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ABSTRACT

Despite the growing emergence of information technology interruptions–those interruptions that are mediated or induced by information technology–little is known about their nature and their consequences on performance. This paper develops a taxonomy of information technology interruptions and presents propositions that relate distinct interruption types and subtypes to individual performance in project environments. A qualitative inquiry of product development teams is used to deductively validate the taxonomy and propositions, and to develop new insights based on an inductive analysis. The paper contributes to research by developing 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 that vary from positive to negative.

Keywords

IT interruptions; new product development; project performance; taxonomy; qualitative research.

INTRODUCTION

In light of the widespread diffusion of information technology (IT) in project environments to streamline the work of project team members, a byproduct of such diffusion is the increasing emergence of technology-based work interruptions (hereafter, IT interruptions), which reflect IT-induced or IT-mediated events that capture attention and break the continuity of a focal task. IT interruptions - such as synchronous and asynchronous information exchanges, computer multitasking, and system breakdowns - are a subset of work interruptions, and are especially significant in project environments. Extant research has shown the importance of IT interruptions in general work settings. For example a study on email interruptions showed that individuals receive over 100 emails per workday and spend 54 hours a year on non-business email (Jackson et al., 2003). Over 70% of such emails are addressed within six seconds and individuals take on average over a minute to recover from each interruption (Jackson et al., 2003).

However, despite significant headway made in HCI research in examining IT interruptions in either contrived laboratory settings or in real-life non-project settings, little is known about the nature and performance consequences of IT interruptions in project environments when tasks are interrelated and nested within larger projects. Also, while much of the research has adopted a general perspective of IT interruptions as a monolithic phenomenon with mostly negative performance consequences (e.g., Bailey et al., 2001, van den Berg et al., 1996), others found that IT interruptions can also have positive consequences (Ang et al., 1993, Jung et al., 2010). This paper suggests that a major reason for the mixed results lies in the fact that IT interruptions have not been systematically conceptualized. We pose the following question: *What are the different types of IT interruptions, and how does each type affect individual performance in a project environment?* To answer this question, we develop a taxonomy of IT interruption types both top-down through a multidisciplinary literature review, and bottom-up through an inductive analysis of qualitative data. The main premise is that IT interruptions have differential impacts, depending on interruption type and content. As we will elaborate, these impacts differ along a range of performance measures.

This research makes three main contributions. First, it develops a conceptualization of IT interruptions which can guide future research. Second, it extends the literature by developing a framework that examines IT interruptions in a realistic context, where individuals work on interdependent tasks that are nested within related projects. Finally, this research presents preliminary propositions that capture the unique behaviors of various IT interruption types and predict their relative effects on performance. In the process of doing so, we show the emergence of a new type of hybrid interruptions, and we predict their effects on performance.

THEORETICAL BASE & LITERATURE REVIEW

Our conceptualization of IT interruptions is shaped by two theoretical perspectives on attention allocation: capacity theory (Kahneman, 1973) and mindfulness (Langer, 1989, Louis and Sutton, 1991). According to capacity theory, interruptions divert limited attentional resources from the focal task and may increase an

individual's task demands such that they exceed attentional capacity, which is detrimental to task performance. Conversely, the mindfulness view suggests that some interruptions may reveal a discrepancy between an individual's actual and perceived performance and trigger a cognitive switch toward a more "mindful" state. Such mindfulness may expand attentional capacity and redirect attention toward better performing the focal task.

We conducted a literature review that was framed within Jett & George's (2003) conception of work interruptions. The review focused on refereed articles from multiple disciplines published within the past 30 years, where interruptions were in the form of IT events. 87 articles were used as a basis of this investigation.

IT INTERRUPTIONS TAXONOMY

Guided by the review, we define IT interruptions as *perceived, IT-based external events with content that captures cognitive attention, and thus breaks the continuity of a focal task*. Two broad IT interruption types are derived from Jett & George's framework: IT intrusions and IT interventions. IT intrusions reflect IT-based events that divert attention from the focal task (e.g., emails that divert a product designer's attention from design work to non-project issues), while IT interventions reflect IT-based events that refocus attention on the focal task (e.g., email feedback information on aspects relating to the project tasks). IT intrusions include the following subcategories: information transfers, task switches, and system intrusions. IT interventions include feedback interventions and formal interventions.

Our taxonomy is constructed in the context of individuals in project teams, who are responsible for one or more tasks that are nested in projects within each individual's project portfolio. Below we elaborate on each component of the taxonomy and propose how each influences the individual performance of project team members, conceptualized using a holistic view (Hackman, 2002) which includes individual productivity (project time; temporal switching costs; quality of work) and learning.

IT Intrusions

We define IT intrusions as *perceived events that are induced by or delivered via IT, and comprising content that is unrelated to an individual's project portfolio. These events break the continuity of actors' work and divert their attention from the focal task*. IT intrusions are defined with respect to interruption content and its relation to the focal task.

Information transfer intrusions

This subcategory comprises IT-mediated information exchanges (information requests and information dissemination) about contexts that are unrelated to individuals' project portfolios. Examples of information request intrusions from the prior literature include events that divert individuals' attention from their primary work activities, such as instant messaging help requests for actors performing game simulations (Dabbish and Kraut, 2004) and requests for office workers to look up information about published articles (Zijlstra et al., 1999).

With information dissemination intrusions, unrelated information is disseminated to individuals while working on the focal project. In the extant literature, the source of such intrusions ranged from general reminders, to various forms of notifications, such as displaying information about websites (Cutrell et al., 2000), and stock performance (e.g., Bailey et al., 2001).

Task switch intrusions

This subcategory reflects events where individuals suspend focal tasks and switch to secondary task contexts that are unrelated to their project portfolio. IT facilitates such task switching through using different applications at the same time, or using the same application to initiate multiple interactions simultaneously. 55% of the articles in the review investigated task switches – albeit at the singular task level, and mostly in laboratory settings (e.g., Adamczyk and Bailey, 2004).

System intrusions

This subcategory describes events that are actually induced – rather than mediated – by IT. First, consistent with the literature on technology features and sensemaking, system properties that are novel or discrepant from expectations can actually intrude on individuals' work and divert attention from the focal task toward the system's interface (Louis and Sutton, 1991). For example, a study of a computerized problem-solving task examined the effects of system response time on emotional states and task performance (Thum et al., 1995). Experimental work by Dabbish and Kraut (2004) investigated the amount of information provided by awareness display systems as a form of intrusion.

Second, system availability represents intrusions where system resources become unavailable to individuals, due to glitches, breakdowns, upgrades, etc. For example, France et al. (2005) identified computer malfunctions as system intrusions to the work of physicians.

IT Interventions

IT interventions are defined as *external IT-based events that occur during task performance, reveal a perceived discrepancy between performance expectations and actual task performance, and direct attention toward the source of the discrepancy*. This definition builds on Jett and George's (2003) discrepancy interruptions, and the literatures on feedback (Ilgen et al., 1979). IT interventions can be delivered by others via IT (e.g., email from a manager with instructions on how to complete a task), or generated by the IT system itself (e.g., system-generated feedback). Two types of IT interventions may

emerge: feedback interventions and formal interventions. As an example of feedback interventions, an experiment of 72 subjects examined computer-generated feedback about decision-making tasks (Ang et al., 1993).

PERFORMANCE EFFECTS OF IT INTERRUPTIONS

IT Intrusions and Individual Project Performance

Project time

All three IT intrusion subcategories consume project time for activities unrelated to an individual's project portfolio. For example, it was found that information transfer intrusions result in interruption lags that may increase overall task completion time (Cutrell et al., 2000). Similarly, France et al. (2005) found that computer malfunctions interrupted physicians in the emergency department and contributed to their inefficiency.

Proposition 1a: IT intrusions negatively influence individual productivity (project time).

Temporal switching costs

In addition to project time, IT intrusions incur productivity costs when individuals switch back and forth between interruptions and focal tasks and go through a process of cognitive suppression/ activation of cues associated with those tasks. This occurs mostly with task switch intrusions, since information transfers and system intrusions typically elicit fewer cognitively demanding secondary tasks that compete for individuals' attention. Many studies found that switching to new, computer-based tasks increased the time to complete those intrusive tasks (e.g., Bailey et al., 2001, van den Berg et al., 1996, McFarlane, 2002).

Proposition 1b: IT intrusions negatively influence individual productivity (switching costs).

Quality of work

IT intrusions may also impede the quality aspect of individual productivity. Such effects are less likely to arise from information transfers and system intrusions since they typically do not insist on action. However, frequent task switching to contexts outside the project portfolio hampers task performance quality (e.g., Speier et al., 1997). We propose that such adverse effects to task performance may escalate to overall project performance.

Proposition 1c: IT intrusions negatively influence individual productivity (quality).

Learning

IT intrusions are also likely to hamper learning, by reducing the time available to integrate new information, and through cognitive and capacity interferences that affect memory retrieval and thus learning. Indeed, extant interruptions research found that task switch intrusions hampered the retrieval of task cues both from prospective memory (McDaniel et al., 2004), and retrospective memory (Oulasvirta and Saariluoma, 2004).

Proposition 1d: IT intrusions negatively influence individual learning.

IT Interventions and Individual Project Performance

Project time and switching costs

Since IT interventions are by definition events that refocus attention on the focal task, they do not entail switching costs between focal and secondary tasks. However, such events may still consume project time as individuals 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.

Proposition 2a: IT interventions negatively influence individual productivity (project time).

Quality and learning

Per the notion of mindfulness, IT interventions enhance individuals' motivation and effort and channel their attention towards performance discrepancies, as to facilitate the successful completion of project tasks (Ilgen et al., 1979, Jett and George, 2003). Actors begin to actively and reflectively process task information in new and meaningful ways, rather than rely on pre-existing, abstract knowledge representations. For example, it was found that IT-induced feedback interventions resulted in a higher number of correct solutions in decision-making tasks, and more so than non-technology-mediated ones (Ang et al., 1993). Jung et al. (2010) found that computer-mediated feedback enhanced the individual performance of idea generation group members. With respect to formal interventions, Waller (1999) found that flight crew groups that experienced nonroutine events in the form of formal interventions performed better if they engaged in active thinking and collective information processing activities.

Proposition 2b: IT interventions positively influence individual productivity (quality).

Proposition 2c: IT interventions positively influence individual learning.

METHODOLOGY

Qualitative Design and Site Selection

A qualitative inquiry was deemed appropriate for data collection to elicit rich insights on the nascent area of IT interruptions, and examine them within their natural project team environment. Sites were selected among product development (NPD) teams, since IT interruptions are situated, temporal events that can be well-captured in the NPD context which relies on team members using IT while working on multiple tasks under tight time pressure.

Eight teams were selected, and we report on three such teams here. Those are referred to as Team Alpha (a small, Canadian-based company that develops engineering software solutions), Team Beta (a large, global company that makes gas turbine engines), and Team Gamma (a small developer of Web Analytics software).

Data Collection and Analysis

Data were collected primarily via in-depth, semi-structured interviews with NPD managers and team members. The interview questions were developed with the help of two qualitative methodology experts, pilot-tested with two NPD professionals, and documented in an interview guide. In all, 19 in-depth interviews were conducted, lasting about one hour each. Each recorded interview was transcribed, coded, and summarized in a contact sheet. Chains of evidence were constructed to reconcile the data with the theoretical dimensions defined earlier, and an analytic induction approach was used to develop additional IT interruption categories and propositions directly from the data.

RESULTS

Data from the qualitative inquiry support both the IT interruptions taxonomy and the performance propositions. For space limitations, we do not present the quotes here, but such evidence is available from the authors. We wish to highlight here evidence for a new type of hybrid IT interruptions which emerged from the data.

HYBRID INTERRUPTIONS

Our inductive data analysis uncovered a new IT interruption type that is a hybrid of intrusions and interventions. Here, individuals are interrupted with information transfers and task switches that, while unrelated to the focal task, are related to the focal project or to other projects within the project portfolio. Such hybrid interruptions are partly intrusions because they divert attention from focal tasks, and partly interventions because their contents help focus attention on aspects that are related to the individual's project portfolio. For example, informants described IT-based information transfers that dealt with other tasks they were involved in, other projects, or tasks of team members within the focal project. Similarly, informants described task switches where they had to switch from their focal task to other tasks within the same project, or to other projects within their project portfolio. Figure 1 illustrates the distinction between IT intrusions, IT interventions, and hybrid interruptions with respect to the relation of the interruptive event to the focal 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.

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 on hybrid IT interruptions that affect tasks embedded in interrelated projects. Hence, we develop these propositions inductively, based on insights from the qualitative inquiry. For example, insights from informants revealed that there were tradeoffs between productivity and learning when it comes to hybrid interruptions.

I would say 30% of [email interruptions] provide some extra additional information for the project. Not just necessarily related to the current project but related to overall development […] So definitely they disrupt your attention to some extent. Sometimes it is even useful distraction. You get new ideas or new information to think of […]it does not distract me from doing the main job with the pace I think it should be done. If it was too much so it slows down the overall project progress then probably I would say 'Hey, too much'. (Software developer 1, Team Alpha)

[Referring to client emails on prior product releases]: *For a single issue we got so many interruptions: one online meeting, two conference calls and 16 e-mails. 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 do not think so.* (Product manager 2, Team Gamma)

With respect to quality, perceptions of hybrid interruptions seemed to be mixed.

Sometimes, when I am in the middle of testing a product feature to see whether there is regression from the previous version, I get interrupted by developers who want me to test another product feature. I find somehow that if I test several features in the same day the quality will not be as consistent as when I test one feature each day even if the total time is the same. (Quality assurance specialist, Team Alpha)

[Referring to interruption requiring splitting attention among tasks that comprise 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 idea and you double check, so it gives you new knowledge that you can apply.* (Quality assurance specialist, Team Alpha)

We propose - based on the qualitative evidence - that hybrid IT interruptions exhibit negative effects on project time and switching costs, mixed effects on quality, and positive effects on learning. On the one hand, they allow project team members to gain access to new insights and knowledge that can be integrated into their focal tasks and projects in a way to enhance an individual's contribution to the quality of product deliverables. However, if excessive, having to split one's attention between the focal 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).

Proposition 3a: Hybrid interruptions negatively affect individual productivity (project time).

Proposition 3b: Hybrid interruptions negatively affect individual productivity (switching costs).

Proposition 3c: Hybrid interruptions have mixed effects on individual productivity (quality).

Proposition 3d: Hybrid interruptions positively affect individual learning.

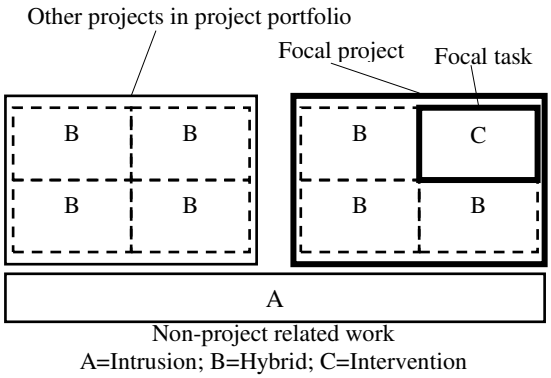

Figure 1. Intrusions; Interventions; Hybrid Interruptions

DISCUSSION & CONCLUSION

This research has integrated insights from prior, disparate research streams to produce a new model of IT interruptions which 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 and its relation to the focal task. The framework developed in this paper extends prior research in several ways. First, it opens new lines of inquiry that enable us to better conceptualize and operationalize phenomenon related to technology interruptions, and to better study such phenomena in situ. Second, the framework of IT interruptions can be refined by incorporating more interruptive events and focusing on other moderating factors. Third, the framework can be applied to other organizational contexts, such as to study the effects of IT interruptions on managerial work.

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