedback on task execution. A typical example of an intervention in the software development context is an interruption via email or bug tracking tool, which notifies a
software developer about a bug found in the software. Such an interruption may only point to the
nature of the problem, or it may also provide hints (e.g., comments from other developers) about
the solution.

The interruptive aspect of interventions stems from its effect of stopping the current
information processing mode and redirecting attention to the source of the discrepancy (Jett &
George 2003; Okhuysen & Eisenhardt 2002). In particular, interventions trigger a mindful mode
of information processing where individuals pay more attention to the task, actively attend to new
information, become open to different points of view, and heedfully relate their actions to those
of others collaborating with them (Jett & George 2003; Louis & Sutton 1991; Zellmer-Bruhn
2003).

Because of interdependencies among group members’ activities, such mindful group
members facing an intervention are motivated to coordinate their efforts organically via a group
problem-solving coordination mechanism (Grant 1996; Malone & Crowston 1994) in order to
resolve the discrepancy (Okhuysen & Eisenhardt 2002; Zellmer-Bruhn 2003). This is particularly
the case in software development situations where there are strong interdependencies among
lifecycle activities and among software modules and components. In such a coordination mode,
group members call upon each other to discuss the source of discrepancy, share knowledge about
the problem scope (e.g., what other parts in the system are affected by it), ask questions, solicit
opinions, summarize standpoints, vote on important issues, and orchestrate a collective approach
to solve the problem (e.g., Boos et al. 2011).

Hence, we expect a cross-level relationship where IT intervention intensity is an
individual-level construct and group problem-solving coordination is a group-level construct with
shared unit properties (shared construct). Group problem-solving coordination is a shared construct because all lower level units contribute to forming the collective construct (i.e., all group members can contribute to the discussions and group problem solving), but the value of the collective construct is not only determined by any single contribution at the lower level (Chan 1998). While individual group members’ standpoints on how to resolve the discrepancy may diverge, the actual coordination behavior where group members engage in these communication activities is likely to be shared across group members, meaning that group members are likely to converge in their tendency to share and discuss issues when faced with a discrepancy (Gittell 2002; van De Ven et al. 1976). In reality, of course, there are always variations with respect to the level of communication and discussion by each group member. However, such variance is not of significant theoretical importance in forming the higher-level construct (Chan 1998). In other words, individual differences in the level of communicating and problem solving are not an essential component in the conceptualization of group problem-solving coordination.

The specific type of composition of this construct is likely to be one of referent shift composition (Chan 1998). It is not an additive model or direct consensus model because the collective behavior of group problem solving is not composed by simply adding up individual problem-solving behaviors. In referent shift composition, the behavior is assessed via the individual-level group members, but the behavior essentially refers to a group behavior rather than an individual behavior that is subsequently aggregated (Chan 1998). Consensus is thus formed on the overall engagement of the group in group problem-solving coordination. Indeed, there is empirical support for such a conceptualization of group problem-solving coordination as a shared construct formed by referent shift composition (Faraj & Sproull 2000; Summers et al. 2012).
Evidence supporting our proposed relationship between IT interventions and group problem-solving coordination can be found in the extant literature. For example, Ritterskamp (2011) theorized that interruptions carrying information critical to the quality or completion of a group’s task (i.e., interventions) provide an emergent means of coordination through which group members process the problem domain and solution possibilities. Empirical evidence supports this relationship both at the single unit-level and at the cross-level. At the single unit-level, an experimental study of 45 problem-solving groups established that interventions trigger clusters of attentional activity in which group members engage in intense discussions, reorient their work processes, rethink how their task is performed, and better coordinate their knowledge (Okhuysen & Eisenhardt 2002). As the cluster increases, more and more team members join the discussion and more ideas are generated about how to resolve the task problems. Another study of 90 operational teams from the pharmaceutical industry found that the more group members faced interruptions, the more likely they were to collectively examine existing task knowledge for improvement and search for new knowledge about how to perform their tasks (Zellmer-Bruhn 2003). At the cross-level, Bechky & Okhuysen’s (2011) film crew investigation observed an intervention in which strong winds prevented the aerial effects coordinator from doing the planned shot. This triggered a group problem-solving coordination mode in which the aerial effects coordinator, the unit production manager, and the cinematographer shared knowledge (e.g., the unit production manager informed them about better weather conditions the following day), discussed alternatives, and jointly figured out how to resolve such a discrepancy. In a similar vein, Faraj & Xiao’s (2006) investigation of a medical trauma center revealed that when group members face crisis situations such as failing patient procedures, they resort to dialogic
coordination modes characterized by joint sensemaking and/or everyone chipping in across group boundaries to resolve the discrepancy.

In the context of software development, interventions such as discovered software bugs have been shown to trigger group problem-solving coordination. For instance, Espinosa et al. (2004) found that software development teams rely a lot on coordination via task organization, but that they "communicate heavily when they encounter unusual situations or errors that need to be repaired" (Espinosa et al. 2004, p. 120). In a field study of four small collocated software teams, Bertram et al. (2010) examined issue (bug) tracking tools that notified developers about discovered software bugs. They found that the tools interrupted developers with important discrepancies to be corrected, especially for the high-priority or "showstopper bugs" (p. 7). They also found that such interventions trigger a social process in which software team members use the tools to collectively conduct a "running dialog on the bug" (p. 5) and figure out ways to resolve them. The authors concluded that:

An issue tracker is not just a database for tracking bugs, features, and inquiries, but also a focal point for communication and coordination for many stakeholders within and beyond the software team. Customers, project managers, quality assurance personnel, and programmers all contribute to the shared knowledge and persistent communication that exists within the issue tracking system (p. 1).

Finally, Chong & Siino (2006) observed in their study of pair programming two developers who were interrupted with questions about why a functionality they developed did not allow a particular kind of test. That interruption then generated an “ensuing discussion [that grew] to encompass the entire team” (p. 31).
Proposition 4: Because of interdependencies among software group members’ activities, IT interventions create a window of opportunity for members to collectively discuss and address task discrepancies and issues. This is expected to trigger a group problem-solving coordination mode.

Group Problem-Solving Coordination & Group Coordination Effectiveness

Group problem-solving coordination is expected to enhance coordination effectiveness mainly by providing a large capacity of information processing and a platform for coordinating the expertise of group members in order to resolve discovered problems effectively (Nidumolu 1995; Okhuysen & Eisenhardt 2002). This relationship is especially salient in the context of software development, which is an information-intensive process. Indeed, group problem-solving coordination allows the software development group to “pool member knowledge and skills and collectively discover effective task strategies” (Andres & Zmud 2002, p. 62). For example, intense discussions between project members and users during requirement analysis should allow the group to better identify the source of problems in capturing requirements and to specify functionalities that will be better aligned with each other (technical coordination effectiveness) and with user needs (process coordination effectiveness). Moreover, group problem solving following a software bug intervention is likely to entail intense discussions among software engineers on how changes in one module affect other modules. In turn, such discussions are expected to enhance the extent to which the different modules work well together (technical coordination effectiveness).
Overall support for this relationship can be found in the knowledge integration literature. Indeed, Grant (1996) theorized that high-interaction group problem solving is one of the primary coordination mechanisms to achieve effective knowledge integration of group members. In an empirical study of 40 student groups, Okhuysen & Eisenhardt (2002) found that following an intervention, group members engage in a group problem-solving mode characterized by collectively seeking different kinds of evidence of the problem, shifting group leadership, and continuously asking each other to contribute. This coordination mode enabled the group to effectively integrate the separate pockets of knowledge of group members. Such integration went beyond knowledge sharing (individuals communicating their uniquely held knowledge to group members) because it meant that the knowledge resources held by group members were combined to create new knowledge (higher technical coordination effectiveness). Also, such group coordination effectiveness was achieved only when the interventions experienced by group members triggered problem-solving mechanisms focused on the group as a whole (group problem-solving coordination), rather than mechanisms that were internally focused (Okhuysen & Eisenhardt 2002).

Further empirical support can be found in the context of software development groups. For example, Espinosa et al. (2004) found that teams that effectively coordinated their tasks rely heavily on physical and digital communications for the less routine aspects of their work (e.g., making key decisions). They also found that technical personnel (software developers and testing specialists) rely on intense communication mechanisms to address errors and resolve discrepancies, and that this enables them to enhance their technical coordination effectiveness. Similarly, the non-technical personnel (e.g., project managers) enhance their temporal and
software process coordination effectiveness through intense group discussions and communications in the face of non-routine events.

Kraut & Streeter (1995) examined the relationship between group problem-solving coordination and coordination success in a field study of 563 team members working on 65 projects in a large software development company. They assessed group problem-solving coordination via the extent of group meetings, staff colocation, use of electronic communication media, and use of interpersonal networks. Coordination success was measured by the lack of duplication and redundancy in the work of group members (technical coordination effectiveness), and the extent to which the group avoids working in “crisis mode” (process coordination effectiveness). The study found that the extent of discussion with managers outside of the project (interpersonal network) enables knowledge sharing and provides group members and management with an accurate view of project progress, which in turn enhances group coordination effectiveness (technical and process dimensions). Also, these beneficial effects were most pronounced when projects exhibited uncertainty.

Another study on 64 software development projects in various industries investigated the effects of horizontal and vertical coordination on project outcomes (Nidumolu 1995). The results show that horizontal coordination (mutual adjustments, communications, and discussions between users and IS staff) enhances process performance and product performance. Although not directly matching, their measures of process performance (quality of interactions among group members; extent to which there was a controlled software process) are conceptually similar to the technical and process dimensions of coordination effectiveness.
Finally, Andres & Zmud (2002) conducted a laboratory experiment investigating the coordination mechanisms of 80 student subjects working in software development teams. That study found that organic coordination mechanisms – those mechanisms that are characterized by informality (horizontal discussions), cooperativeness (shared decision making) and decision decentralization – improve productivity and process satisfaction, especially when tasks are highly interdependent. While coordination effectiveness was not directly assessed as a separate construct, the process satisfaction scale included some items assessing coordination effectiveness. Consistent with the results from other studies, the authors concluded that “[I]informal horizontal communication channels enable the timely sharing of problem-solving expertise and clarification of one’s task outputs, which must ultimately be integrated with the work of others” (p. 45).

While we expect group problem-solving coordination – based on the above discussion – to enhance group coordination effectiveness via the technical and process dimensions, this is not necessarily the case for the temporal dimension. This is because while groups can work more productively together when in a problem-solving mode (Teasley et al. 2002), there are also process losses that diminish the expected efficiency gains. For example, electronic brainstorming research has established that group brainstorming triggers both process gains (e.g., cognitive stimulations; interaction synergies) and process losses (e.g., cognitive interferences; evaluation apprehension) that affect productivity (Pinsonneault et al. 1999). Furthermore, the group problem-solving mode triggered by interventions may sometimes slow down coordination because of additional time required to identify, locate, and resolve the discrepancy, rework aspects of the task, and so forth. We propose the following:
Proposition 5: Because it helps integrate the knowledge resources of software group members and aligns their efforts around an established process to deal with the discovered discrepancies, group problem-solving coordination is expected to enhance group coordination effectiveness (technical and process dimensions).

The Moderating Effects of Perceived Quality and Intervention Level

While IT interventions are likely to trigger a group problem-solving mode, this relationship is activated by two moderating factors operating at the individual level: (1) perceived quality of the intervention; (2) perceived intervention level (individually-oriented versus group-oriented).

Perceived Quality of the Intervention

The influence of perceived quality is rooted in the literature on feedback interventions (Ilgen et al. 1979; Kluger & DeNisi 1996). Specifically, feedback intervention theory posits that unless the individual receiving the intervention believes in its quality and the success of the behavioral shift required by it, he or she will not be sufficiently motivated to engage in actions that reduce the discrepancy (Kluger & DeNisi 1996). Gabelica et al. (2012) articulated this effect succinctly in their review of the interventions literature:

Indeed, if a feedback is interpreted as irrelevant and not useful for task completion or team functioning, team or team members can react to this feedback by ignoring, discounting, rejecting, and consequently not processing it. They would not use the feedback to make the desirable changes
for improvement nor implement more effective and efficient strategies if they do not assign meaning to the received feedback (p. 128).

Similarly, Ilgen et al.’s (1979) review of the feedback interventions literature pointed out that for the interventions to be acted upon, they have to be perceived as being valuable, correct, accurate, and useful to the recipient.

In the software development context, group members receive various interventions such as bug fixing requests and requirement change requests. Such interventions are likely to exhibit variations in perceived quality at the individual level. For example, software group members may believe that some required software changes are infeasible or too costly and should be postponed, or simply ignored. Unless they believe that such interventions are credible and really require immediate rework, they are unlikely to perceive a problem requiring pressing attention and thus unlikely to engage in group problem-solving coordination. In one study of 575 software team members, Hoegl & Parboteeh (2006) found that the perceived quality (feedback correctness and precision) and constructiveness of task feedback increased the software team members’ commitment to the team. We propose the following:

*Proposition 6: Because it motivates software group members facing IT interventions to engage in problem-solving behaviors rather than postpone or ignore the intervention, perceived quality is expected to activate the group problem-solving coordination mode (positive moderation effect).*
Perceived Intervention Level

The other factor that is expected to moderate the effect of IT interventions on group problem-solving coordination is the perceived level of the intervention (individual versus group level). Whether the intervention triggers an individual or group response is contingent on whether the intervention concerns an individual team member or the group as a whole. The explanation of this effect dates back to Zander & Wolfe (1964), who found that team members provided with team-level feedback shared more information with each other and expressed more trust in other team members. By contrast, team members facing individual-level feedback interventions developed less interest and trust to collaborate with one another. More recently, Hinsz et al. (1997) reviewed the feedback literature and concluded that team-level interventions switch the attention of team members from themselves to the team as a whole. Team members then attribute success, for example, to team processes whereas those provided with individual feedback attribute success to themselves. DeShon et al. (2004) examined 237 subjects forming 79 teams working on interdependent radar-tracking tasks. The results showed that when the feedback interventions provided to individuals were concerning the team, this leads to stronger team-focused (rather than individual-focused) efforts, and ultimately enhances team performance. Walter & Van der Vegt (2009) explicitly measured how the feedback was perceived by group members. They found that feedback perceived as concerning the overall team acts as a moderator that influences team learning facilitation and team innovation.

Others found that the effects of perceived intervention level depend on the level of interdependence within the team. For example, Archer-Kath et al. (1994) reported that individual feedback was more effective (e.g., leading to more positive group relations) than group feedback in student learning teams with low interdependence. Gabelica et al. (2012) suggested that team-
level feedback impacts team functioning especially when the team’s tasks are interdependent. Consequently, the moderating effect is expected to be very salient in software development groups where there are high levels of interdependencies. Indeed, Hoegl & Parboteeah’s (2006) study of 145 software development teams showed that task feedback concerning the team as a whole leads to increased team goal commitment. Consider the example of an email intervention delivered to a software group member, revealing a problem in a separate module segment that is not tied to other modules. That individual is likely to respond to the intervention alone without involving other group members. Subsequently, the effects of such an intervention are likely to occur at the individual level and thus fall beyond the scope of this paper. Conversely, if the email reveals a problem in a module segment that is intertwined with other developers’ modules, the group member is likely to engage the other members in group discussions and problem solving.

As another example, suppose a software group member receives an intervention revealing that the requirement analysis team did not define a requirement elicitation methodology. This is likely to trigger a problem-solving mode where individuals from the requirement team would get together and discuss how to collectively develop such a methodology (e.g., discuss requirement specifications definitions; develop a common requirement elicitation template), and how such methodology is likely to influence other software team members such as the design team.

Together, the above discussions suggest that when the IT interventions delivered to software group members concern the software team as a whole, this will likely motivate group members to direct their efforts toward group problem-solving coordination processes.

*Proposition 7: Because they direct the attention of software development group members toward team processes rather than personal behaviors, IT interventions that are perceived as*
oriented toward the team rather than the individual are expected to activate the group problem-solving coordination mode (positive moderation effect).

DISCUSSION AND IMPLICATIONS

The main objective of this paper is to shed light on the unexplored multilevel influence of IT interruptions on coordination effectiveness of software development groups. To understand the effects of such interruptions, we draw on coordination theory as a lens to delineate the interdependencies affected by different interruption types in software development activities, and the coordination mechanisms used to deal with such interdependencies. In doing so, we propose that, on one hand, intrusions will debilitate coordination effectiveness because they ripple through the group’s activities as a result of sharing and flow interdependencies, thereby constraining task execution. However, such coordination problems can be mitigated by the use of task organization coordination (role switching and temporal coordination). On the other hand, some intervention types (those with high perceived quality and that are related to the overall group) are likely to enhance coordination effectiveness because they provide windows of opportunity during which group members coordinate using group problem solving. Thus, different interruption types create different coordination issues and leverage different coordination mechanisms that shape the group’s coordination outcomes.
Suggestions for Future Research

Before discussing the implications of this research, some future research opportunities for extending our framework are identified. First, in linking IT interruptions to group coordination outcomes, we only considered explicit coordination mechanisms (task organization and group problem solving). More and more, implicit coordination is also becoming recognized as an integral aspect of group performance (Espinosa et al. 2004; Rico et al. 2008). While explicit coordination uses purposive planning or communications, implicit coordination is about anticipating actions and task demands and dynamically adjusting behavior (Rico et al. 2008). This subconscious mechanism has been found to be a complementary factor explaining group coordination and performance outcomes (Espinosa et al. 2004; Faraj & Sproull 2000). Therefore, our framework can be extended by including implicit coordination and examining how it interacts with IT interruptions and coordination outcomes.

Second, while we conceptualized interruptions as an individual-level phenomenon that spills over to the group level via interdependencies, an alternative way is to focus on subgroups in order to directly tackle the disparate interpretations of interruptions depending on the task roles of the interruption targets. Subgroups are entities within the group that share a unique form or degree of interdependence (Carton & Cummings 2012). In our context, we can classify different subgroups within the software development group such as analysts, designers, developers, testers, and integrators. This distinction has implications for our conceptualization of interruptions. For example, interrupting a developer with a task that is mostly relevant to the testing subgroup is considered an intrusion to the developer, but interrupting a testing specialist with the same task would be considered an intervention to the testing specialist. Hence, a subgroup or group faultline...
perspective can help us develop a more holistic representation of interruptions taking the different interests of the software development subgroups into account.

Third, empirical testing of the propositions developed in this paper is warranted to draw more valid conclusions. To do so, reliable and valid measures of intrusions and interventions need to be developed. Several approaches can be used to obtain such measures each with its advantages and disadvantages such as self-reported measures, direct observation, and diary studies. Also, testing the propositions requires multilevel modeling in order to test the multilevel effects of interruptions.

Finally, by classifying interruption types based on their content relevancy to the primary activities, we focus on two main types: intrusions and interventions. While this has limited the scope of our discussion to a manageable chunk of the interruptions phenomenon, we recognize that other interruption types (e.g., breaks and distractions; see Jett & George 2003) may also be interesting to examine (although these may have less salient effects at the group level). Alternately, other classifications of interruptions can be adopted in future research such as interruption mode, source, or temporal characteristics such as frequency and duration.

**Implications for Research and Practice**

This paper’s contributions have several implications for theory and practice. A main contribution of this research is to recognize how IT-based interruptions are experienced individually but spill over to the group level. Thus far, extant research has almost exclusively conceptualized interruptions as an individual phenomenon that affects individuals working on isolated tasks. Instead, we theorize – using coordination theory – on the multilevel effects of such
interruptions by exploring the coordination issues and mechanisms elicited by different types of interruptions. This contribution has several implications. First, not all interruptions are created equal. While much of the previous interruptions research conceives of interruptions as a monolithic, mostly negative phenomenon (e.g., Adamezyk & Bailey 2004; Ang et al. 1993; Beeftink et al. 2008; Burmistrov & Leonova 1996; Cutrell et al. 2000; Einstein et al. 2003), we develop propositions that suggest how different types of interruptions can exhibit positive or negative consequences. Second, and most important, this research has implications for researchers and practitioners to consider not only the immediate effects of singular interruptive events on an individual’s tasks, but rather to examine the wider social context in which the interruptions occur. Specifically, interruptions should be considered more holistically by examining how they affect interdependencies among the group’s activities and the subsequent consequences on the group’s coordination outcomes.

This research also contributes to the IT impacts literature by highlighting that IT implementations exhibit not only intended effects but also unintended effects, which remains an under-researched phenomenon. Orlikowski crystallized this tension in her longitudinal field study in the customer support department of a large software company (Orlikowski 1996). Using a situated change perspective, she showed that the organizational consequences of IT use are both intended and unintended and result from day-to-day reactions to unanticipated environmental contingencies. To address customer issues such as discovered software bugs, the customer support professionals used collaborative IT tools (Lotus Notes), which enabled both intended and unintended practices, each with its own set of outcomes. Also, the study showed how the customer service group reacts to some of the unintended consequences by drawing on new
coordination mechanisms (e.g., creating an intermediary monitoring role to handle the unanticipated reluctance to transfer calls).

Our study is thus similar to Orlikowski (1996) in identifying some of the unintended consequences of IT use. However, a key difference between both studies is the role of the technology and the nature of the consequences. Specifically, Orlikowski (1996) examines the task practices that result when the technology is appropriated into individuals’ work practices. By contrast, this paper focuses on the coordinative (team) practices that result when the technology disrupts the continuity of individuals’ work practices. Thus, we believe that our perspective provides a different angle with which to examine the intended and unintended effects of IT use.

For practitioners, one of the important implications of this research is that they can better manage interruptions within their organizations by using a coordination perspective. More specifically, managers can leverage different coordination mechanisms to mitigate the negative effects and reinforce the positive effects of different types of interruptions. On one hand, intrusions can be managed by relying on task organization coordination among group members. For example, project managers can design their teams by implementing role switching and temporal coordination (schedules and deadlines; task prioritization; synchronization) in order to prevent any negative effects of intrusions from propagating. This mitigating mechanism is crucial for managers since, for example, fixing an error that spans across multiple components requires three times more changes than localized errors. Also, such multi-component errors spill over to other phases seven times as much as localized errors (Li 2010). Given that software engineers spend over 70% of their time testing and debugging, with the average bug taking over 17 hours to fix and costing $50 billion per year (Ko & Myers 2005), the implications of using the proper coordination mechanism to control interruptions are clear.
On the other hand, managers can encourage groups to rely on group problem solving as a coordination mode to deal with any discrepancies interrupting the task flow such as discovered software errors. This is critical since prior research found that interventions create windows of opportunity that can be leveraged to address and resolve important task problems (Okhuysen & Eisenhardt 2002; Zellmer-Bruhn 2003).

**CONCLUSION**

In conclusion, IT interruptions elicit divergent, multilevel effects that extend beyond the individual being interrupted. To better understand the disparate effects that occur via different types of interruptions, the notion of interruptions needs to be extended to the group context by looking at what interdependencies exist, how these are affected by different interruption types, and how they are managed. Our study represents a step toward such extension of individual-level interruptions research to the group level in order to explain group coordination outcomes. It is our hope that our proposed model is empirically tested and further extended.
REFERENCES


LePine, J. A., Piccolo, R. F., Jackson, C. L., Mathieu, J. E., and Saul, J. L. "A meta-analysis of
teamwork processes: Tests of a multidimensional model and relationships with team
Li, Z. Characterizing and Diagnosing Architectural Degeneration of Software Systems from
Defect Perspective, Unpublished Dissertation, The University of Western Ontario,
Louis, M. R., and Sutton, R. I. "Switching Cognitive Gears: From Habits of Mind to Active
Lytytinen, K., and Robey, D. "Learning failure in information systems development," Information
Madjar, N., and Shalley, C. E. "Multiple Tasks' and Multiple Goals' Effect on Creativity: Forced
Incubation or Just a Distraction?," Journal of Management (34:4), 2008, pp 786-805.
Malhotra, A., Majchrzak, A., Carman, R., and Lott, V. "Radical innovation without collocation: A
Malone, T. W., and Crowston, K. "The Interdisciplinary Study of Coordination," ACM
Malone, T. W., Crowston, K., Lee, J., Pentland, B., Dellarocas, C., Wyner, G., Quimby, J.,
Osborn, C. S., Bernstein, A., Herman, G., Klein, M., and O'Donnell, E. "Tools for
Inventing Organizations: Toward a Handbook of Organizational Processes," Management
Mark, G., Gonzalez, V. M., and Harris, J. "No task left behind? Examining the nature of
fragmented work," Proceedings of the CHI Conference on Human Factors in Computing
Marks, M. A., Mathieu, J. E., and Zaccaro, S. J. "A Temporally Based Framework and Taxonomy
Massey, A. P., Montoya-Weiss, M. M., and Hung, Y.-T. "Because Time Matters: Temporal
Coordination in Global Virtual Project Teams," Journal of Management Information
of Recent Advancements and a Glimpse Into the Future," Journal of Management (34:3),
Matsui, T., Kakuyama, T., and Onglatco, M. L. U. "Effects of goals and feedback on performance
McDaniel, M. A., Einstein, G. O., Graham, T., and Rall, E. "Delaying execution of intentions:
overcoming the costs of interruptions," Applied Cognitive Psychology (18:5), 2004, pp
533-547.
McFarlane, D. C. "Comparison of Four Primary Methods for Coordinating the Interruption of
People in Human-Computer Interaction," Human-Computer Interaction (17:1), 2002, pp
63-63.
Miller, S. L. "Window of Opportunity: Using the Interruption Lag to Manage Disruption in
Complex Tasks," Proceedings of the 46th Annual Meeting of the Human Factors and
Ergonomics Society, Human Factors and Ergonomics Society, Baltimore, Maryland,
2002, pp. 245-249.


Walter, F., and Van der Vegt, G. S. "Harnessing positive mood for team learning facilitation: The role of perceived team feedback," Academy of Management Conference, Chicago, IL, 2009.


## APPENDIX 1: MECHANISMS BY WHICH INTRUSIONS RIPPLE THROUGH THE GROUP’S ACTIVITIES

**Figure 2: Interruption Spill-Overs in the Software Development Process**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Scope of IT-based Interruption</th>
<th>Example (based on hypothetical model shown in Figure 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Intrusion spillover within workers across tasks</td>
<td>Worker #2, who is involved in requirements elicitation activity, faces a system breakdown intrusion. This interruption may have spillover effects that delay worker #2 in another group activity involving the high-level design.</td>
</tr>
<tr>
<td>B</td>
<td>Intrusion spillover across workers within a task</td>
<td>Worker #6, who is working in group programming mode, is frequently interrupted by email requests for information. These intrusions may also affect the other group members by having to wait for input from worker #6, and/or through secondary disruption effects.</td>
</tr>
<tr>
<td>C</td>
<td>Intrusion spillover across tasks</td>
<td>A task switch intrusion that delays group members in the development activities may also affect the subsequent testing and validation activities that depend on input from the former</td>
</tr>
</tbody>
</table>
## APPENDIX 2: TYPES OF DEPENDENCIES AND COORDINATION MECHANISMS\(^{37}\)

<table>
<thead>
<tr>
<th>Dependency</th>
<th>Coordination Mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fit dependency (tasks share common output)</strong></td>
<td>• Negotiate a mutually agreeable result (e.g., two module owners developing an interface between two modules)</td>
</tr>
<tr>
<td>shareable resource, overlapping (two tasks specify different aspects of a resource)</td>
<td>1. Check for duplicate tasks</td>
</tr>
<tr>
<td>shareable or reusable resource, same characteristics</td>
<td>2. If tasks can be done simultaneously, merge tasks (e.g., one person to do them) or pick one task to do</td>
</tr>
<tr>
<td>non-reusable resource (conflicting)</td>
<td>3. If tasks are done at different times, reuse result of first task (e.g., reuse bug fixing solution)</td>
</tr>
<tr>
<td><strong>Sharing dependency (tasks share common input)</strong></td>
<td>• Pick one task to do</td>
</tr>
<tr>
<td>shareable resource</td>
<td></td>
</tr>
<tr>
<td>reusable resource</td>
<td>• No conflict</td>
</tr>
<tr>
<td>non-reusable resource</td>
<td>1. Notice conflict</td>
</tr>
<tr>
<td></td>
<td>2. Schedule use of the resource (e.g., first come/first served; priority order; budgets; managerial decision; market bidding; synchronization [when two tasks need to be done simultaneously])</td>
</tr>
<tr>
<td></td>
<td>3. Could also acquire additional resources</td>
</tr>
<tr>
<td><strong>Flow dependency (output of one task is input of another)</strong></td>
<td>• Pick one task to do or acquire additional resources</td>
</tr>
<tr>
<td>Prerequisite constraints (right time)</td>
<td>• Order tasks – notification; sequencing; tracking</td>
</tr>
<tr>
<td>Accessibility (right place)</td>
<td>• Inventory management (e.g., JIT) - Ship by right transportation modes or make at point of use</td>
</tr>
<tr>
<td>Usability (right thing)</td>
<td>• Standardization; ask users; participatory design</td>
</tr>
</tbody>
</table>

---

\(^{37}\) Source: Malone et al. (1999)
CHAPTER V. DISSERTATION SUMMARY AND CONCLUSION

SUMMARY OF THE DISSERTATION

IT interruptions represent a very salient and important phenomenon in the organizational environment, albeit one we know very little about. The goal of this dissertation is to shed more light on this phenomenon. This is done by developing a conceptualization of IT interruptions and examining the impacts of different types of IT interruptions on individual and group outcomes. Each of the three essays of this dissertation contributes part of the knowledge required to achieve this goal.

The first essay develops a conceptualization of IT interruptions based on a two-dimensional classification by (1) the direction of attention allocation based on the interruption’s content relevancy to primary task activities, and (2) the specific content of the interruption. Using a qualitative research design, a preliminary performance investigation is conducted in the first essay to further distinguish the different interruption types and subtypes. The results show variations in the effects on performance. IT intrusions exhibit negative performance effects while IT interventions enhance quality and learning but at the cost of decreased efficiency. A third category of hybrid interruptions emerges from the data analysis and is found to exhibit both positive and negative influences on performance.

The second essay further investigates the effects of IT interruptions on performance. By focusing on the case of email interruptions, that essay hypothesizes that different attention allocation mechanisms are responsible for mediating the effects of email interruptions on individual performance. Specifically, subjective workload mediates between email intrusion intensity and performance. Alternately, mindfulness mediates between email interventions
intensity and performance. The negative performance effects are reduced by the compensating factors of perceived control and multitasking self-efficacy.

The third and final essay explores the multilevel impacts of IT-based interruptions. While the interruptions are experienced individually, interdependencies between the tasks of group members are responsible for creating group-level effects. These effects also vary from positive to negative depending on the type of interruption. On one hand, intrusions debilitate group coordination effectiveness, but these effects can be mitigated by exercising task organization coordination. On the other hand, interventions enhance group coordination effectiveness by creating windows of opportunities during which group members practice group problem-solving coordination.

THEORETICAL CONTRIBUTIONS

Together, the three essays making up this dissertation provide important contributions to research and practice. First, the dissertation develops a conceptualization of the very widely spread but loosely defined phenomenon of IT interruptions. Much of the extant research manipulates this construct in laboratory setting without clearly defining it (e.g., Adamczyk & Bailey 2004; Cutrell et al. 2001; Cutrell et al. 2000; Czerwinski et al. 2000; Dabbish & Kraut 2004; Speier et al. 1997). This dissertation conceptualizes IT interruptions as a concrete phenomenon that has specific content, and which directs attention based on the relationship of such content to the primary task activities.

Second, the dissertation makes a very important point, which is that not all interruptions are created equal. Extant research has largely considered interruptions as a monolithic, negative phenomenon. This dissertation distinguishes between different types of IT interruptions and,
more importantly, shows that each type has a separate channel of influence on individual and group outcomes.

Third, the relationship between interruptions and performance has remained largely a black box. Empirical results relating interruptions to performance have been mixed and the mechanisms that link those two constructs have not been systematically explored. This research clearly hypothesizes on the positive and negative effects of different IT interruption types and traces the trajectory of each type to performance by identifying the attention allocation mechanisms that act as mediating factors. More specifically, this dissertation suggests – and shows – that subjective workload mediates between IT intrusions and individual performance while mindfulness mediates between IT interventions and performance. These mediating mechanisms are derived from psychological theories of attention allocation (cue utilization theory and mindfulness theory), and they help explain why the effects of IT intrusions and IT interventions are negative and positive, respectively.

Fourth, this dissertation identifies important compensating mechanisms that offset some of the negative effects of the IT intrusions. Specifically, perceived control and multitasking self-efficacy are presented as mitigating factors that exhibit interacting and direct effects on performance and subjective workload, respectively.

Fifth, this dissertation addresses a very important but largely untapped area, which focuses on the multilevel effects of interruptions. Although most organizational work occurs in settings where individuals perform tasks that are interdependent with the tasks of others, much of the research is confined to individuals who work on artificial, isolated tasks (e.g., Adamczyk & Bailey 2004; Cutrell et al. 2001; Cutrell et al. 2000; Czerwinski et al. 2000; Dabbish & Kraut 2004; Speier et al. 1997). This dissertation employs coordination theory as a theoretical tool to
unearth some of the multilevel effects of IT-based interruptions. The important insight emanating from this topic is that while interruptions are experienced individually, interdependencies among group members’ tasks cause ripple effects across the group. Using our taxonomy of the two different interruption types, we argue that each type influences group coordination effectiveness differently. Whereas intrusions debilitate group coordination effectiveness, which can be mitigated by task organization coordination, interventions enhance group coordination effectiveness through its effects on group problem-solving coordination. This theorization on the group-level effects of interruptions provides a much needed contribution to the literature.

**PRACTICAL CONTRIBUTIONS**

This dissertation also has implications for practitioners. Indeed, managers could apply the insights on the different types of interruptions by developing separate interruptions management policies for each type. For example, they may attempt to control the timings of some IT intrusions to occur at subtask boundaries or at points where a natural transition has taken place (e.g., by delaying some email arrival to points where a natural project milestone has been reached). Of course, this would require sophisticated filtering technologies and specific knowledge on the task progress and awareness of the interruption targets’ work states (Dabbish & Kraut 2004). Alternately, managers may design IT interventions to occur at moments where the task needs to be energized. For example, critical task feedback can be delivered electronically to individuals at periods where momentum has been lost or redirection is needed.

Furthermore, managers may apply the findings from this dissertation to help mitigate the negative effects of IT interruptions. More specifically, they can select individuals with a high level of multitasking self-efficacy for tasks that are known to be frequently interrupted.
Similarly, they may manipulate the degree of perceived control individuals have (e.g., via email handling rules and policies).

**AVENUES FOR FUTURE RESEARCH**

This dissertation opens up several avenues for future research inquiries. First, given the strong influence of IT intrusions and IT interventions on cognitive and behavioral outcomes, we feel that research efforts should be directed at identifying the antecedents of IT interruptions. This avenue may yield several sub-avenues that investigate the interruptions phenomenon as a dyadic interaction between the interruption source and target. While there is already active research in this area such as studies that investigate the interruption source’s awareness of the interruption source’s state (Dabbish et al. 2007; Dabbish & Kraut 2004), or performance tradeoffs between the source’s task delays and the target’s interruptions (Rennecker & Godwin 2005), much remains untapped in this area. For example: *What characteristics of the interruption target (e.g., knowledge; expertise; responsiveness; friendliness; availability) lead to an increased frequency of interruption?* Another question would be: *To what extent does the job role of the interruption source matter?* One would expect that interruptions from supervisors and managers would exhibit a larger influence on interruption frequency than interruptions from coworkers. Furthermore, properties of the IT artifact should be further explored. For example, more effort is needed to understand the extent to which the IT medium influences the frequency and/or duration of the interruption.

Second, the research conducted in this dissertation takes on a relatively deterministic variance approach (Mohr 1982). Since interruptions elicit a process of reactions including detecting, processing, and integrating the interruptions content (Iqbal & Horvitz 2007;
McFarlane 2002; Okhuysen & Eisenhardt 2002), future research could invest in a complementary process perspective of interruptions. At each step of this process, several cognitive and behavioral characteristics may be identified. Another question that may be answered via process research is: How do individuals assign meaning to an interruption and how do such meanings change over time? For example, in one interview from the first essay an informant pointed out that an email interruption could initially be perceived as an intrusion that is unrelated to his work portfolio, but could later develop to become a very relevant intervention. Research in this domain can draw on Langley’s (2009) concept of meanings as a primary object of research. Here, the interest would be not in the objective features of the interruption, but rather in its evolving meaning to individuals.

Finally, more empirical effort is needed to test the insights gained in this dissertation. For example, we feel that the conceptualization of IT interruptions developed in the first essay should be further validated and tested. In the second essay, we only partially tested that conceptualization by examining the IT interruption types without explicitly going into the level of the interruption subtypes. This was done in the interest of parsimony and since it was important to control cognitive demand on the survey respondents. Furthermore, the conceptual model developed in the third essay warrants empirical investigation. Since understanding the multilevel impacts of interruptions is a largely untapped domain, empirical testing of our model shall constitute an important theoretical contribution.
REFERENCES


