



# Transactions on Human-Computer Interaction

## THCI

Original Research

### Boundaryless Technology: Understanding the Effects of Technology-Mediated Interruptions across the Boundaries between Work and Personal Life

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#### Abstract

This study examines how technology-mediated cross-domain interruptions affect people's work and personal life on two aspects: level of conflict between work and personal life and people's ability to fulfill their responsibilities in each of the two domains. Based on the direction of an interruption, we differentiate between two types of cross-domain interruptions: work-to-nonwork (WTN) and nonwork-to-work (NTW). Drawing on interruption research and work-life interaction literature, we conceptualize distinct effects of the two interruption types on outcome variables. Data were collected through surveys from 137 knowledge workers. Results reveal asymmetric effects of WTN and NTW interruptions on work and personal life. The frequency of WTN interruptions is found to be positively associated with work-life conflict and negatively associated with fulfillment of personal life responsibilities, whereas the frequency of NTW interruptions significantly affects fulfillment of work responsibilities but not work-life conflict. Thus, results point to asymmetrically permeable boundaries between work and personal life. Results also suggest that the effects of WTN interruptions on fulfillment of personal life responsibilities are partially mediated by WTN conflict. The study concludes with implications for research and practice.

**Keywords:** Technology-Mediated Interruption, Work-to-nonwork (WTN), Nonwork-to-work (NTW), Work, Personal Life, work-life conflict, performance.

Joe Valacich was the accepting Senior Editor.

Chen, A. and Karahanna, E. (2014) "Boundaryless Technology: Understanding the Effects of Technology-Mediated Interruptions across the Boundaries between Work and Personal Life," *AIS Transactions on Human-Computer Interaction*, (6) 2, pp. 16-36.

## 1. Introduction

Technologies have wrought profound changes in professional and personal communications: they have changed our sense of time and location and blurred the boundaries between work and personal life. Mobile devices and applications are pervasive in today's workplace. However, along with the gained convenience and efficiency brought about by mobile devices that extend temporal and spatial territories, unintended (and often counterproductive) consequences have also emerged (Ayyagari, Grover, & Purvis, 2011; Weber, 2004). The same technologies that intend to bring about efficiency and productivity can actually pose a threat to the expected gains through an unavoidable by-product: technology-mediated interruptions. Knowledge workers have become accustomed to new ways of working, playing, and communicating. Mobile devices and applications allow people to be alerted for each incoming phone call, text message, instant message, email, calendar event, status update notification from social networking sites (e.g., Twitter and Facebook), breaking news, location-based information (e.g., a friend showing up nearby, promotions in the restaurants nearby), and so on. As a result, technologies create an ongoing stream of interruptions that are externally generated (i.e., initiated by other individuals or entities) and pushed to recipients.

As one of the most pressing human computer interaction (HCI) problems, technology-mediated interruptions represent a significant challenge to knowledge workers' ability to engage in anything that requires or deserves sustained attention (Friedman, 2006; McFarlane & Latorella, 2002). On average, a knowledge worker spends about 28 percent of a typical working day on unnecessary interruptions (Spira & Feintuch, 2005). At Intel, lost productivity due to the time spent handling unnecessary emails and recovering from interruptions translates into an estimated annual cost of \$1 billion (Hemp, 2009). Given their impact on workplace productivity, technology-mediated work-related interruptions have drawn significant scholarly attention. They have been found to negatively affect decision making performance (Gupta, Li, & Sharda, 2013; Liebowitz, 2011; Speier, Vessey, & Valacich, 2003), appraisal of work load (Kirmeyer, 1988), and emotion (Zijlstra, Roe, Leonora, & Krediet, 1999). Technology-mediated interruptions can also generate more subtle outcomes. Fragmenting an individual's workday, interruptions have been identified as a creativity killer (Amabile, 1998). Research has also shown that, as the human brain is asked to track too many data points in a multitasking-driven environment, an individual can behave in a counterproductive or unproductive manner, which can cause the individual to develop attention deficit traits (Hallowell, 2005).

In addition to these workplace consequences, technology-mediated work-related interruptions can also affect knowledge workers' personal lives. Given the increasingly permeable boundary between work and personal life due to mobile technologies, the occurrence and impact of work-related interruptions are no longer confined to the workplace. According to a 2008 AOL survey of 4000 email users in 20 major U.S. cities (AOL, 2008), 62 percent checked work-related emails over the weekend and 39 percent checked emails in a bar or club. How work makes inroads into knowledge workers' personal life through technology-mediated interruptions has been heatedly discussed in the popular media (e.g., Meece, 2011; Scelfo, 2010). Although the impact of technology-mediated work-related interruptions on people's personal lives has been acknowledged in scholarly literature (e.g., such interruptions are suggested as a factor for the positive association between the use of technologies beyond work hours and work-life conflict (Boswell & Olson-Buchanan, 2007)), the effects of such interruptions have not been directly theorized or tested in the literature. In the meantime, people's work domain is also subject to the influence of interruptions that originate from their personal life. The same technology that makes knowledge workers accessible to their colleagues and clients even after work also allows them to be reached by their family or friends while they are at work. While entertaining requests from personal life at work is seldom endorsed by organizational cultures that encourage professionalism and dedication, there is a paucity of scholarly research on how interruptions from people's personal life affect their work domain. Despite the wealth of literature investigating the effects of technology-mediated work-related interruptions in the work domain, cross-domain interruptions (i.e., interruptions that cross the boundaries between work and personal life) have not yet received much attention from researchers and thus need to be better understood. Specifically, cross-domain interruptions include work-to-nonwork (WTN) interruptions (that originate from work but take place in the domain of personal life) and nonwork-to-work (NTW) interruptions (that originate from personal life but take place in the work domain).

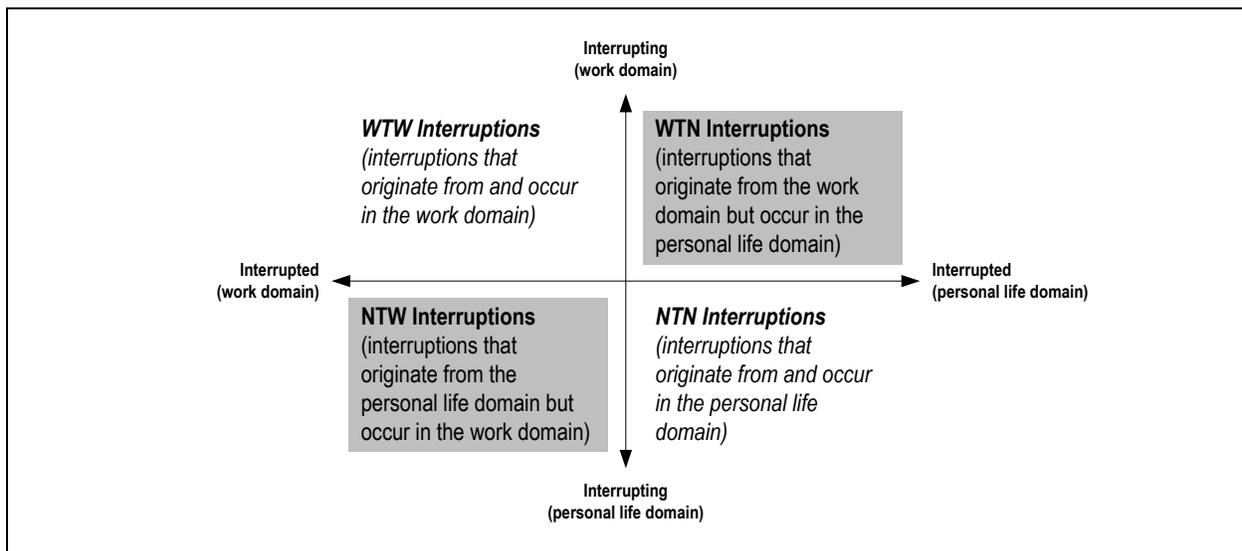
In summary, extant knowledge of technology-mediated interruptions is largely built on studies that focus on interruptions originating from and taking place in the work domain. These studies have significantly enhanced our understanding of technology-mediated interruptions. However, (1) the confinement of the

effects of work-related interruptions solely in the work domain and (2) the exclusion of nonwork-related<sup>1</sup> interruptions occurring in the work domain in these studies leave a gap in our understanding of how these cross-domain interruptions influence a knowledge worker's work and personal life. Therefore, this study addresses this gap by focusing on both WTN and NTW interruptions and examining their impact on both domains. By doing so, we extend research beyond the extant paradigm of work-related interruptions in the workplace (Russell, Purvis, & Banks, 2007) and, at the same time, answer the call to examine interruptions in richer contexts beyond the singular, isolated task level (Addas, 2010).

## 2. Theoretical Background

An interruption refers to "an externally generated, randomly occurring, discrete event that breaks continuity of cognitive focus on a primary task" (Corragio, 1990, p. 19). As a discrete occurrence, an interruption has a finite duration with clear starting and ending points. Technology-mediated interruptions are interruptions that occur via information communication technologies including both devices (e.g., iPad, BlackBerry) and applications (e.g., email and texting). For example, when people are called on their BlackBerry by a colleague during their family movie night, a technology-mediated interruption occurs via the phone function on the BlackBerry. Face-to-face interruptions such as a colleague knocking on the door or a child inviting themselves into one's home office are outside the scope of this research. As a form of dual task interference, the interruption phenomenon entails at least two tasks: the interrupting task (i.e., the interruption) and the interrupted task (i.e., the ongoing task whose continuity is broken by the interruption). In the case of technology-mediated interruptions, the interrupting task (i.e., the interruption) occurs via technology. The interrupted task, however, is not necessarily mediated by technology.

The definition of interruption also implies a typology based on the interrupting and the interrupted domains (Figure 1). The interrupting domain is the domain where an interruption originates. For example, a work-related interruption, such as a phone call from a client, originates from the work domain. The interrupted domain is the domain where an interruption occurs (e.g., receiving a client's phone call during the weekend when one is off from work implies that the interrupted domain is one's personal life). Given that we focus on cross-domain interruptions in this study, the interrupting task and the interrupted task are from different domains, which leads to two types of cross-domain interruptions (i.e., WTN and NTW interruptions, indicated by the shaded quadrants in Figure 1).



**Figure 1. Four Types of Interruptions Based on Direction**

Extant research on interruptions has primarily focused on the effects of work-related interruptions in the work domain (WTW) and has largely ignored their effects beyond the workplace (i.e., WTN). It has also

<sup>1</sup> In our discussion we use the terms "nonwork" and "personal life" interchangeably to refer to individuals' life domain outside of work. Whenever possible, we stick to the term "personal life" but, in other occasions switch, to the term "nonwork" for brevity (e.g., work-to-nonwork, nonwork-to-work, nonwork-related, nonwork performance, and nonwork load).

ignored NTW interruptions and their effects. Thus, we extend extant research on interruptions in three important ways. First, we differentiate between WTN and NTW interruptions based on originating/occurring direction. Given that both WTN and NTW technology-mediated interruptions represent important forms of technology use prevalent in knowledge workers' professional and personal life, it is critical to examine both to more fully understand the interruption phenomenon. The distinction is not merely semantic. We posit that WTN and NTW interruptions have asymmetric effects across work and personal life and thus our understanding of one does not necessarily generalize to our understanding of the other.

Second, the study focuses on cross-domain interruptions. We believe that cross-domain interruptions have different effects than within-domain interruptions (i.e., those that are initiated and occur in the same domain). Due to task interdependency, interruptions in the same domain can be beneficial by providing information that is related to the ongoing task and enabling its completion (Jett & George, 2003). For example, people in the workplace usually juggle multiple tasks simultaneously such as managing multiple open work-related communications (Reinsch, Turner, & Tinsley, 2008). Technology-mediated interruptions in this setting are an indispensable element in technology-mediated collaborative work and often related to the ongoing task. Thus, although such interruptions can produce counterproductive effects, they can also benefit the performance of the ongoing task by providing relevant information (Cameron & Webster, 2013). However, given the distinct nature of work and personal life activities, WTN and NTW interruptions are unlikely to provide information related to an ongoing task in the interrupted domain since the ongoing tasks pertain to different domains and generally have little to do with each other. Furthermore, cross-domain interruptions often incur higher transition costs than interruptions that originate and occur in the same domain because the mental model and behaviors deemed appropriate in one domain often significantly differ from those considered proper in the other domain (Ashforth, Kreiner, & Fugate, 2000). Therefore, we expect cross-domain interruptions to generate different implications to work and personal life than within-domain interruptions.

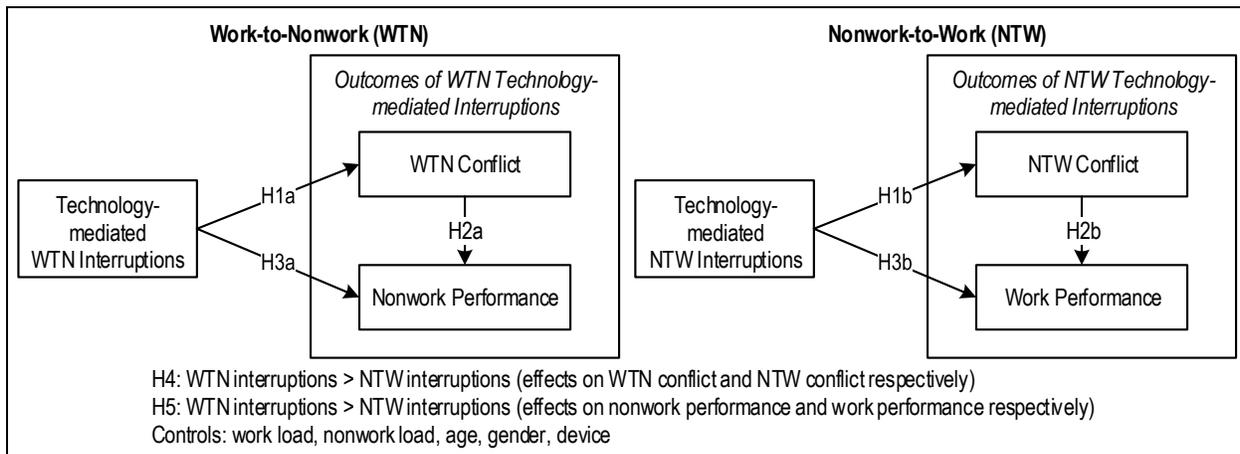
Third, this study examines interruptions that occur via a range of technologies. With very few exceptions (e.g., Latorella, 1996), previous studies focus on interruptions that occur through a single device such as the BlackBerry (e.g., Mazmanian, Yates, & Orlikowski, 2006) or a single application such as IM (e.g., Garrett & Danziger, 2007), rather than through all devices and applications an individual uses. Today's knowledge workers typically rely on a portfolio of communication applications such as email, phone call, IM, and texting that usually run on multiple devices including computers, smart phones, and tablets. These technologies have collectively created an electronic leash for users who can receive an email on their laptops and respond to it on their smart phones. Therefore, assessing the cumulative effects of interruptions that occur through a variety of applications independent of specific devices can provide a more realistic approximation of technology-mediated interruptions experienced by an individual and thus lead to a better understanding of how interruptions affect knowledge workers' work and personal life, which extends previous studies that are based on a single device or application.

### 3. Research Model and Hypotheses

A WTN technology-mediated interruption refers to a discrete occurrence that is externally generated from the work domain, is presented to an individual via technologies, and breaks the cognitive focus on an ongoing task in one's personal life domain (e.g., receiving a work-related phone call while having dinner at home). A NTW technology-mediated interruption refers to a discrete occurrence that is externally generated from the personal life domain, is presented to an individual via technologies, and breaks the cognitive focus on an ongoing task in one's work domain (e.g., having an IM chat with friends on one's laptop during a work meeting).

Drawing on the literature on interruptions (Latorella, 1996, 1998; McFarlane & Latorella, 2002) and work-life conflict (Greenhaus & Buetell, 1985), we theorize about the effects of cross-domain interruptions on the domain in which the interruption occurs (termed the interrupted domain) in terms of conflict between the two domains and about the fulfillment of responsibilities in the interrupted domain. Our focus on two types of cross-domain technology-mediated interruptions leads to two parallel research models (Figure 2): (1) the WTN model, where we theorize the effects of WTN interruptions on people's personal life in terms of WTN conflict and fulfillment of personal life responsibilities (which we term nonwork performance), and (2) the NTW model, where we theorize the effects of NTW interruptions on people's work in terms of NTW conflict and fulfillment of work responsibilities. The choice of work-life conflict and performance as outcomes

enables us to assess effects both at the holistic level (i.e., WTN conflict and NTW conflict that reflect an interplay between the two domains) and at the atomistic level (i.e., work performance and nonwork performance that reflect outcomes in just the interrupted domain).



**Figure 2. WTN and NTW Models**

### 3.1. Work-Life Conflict

Cross-domain interruptions provide an opportunity for shifting personal resources such as time, attention, and energy across the boundaries between work and personal life. Through WTN interruptions, resources from knowledge workers' personal lives are used to address work demands, whereas NTW interruptions allow them to mobilize their resources in the work domain to accommodate nonwork demands. As people's time, attention, and energy are finite resources, the shift of personal resources between work and personal life may create tension between the two domains. This tension can be exacerbated due to the externally generated nature of interruptions, when individuals get interrupted at an inopportune time with their availability unbeknownst to their communication partners who initiate the interruptions.

Conflict between work and personal life is a form of inter-role conflict due to incompatible demands from people's work and personal life so that participation in one makes participation in the other more difficult (Greenhaus & Beutell, 1985). The conflict between work and personal life is bidirectional by nature: WTN (from work to personal life) and NTW (from personal life to work). WTN conflict occurs when the general demands of, time allocated to, and strain produced from the work domain interferes with one's engagement in their personal life domain; whereas NTW conflict occurs when the general demands of, time allocated to, and strain produced from the personal life domain interferes with one's engagement in their work domain (Greenhaus & Beutell, 1985; Netemeyer, Boles, & McMurrian, 1996).

Two important underlying sources of conflict between work and personal life are time-based and strain-based conflicts (Greenhaus & Beutell, 1985), which directly result from consuming personal resources such as time, attention, and energy (both mental and physical). First, both WTN and NTW interruptions can foster time-based conflict. WTN interruptions extend work hours by invading one's personal life. They force knowledge workers to devote their personal time to work, which makes it more difficult for them to engage in personal life tasks. Prolonged work hours due to the use of mobile devices have been found to be associated with elevated work-life conflict (e.g., Middleton, 2007; Williams, Pocock, & Skinner, 2008). By the same token, NTW interruptions consume time that would otherwise be devoted to work, which makes it more challenging to fulfill work-related responsibilities with limited resources.

Second, both WTN and NTW interruptions can also create strain-based conflict. Strain-based conflict occurs when stress arising in one role spills over or is transferred to the other role, with the consequent strain symptoms (e.g., anxiety, irritability) being manifest in the second role (Greenhaus, Allen, & Spector, 2006). Cross-domain interruptions allow individuals to make effortless transitions between work and personal life, which facilitates the spillover of strain across the boundaries. Through each of these seemingly effortless transitions, strain generated from one domain may unavoidably and unknowingly transfer to the other domain, and eventually give rise to elevated levels of physical or psychological fatigue,

which undermines people's involvement in the interrupted domain. For example, a study of BlackBerry users has shown that people attribute stress and burnout to use of work-related email during their time off and lack of temporal/physical boundaries between work and life (Mazmanian et al., 2006). The diminishing boundaries between work and personal life make it increasingly difficult for stress and anxiety to be contained in the domain where they are generated. Other empirical evidence corroborates that people who set fewer boundaries for using information communication technologies for work in their personal life report higher work-life conflict (Olson-Buchanan & Boswell, 2006).

Although there is limited empirical evidence on the effects of NTW interruptions on NTW conflict, we expect the rationale discussed for the effect of WTN interruptions to hold in the NTW context as well. NTW interruptions induce psychological transitions from work to personal life, during which people are more likely to be reminded of the stress and anxiety that they leave behind when physically exiting their personal life domain or even be exposed to new ones that emerge while they attend to the additional nonwork demands brought about by interruptions.

**H1a:** *Frequency of WTN technology-mediated interruptions will be positively related to WTN conflict.*

**H1b:** *Frequency of NTW technology-mediated interruptions will be positively related to NTW conflict.*

### 3.2. Performance of the Interrupted Domain

While WTN conflict and NTW conflict capture how the dynamics between knowledge workers' work and personal life domains can be adversely affected by cross-domain interruptions, work performance and nonwork performance focus on how knowledge workers' effectiveness in work and personal life as the interrupted domain can be compromised due to cross-domain interruptions. Performance refers to how well one fulfills the general demands and responsibilities associated with a particular domain (Frone, Yardley, & Markel, 1997), which is a function of the amount of resources allocated to that domain. Cross-domain interruptions, by "stealing" the resources from the interrupted domain, may have both mediated and direct effects on knowledge workers' performance in that domain.

Cross-domain interruptions may indirectly affect knowledge workers' performance in the interrupted domain through the mediating effects of conflict between work and personal life. As we mention in Section 3.1, cross-domain interruptions can nurture conflict between work and personal life by shifting time and energy to the interrupting domain and thus leaving fewer resources to devote to the interrupted domain, which may eventually jeopardize knowledge workers' performance in the interrupted domain.

In the case of WTN interruptions, time-based conflict arises from WTN interruptions that transfer time and attention from personal life to work. It represents a form of resource drain in people's personal life; it hinders nonwork performance in that it reduces the stock of available resources for personal life demands (Edwards & Rothbard, 2000). Strain-based conflict also undermines people's ability to fulfill the responsibilities and demands in their personal life. It compromises nonwork performance through narrowed attention, self-absorption, or reduced overall well-being (e.g., health, satisfaction) (Edwards & Rothbard, 2000; Fredrickson & Joiner, 2002; Greenhaus & Beutell, 1985; Rothbard, 2001). The strain produced by work, such as anxiety, depression, frustration, irritability, tension, and fatigue that spill over through individuals' engagement in WTN interruptions can linger even after resumption of the ongoing task in the personal life domain and therefore interfere with performing their nonwork responsibilities (Bartolome & Evans, 1980).

In summary, WTN conflict mediates the effects of WTN interruptions on nonwork performance by hampering people's ability to engage in their personal life. By the same token, we expect NTW conflict to mediate the effects of NTW interruptions on work performance by hampering people's ability to engage in their work. For example, when people are bombarded with communications from family and social media updates from friends, keeping up with the information flow can be time consuming (time-based conflict) and bring about stress and anxiety from personal life (strain-based conflict), and will eventually interfere with their engagement at work, making it increasingly difficult to tackle their workplace to-do list.

**H2a:** *WTN conflict mediates the negative effect of WTN interruptions on nonwork performance.*

**H2b:** *NTW conflict mediates the negative effect of NTW interruptions on work performance.*

In addition to mediated effects, cross-domain interruptions may also directly affect knowledge workers' performance in the interrupted domain. The absence of a felt conflict between work and personal life, in terms of time-based and strain-based conflict, does not necessarily mean a positive outcome or a satisfactory experience in the interrupted domain. An interruption may not preclude knowledge workers' engagement in the interrupted domain, but can still undermine how effective they are in fulfilling the demands and responsibilities in the interrupted domain. Although people may boast about their technology-enabled capability to multitask, there is a growing concern with the deteriorating capability to stay on a task with undivided attention (e.g., Richtel, 2010). Technology-mediated interruptions deprive knowledge workers of the ability to concentrate on a task or immerse themselves in an activity.

Whereas our brains take about eight uninterrupted minutes to get into productive thinking and creative state, knowledge workers are typically interrupted every three minutes (Fried, 2005). Although people may find it manageable to chat with a friend on messenger while writing a work report simultaneously, they may unknowingly end up with an error-laden report that lacks creativity and that would have been in a better shape given fewer interruptions. Individuals who get interrupted take longer to complete a decision-making task and make poorer decisions than those who are allowed to concentrate on the task (Speier et al., 2003). Likewise, frequency of IM-based interruptions from peers and supervisors is associated with lower task quality in terms of errors made in a work-related task (Gupta et al., 2013).

We expect the above arguments, which are situated in a work-related context, to apply to personal life as well given the same mechanisms of how interruptions may jeopardize performance by hampering individuals' ability to stay focused. For example, the amount of time spent responding to several work emails or sending a few text messages on a family movie night may be negligible, but these interruptions may prevent people from immersing themselves in the movie and the family bonding time. When distracted by work-related interruptions from time to time during a family event, people may be proud of their ability to juggle work and personal life demands but be surprised to find their family offended by their absent-minded presence. Given the foregoing discussion, we expect WTN and NTW interruptions to negatively affect how well knowledge workers fulfill their personal life and work demands (i.e., nonwork performance and work performance respectively) by compromising their ability to concentrate on a task and immerse themselves in a domain. These effects will become more pronounced as the frequency of interruptions increases.

**H3a:** *Frequency of WTN technology-mediated interruptions will be negatively related to nonwork performance.*

**H3b:** *Frequency of NTW technology-mediated interruptions will be negatively related to work performance.*

### 3.3. WTN Interruptions vs. NTW Interruptions

We developed the preceding hypotheses based on the common nature shared by WTN and NTW interruptions; namely, both being cross-domain occurrences that break the continuity of an ongoing task and lead to competition between work and personal life for resources such as time, attention, and energy. However, an important distinction between the two types of cross-domain interruptions is the direction in terms of WTN (from work to personal life) or NTW (from personal life to work). The boundaries between work and personal life do not have the same level of permeability depending on the direction in which the boundary is penetrated (i.e., from work to personal life or from personal life to work) (Pleck, 1977). Given that work and personal life are distinctive domains with asymmetrically permeable boundaries, we expect knowledge workers to handle cross-domain interruptions differently based on their direction.

The asymmetrical permeability manifests in how individuals treat work and personal life in fundamentally different ways. People tend to give work higher priority than the personal life domain, which suggests higher permeability from work to personal life. Researchers of work-life interface have already acknowledged the asymmetric nature of the interaction between work and personal life by distinguishing between WTN conflict and NTW conflict. For example, several studies have found that individuals perceive higher WTN conflict than NTW conflict (Aryee, Luk, Leung, & Lo, 1999; Frone et al., 1997; Parasuraman, Purohit, Godshalk, & Beutell, 1996). One viable interpretation is that people are more willing to allow work demands to interfere with personal life than to tolerate nonwork demands getting in the way of work (Kinnunen, Vermulst, Gerris, & Mäkikangas, 2003; Frone et al., 1992).

Considering people's differential treatment of work and personal life in general, we expect them to be more responsive to WTN interruptions than to NTW interruptions. Therefore, while both WTN and NTW interruptions can increase the conflict between work and personal life and hinder performance, the effects of NTW interruptions are likely less detrimental than those of WTN interruptions. Due to the preferential treatment given to the work domain over personal life, WTN interruptions may have better chances at negotiating additional time, attention, and energy from personal life than NTW interruptions from work, and therefore nurture WTN conflict to a greater extent than NTW conflict. NTW interruptions, on the other hand, are more carefully scrutinized and moderated especially in organizational cultures that value professionalism and dedication to work.

**H4:** *Frequency of NTW interruptions has a weaker effect on NTW conflict than frequency of WTN interruptions has on WTN conflict.*

As such, due to the preferential treatment given to the work domain over personal life, knowledge workers tend to let more WTN interruptions into their personal life but, at the same time, tend to block more NTW interruptions from invading their work domain. Therefore, the work domain is more likely to be given individuals' undivided attention and best productivity time, which induce high performance. As such, we expect nonwork performance to be more susceptible to the adverse impact of WTN interruptions than work performance to the adverse impact of NTW interruptions.

**H5:** *Frequency of NTW interruptions has a weaker effect on work performance than frequency of WTN interruptions has on nonwork performance.*

### 3.4. Control Variables

We included five control variables in this study: work load, nonwork load, age, gender, and whether one's primary communication device was provided by one's employer. First, work load and nonwork load allowed us to control for the level of demands from an individual's work and personal life domains. Work load refers to an individual's perception of having too much work to do and not enough working time to do it, while nonwork load refers to an individual's perception of having too many personal life demands and not enough time for all (Schaubroeck, Cotton, & Jennings, 1989; Beehr, Walsh, & Taber, 1976). Work load has been found to reduce job performance (Gilboa, Shirom, Fried, & Cooper, 2008) and increase work-life conflict (Ahuja, Chudoba, Kacmar, McKnight, & George, 2007).

Second, demographic variables such as age and gender have been included as important factors in prior research on work-life domain interaction. Asymmetrical spillover effects have been suggested for both genders, with nonwork demands more likely to spill over into work for women and work demands more likely to spill over into personal life for men (Pleck, 1977). Moreover, men and women tend to weigh work and nonwork roles differently (Cinamon & Rich, 2002). We also included age as a control variable based on previous research on work-life interaction (e.g., Golden, Veiga, & Simsek, 2006) and strain (e.g., Ahuja et al., 2007; Moore, 2000).

Third, we also included a control variable that captures whether or not one's primary communication device was provided by their employer. How individuals treat WTN interruptions is socially and culturally shaped by their perceived organizational expectation of responsiveness (Hudson, Christensen, Kellogg, & Erickson, 2002; Mazmanian et al., 2006). A communication device provided or subsidized by one's employer can contribute to such perception and subsequently affect how individuals assess these interruptions.

## 4. Methodology

We empirically tested the research model and hypotheses in two stages. In the first stage, we interviewed 16 knowledge workers from 12 organizations on technology-mediated interruptions that they experienced in their work and personal life. The interviews totaled 20 hours and yielded qualitative data that informed our conceptualization and scale development.

In the second stage, we empirically tested the research model and hypotheses with a field study using a survey methodology for data collection. Through a web-based survey, we collected data from employees

at a Fortune 1000 technology firm. A total of 137 completed surveys were returned, yielding a response rate of 33.7 percent. Results of unpaired t-tests suggested no significant differences between individuals who responded before and after the reminder, which alleviates to some extent concerns about non-response bias (Armstrong & Overton, 1977). The respondents were fairly distributed across gender (59.4% female and 40.6% male) and age (53.5% below 50 and 46.5% over 50); most were not single (15% single and 85% married/significant other); and the majority used a device provided by their company (84.4% compared to 15.6% whose device was not provided by the company). We conducted a t-test to assess whether the single group significantly differed from the relationship group (i.e., married or significant other), and whether those who used a company-provided device significantly differed from those who do not across the variables in our research model. The non-significant results across all constructs suggest that there were no significant differences based on relationship status and on company-provided device.

All the variables in our model are measured with multiple items, which Table 1 summarizes. With the exception of WTN and NTW interruptions, we adapted the remaining items used in the study from existing validated scales.

**Table 1. Constructs and Measurement**

Construct (Definition)	Items <sup>a</sup>
<p>Frequency of WTN technology-mediated interruptions (the frequency with which one is interrupted in their personal life by an occurrence through a technology device or application that comes from one's work and breaks the cognitive focus on an ongoing task)</p> <p><b>Source:</b> Developed based on the literature and the interviews conducted during the first stage of data collection.</p>	<p><b>Frequency of WTN Interruptions</b></p> <p>Overall: During nonwork hours, how frequently are you interrupted by colleagues/other work contacts about work-related matters</p> <ul style="list-style-type: none"> <li>- [WTN-overall] overall through technologies such as phone call, email, IM, texting etc.?</li> </ul> <p>Composite: composite index created by the following items:</p> <ul style="list-style-type: none"> <li>- [WTN-phone] via phone call only?</li> <li>- [WTN-email] via email only?</li> <li>- [WTN-IM] via IM only?</li> <li>- [WTN-texting] via texting only?</li> </ul>
<p>Frequency of NTW technology-mediated interruptions (the frequency with which one is interrupted at work by an occurrence through a technology device or application that comes from one's personal life and breaks the cognitive focus on an ongoing task)</p> <p><b>Source:</b> Developed based on the literature and the interviews conducted during the first stage of data collection.</p>	<p><b>Frequency of NTW Interruptions</b></p> <p>Overall: During work hours, how frequently are you interrupted by family/friends/other nonwork contacts about nonwork-related matters</p> <ul style="list-style-type: none"> <li>- [NTW-overall] overall through technologies such as phone call, email, IM, texting etc.?</li> </ul> <p>Composite: composite index created by the following items:</p> <ul style="list-style-type: none"> <li>- [NTW-phone] via phone call only?</li> <li>- [NTW-email] via email only?</li> <li>- [NTW-IM] via IM only?</li> <li>- [NTW-texting] via texting only?</li> </ul>
<p>Work-to-nonwork conflict (occurs when the general demands of, time allocated to, and strain produced by the work interferes with one's engagement in personal life activities)</p> <p><b>Source:</b> Netemeyer et al. (1996)</p>	<p>[WTNC1] The demands of my work interfere with my personal life.</p> <p>[WTNC2] My work produces strain that makes it difficult to fulfill my nonwork responsibilities.</p> <p>[WTNC3] The amount of time my work takes up makes it difficult to fulfill nonwork responsibilities.</p>
<p>Nonwork-to-work conflict (occurs when the general demands of, time allocated to, and strain produced by personal life interferes with one's engagement in work-related activities)</p> <p><b>Source:</b> Netemeyer et al. (1996)</p>	<p>[NTWC1] The demands of my personal life interfere with my work.</p> <p>[NTWC2] My personal life interferes with my work responsibilities such as getting to work on time and accomplishing daily tasks.</p>

	[NTWC3] Due to the demands in my personal life, I frequently have to make changes to my work plans.
Work performance (refers to the fulfillment of the general demands and responsibilities associated with work) <b>Source:</b> Frone et al. (1997)	[WP1] I am viewed by my supervisor as an exceptional performer.
	[WP2] I am viewed as an exceptional performer in this organization.
	[WP3] I have a reputation in this organization for doing my work very well.
	[WP4] My colleagues think my work is outstanding.
Nonwork performance (refers to the fulfillment of the general demands and responsibilities associated with personal life) <b>Source:</b> Ashford, Rothbard, Piderit, & Dutton (1998); Kossek, Colquitt, & Noe (2001)	[NP1] My family thinks that I fulfill my family responsibilities very well.
	[NP2] My friends think that I fulfill the demands of my personal life very well.
	[NP3] My family thinks that I fulfill my family demands very well
	[NP4] I am viewed by my family/friends as fulfilling the responsibilities in my personal life very well
Work load (refers to an individual's perception of having too much work to do, but without enough working time to do them) <b>Source:</b> Schaubroeck et al. (1989); Beehr et al. (1976)	[WL1] I never seem to have enough time to get all of my work done during work hours.
	[WL2] It often seems that I have too much work during work hours for one person to do.
Nonwork load (refers to an individual's perception of having too many personal responsibilities to fulfill, but without enough personal time to do them) <b>Source:</b> Schaubroeck et al. (1989); Beehr et al. (1976)	[NL1] I never seem to have enough time to get every nonwork task done during nonwork hours.
	[NL2] It often seems that I have too many nonwork-related demands for one person to do during nonwork hours.
a. Items measuring the two independent variables (i.e., frequency of WTN and NTW technology-mediated interruptions) are 7-point Likert scales ranging from 1=very rarely, 4=occasionally, to 7=very frequently. All other items are 7-point Likert scales ranging from 1=strongly disagree, 4=neutral, to 7=strongly agree.	

## 5. Results

We used IBM SPSS Amos 21.0.0 to assess the psychometric properties of the scales and to test the research model. Descriptive statistics for the constructs, including means and standard deviations, are presented in Table 2.

### 5.1. Measurement Model

The confirmatory factor analysis (CFA) fit statistics shown in Table 3 indicate that both WTN and NTW measurement models have acceptable fit. We further examined the scales' internal consistency reliability and their convergent and discriminant validity. Composite reliabilities ranged from 0.86 to 0.95 (see Table 2), and were above the recommended 0.707 guideline (Fornell & Larcker, 1981). Thus our scales exhibit good reliabilities.

**Table 2. Inter-Construct Correlations**

WTN model	Mean (SD)	Reliability	1	2	3	4	5
1. Freq. of WTN	3.24 (1.23)	0.92	0.852				

interruptions							
2. WTN Conflict	3.72 (1.55)	0.88	0.625***	0.752			
3. Nonwork Performance	5.4 (1.25)	0.95	-0.541***	-0.623***	0.887		
4. Work Load	4.61 (1.66)	0.95	0.477***	0.746***	-0.376**	0.893	
5. Nonwork Load	3.88 (1.61)	0.88	0.268	0.332	-0.217	0.222	0.861
<b>NTW model</b>	Mean (SD)	Reliability	1	2	3	4	5
1. Freq. of NTW interruptions	2.96 (1.05)	0.9	0.884				
2. NTW Conflict	2.31 (1.23)	0.86	0.287*	0.716			
3. Work Performance	5.81 (0.93)	0.92	-0.171	-0.145	0.806		
4. Nonwork Load	3.88 (1.61)	0.88	0.468**	0.518***	-0.015	0.767	
5. Work Load	4.61 (1.66)	0.94	0.009	0.112	0.187*	0.236*	0.937

\*\*\*p<0.001 \*\*p<0.01 \*p<0.05

**Table 3. Model Fit Statistics<sup>2</sup>**

WTN model	Measurement Model (n=137)	Structural Model (n=137)
CFI	0.941	0.910
Chi-square/df	2.077 (114.245/55)	2.021 (183.921/91)
RMSEA	0.089	0.087
NTW model	Measurement Model (n=137)	Structural Model (n=137)
CFI	0.939	0.930
Chi-square/df	1.755 (96.515/55)	1.537 (139.854/91)
RMSEA	0.074	0.063

We further assessed discriminant validity in two ways. First, we compared the square root of the average variance extracted (AVE) (see Table 2) to the inter-construct correlations to assess whether the constructs shared more variance with their indicators (i.e., square root of AVE) than with each other (i.e., inter-construct correlations). As Table 2 shows, the square root of AVE (shaded leading diagonal) for every construct was larger than the inter-construct correlation (coefficients in the same row and in the same column) providing evidence of discriminant validity. Second, evidence of good discriminant validity is demonstrated when pairwise chi-squared tests indicate that a constrained CFA model where the correlation between a pair of constructs is constrained to 1 is statistically different than the unconstrained CFA model. Pairwise chi-squared tests for all pairwise combinations of constructs were significant, which provides further support for discriminant validity. Finally, the AVE for each construct was over 0.50, which suggests that at least 50 percent of the measured variance among indicators were explained by the latent factors (Fornell & Larcker, 1981), which provides support for convergent validity. Therefore, collectively these results point to adequate convergent and discriminant validity of all the constructs in our model.

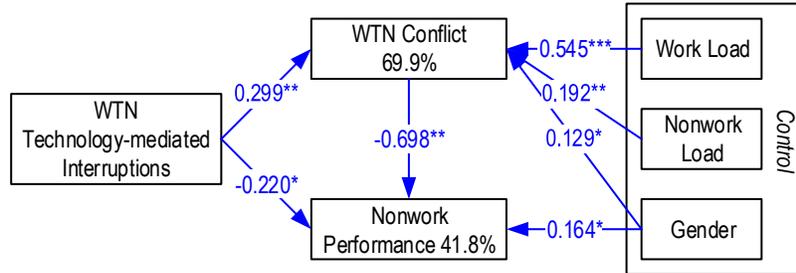
Given that we gathered both our independent and dependent variables at the same time from the same respondent using the same survey, common method bias is a potential concern. To assess common method bias, we conducted a CFA with all items loading on a common method factor in addition to their substantive factor. Results show that, although the loadings on the common method factor were significant (1) in the WTN model, the common method factor had an AVE of only 4.1 percent compared to 49.1-88.1 percent for trait factors; and (2) in the NTW model, the common method factor had an AVE of only 2.1 percent compared to 55.1-78.1 percent for trait factors. Thus, these results suggest that common method bias does not appear to be a significant concern.

## 5.2. Hypothesis Testing

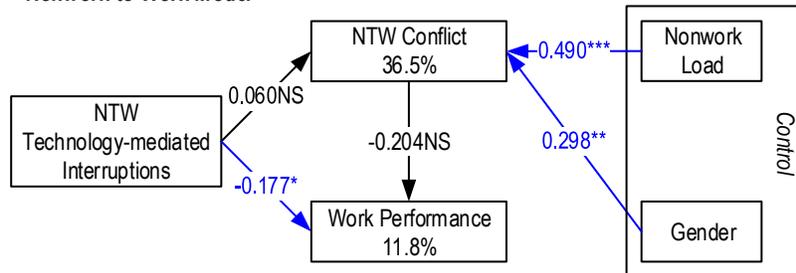
We tested the structural model using IBM SPSS Amos<sup>3</sup>. According to the fit indices (Table 3), the structural model demonstrates acceptable fit with the data. Figure 3 present the results of the structural model test.

<sup>2</sup> The fit indices shown in Table 3 suggest that the data fits the model well. The values are above the suggested cutoff of 0.90 for CFI and below the suggested cutoff of 0.10 for RMSEA and 3.0 for Chi-square/df (Kline, 2005).

<sup>3</sup> Statistical significance was assessed using one-tailed t-tests given the directional nature of our hypotheses.

**Work-to-Nonwork Model**

Controls	Work load	Nonwork load	Age	Gender	Device
WTN conflict	0.545***	0.192**	0.104NS	0.129*	0.029NS
Nonwork performance	0.265NS	0.087NS	0.099NS	0.164*	-0.035NS

**Nonwork-to-Work Model**

Controls:	Nonwork load	Work load	Age	Gender	Device
NTW conflict	0.490***	-0.009NS	-0.084NS	0.298**	0.006NS
Work performance	0.156NS	0.158NS	0.082NS	0.074NS	0.155NS

\*\*\* $p < 0.001$ ; \*\* $p < 0.01$ ; \* $p < 0.05$  NS: Non-significant

Blue color indicates significant paths ( $p < 0.05$ )

Only significant paths from the control variables are shown in the figures.

**Figure 3. Structural Model with Results**

### 5.2.1. Conflict between Work and Personal Life

The WTN model explained 69.9 percent of the variance in WTN conflict with WTN interruptions ( $\beta = 0.299$ ,  $p = 0.002$ ) and the control variables work load ( $\beta = 0.545$ ,  $p < 0.001$ ), nonwork load ( $\beta = 0.192$ ,  $p = 0.009$ ), and gender ( $\beta = 0.129$ ,  $p = 0.048$ ) being significant predictors. Thus, H1a is supported.

The NTW model explained 36.5 percent of the variance in NTW conflict with the control variables nonwork load ( $\beta = 0.490$ ,  $p < 0.001$ ) and gender ( $\beta = 0.298$ ,  $p = 0.001$ ) being significant predictors. Given the non-significant main effect of NTW interruptions ( $\beta = 0.060$ ,  $p = 0.282$ ), H1b is not supported.

### 5.2.2. Performance of the Interrupted Domain

For the WTN model, results show that WTN conflict significantly mediated the effects of frequency of WTN interruptions on nonwork performance (Sobel test statistic=-2.147,  $p=0.032$ ), which supports H2a. Further, frequency of WTN interruptions ( $\beta=-0.220$ ,  $p=0.043$ ) was negatively related to nonwork performance, which supports H3a. Collectively, the WTN model explained 41.8 percent of the variance in nonwork performance.

For the NTW model, H2b is not supported as shown by the non-significant effect of NTW interruptions on NTW conflict ( $\beta=-0.060$ ,  $p=0.282$ ). Frequency of NTW interruptions was negatively related to work performance ( $\beta=-0.177$ ,  $p=0.045$ ), which supports H3b. Collectively, the NTW model explained 11.8 percent of the variance in work performance.

### 5.2.3. WTN Interruptions vs. NTW Interruptions

As shown by the results, WTN interruptions significantly affected both WTN conflict ( $\beta=0.299$ ,  $p=0.002$ ) and nonwork performance ( $\beta=-0.220$ ,  $p=0.043$ ), whereas the effects of NTW interruptions were statistically significant only on work performance ( $\beta=-0.177$ ,  $p=0.045$ ) but not on NTW conflict ( $\beta=0.060$ ,  $p=0.282$ ). Comparing the WTN and NTW models provides support for H4 that WTN interruptions have a stronger effect on WTN conflict than NTW interruptions on NTW conflict. We further statistically compared the effects of WTN and NTW interruptions<sup>4</sup>. The significant t-statistic provided statistical support for H5 that WTN interruptions have a stronger effect on nonwork performance than do NTW interruptions on work performance ( $t=-0.314$ ,  $p<0.01$ ). This suggests that WTN interruptions affect one's personal life to a greater extent than NTW interruptions affect one's work domain.

## 6. Discussion

The study provides a nuanced conceptualization of cross-domain technology-mediated interruptions, and categorizes them into two types based on their direction (i.e., WTN and NTW). Drawing on interruption studies in HCI and the work-life literature, we developed a research model that examines how cross-domain interruptions affect the conflict between work and personal life and performance in the domains in which the interruption is experienced (termed interrupted domains). Results based on survey responses from 137 knowledge workers from a single organization provide support for all the theorized relationships for WTN interruptions and partial support for NTW interruptions. This supports our theoretical contention that the direction of an interruption (i.e., whether it is from work to personal life or from personal life to work) is consequential.

Specifically, work-related interruptions during people's time off and nonwork-related interruptions in the workplace have distinct effects on their corresponding outcomes, which suggests that the effects of cross-domain interruptions are asymmetrical across work and personal life domains. WTN interruptions seem to be associated with more negative outcomes on personal life than NTW interruptions on the work domain. Whereas frequency of WTN interruptions seems to be a significant antecedent to both WTN conflict and fulfillment of personal responsibilities and appears to erode personal time and energy, NTW interruptions significantly affect work performance but not NTW conflict. The asymmetrical effects observed in our study are consistent with the findings of previous work-life studies where individuals perceive higher degree of work interference with personal life than personal life interference with work (e.g., Aryee et al., 1999; Frone et al., 1997; Parasuraman et al., 1996). Despite the possibility of individuals under-reporting how much their nonwork demands interfere with work, the perceived asymmetrical effects may also be due to our respondents' tendency to give preferential treatment to work over their personal life, which is often a deliberate choice given the preponderant role played by work in generating the financial foundation of their personal life and given the norms of workplace professionalism, at least in cultures such as the United States. In this context, it is possible that people may make the boundary of their personal life more permeable so that they can attend to work demands even during their time off. On the contrary, they may take precautions to avoid jeopardizing work performance when dealing with NTW interruptions at work. This significantly reduces the probability that occurrences of NTW interruptions interfere with the work domain.

<sup>4</sup> To compare the effects, we calculated a t-statistic using the formula  $t = \frac{\beta_1 - \beta_2}{\sqrt{s_1^2 + s_2^2}}$ , where the denominator is the pooled standard error of the path coefficients  $\beta_1$  and  $\beta_2$ .

Another important finding of the study is that WTN interruptions have both direct and mediated effects on nonwork performance. This suggests two ways that WTN interruptions can affect nonwork performance. First, WTN interruptions affect people's nonwork performance by adversely influencing their ability to engage in personal life (an indirect effect via work-life conflict). Second, WTN interruptions can also negatively affect nonwork performance without engendering WTN conflict. Some technology-mediated interruptions are communicative or information-seeking in nature. Although the amount of resources they consume is not substantial enough to hinder individuals from engaging in the interrupted domain, they nonetheless undermine the quality and effectiveness of such engagement (e.g., increased error rate, and reduced enjoyment). The mediated effects on performance may represent more intuitively expected outcomes of interruptions than the direct effects. Ubiquitous modern technologies enable knowledge workers to juggle demands from multiple sources to balance work and personal life (Erickson, 2008). Under the guise of the gained convenience, however, there is a growing difficulty to stay on a task with undivided attention, which can result in subdued creativity and compromised quality. These subtle outcomes may not be immediately felt or eventually attributed to interruptions. Although some may argue that human brains may be able to adapt to interruptions (Sullivan & Thompson, 2013), the subtle ways (e.g., in terms of subdued creativity and compromised quality) that knowledge workers can be adversely affected in their work and personal life are nonetheless noteworthy before the mechanisms and outcomes of such adaptation become clearer.

## 7. Limitations and Future Research

Our findings' implications need to be interpreted in light of the limitations of the study. First, given the cross-sectional nature of research design, causality statements were based on our theoretical development and not on the time-ordering of our measurement. Future studies could take a longitudinal approach to more fully assess causality. For example, while WTN and NTW conflict can influence nonwork and work performance respectively, the opposite direction is conceivable as well. Lack of performance may induce conflict; that is, one's feeling that they are coming up short in performance could trigger perceptions of conflict. Longitudinal studies are needed to disentangle these effects.

Second, respondents may have over-reported desirable behaviors and outcomes and under-reported undesirable ones given that we assessed our variables with self-reported measures. On one hand, although our measures are widely used in the work-life literature (e.g., Hammer, Kossek, Anger, Bodner, & Zimmerman, 2011; Kossek et al., 2001), it is possible that frequency of NTW interruptions and its negative effect (i.e., NTW conflict) are under-reported. On the other hand, in order to be viewed in a more socially desirable way, respondents may have over-reported their assessment of work-life conflict and performance, which would result in the effects of cross-domain interruptions on these outcome variables being conservatively estimated.

Third, we tested our model with a sample population from a single organization in the United States. Though data collection from a single organization has the advantage of controlling for many organizational-level variables (e.g., organizational culture) and though the research site was not an atypical organization in terms of its culture or nature of knowledge workers, generalizability of the results requires replication across different organizations and industries. And the study was conducted in the United States where there is a lot of emphasis on instrumental values and more blurring of work and personal life. Furthermore, composition of the sample population may have also affected our findings. Men and women prioritize their work and family roles differently (e.g., Jennings & McDougald, 2007; Martins et al., 2002). People may give greater priority to family as they age (Jennings & McDougald, 2007) and millennials tend to prioritize their lifestyle and relationships over work (Smith, 2010). Although we controlled for age and gender, other characteristics (e.g., family status and religion) of the sample population may have affected the generalizability of our findings. An interesting direction for future research would be to examine these relationships using a sample population with a different composition such as across organizations with work climate varying on the degree to which they accept attending to nonwork demands during work, in cultures where there is a higher separation between work and personal life, and with a different distribution in terms of family status and religion. Though prior studies report different patterns of prioritization (e.g., Jennings & McDougald, 2007; Martins, Eddieston, & Veiga, 2002), no theoretical explanations have been provided to explain these results. Providing rich theorizing to explain the empirically observed prioritization patterns would be a fruitful avenue for future studies. For example, role salience may be a promising theoretical lens that could explain why people prioritize their work and personal life domains differently.

The research model and the hypotheses developed in this study provide avenues for future research. First, an interesting research avenue for cross-domain interruptions would be to identify potential consequences other than those examined in this study. We examined the consequences of WTN and NTW interruptions through domain-specific constructs (i.e., conflict and performance). Other consequences such as psychological outcomes in terms of emotional dissonance and exhaustion (Rutner, Hardgrave, & McKnight, 2008) could be further identified and tested. Furthermore, a follow-up study should be conducted to identify the factors that account for the distinct effects of WTN and NTW interruptions on work and personal life. As our data suggests, WTN and NTW interruptions do not lead to symmetrical effects. Additional research on this would enable researchers to understand how use of the same communication technologies can generate distinct outcomes, and allow practitioners to develop different sets of tools that enable knowledge workers to optimize their experience in both domains.

Second, future research could focus on identifying the specific aspects of an interruption that account for its negative consequences. Whereas the negative consequences of work-related interruptions in the work domain have been well documented, our study has only found partial support for the hypothesized negative effects of NTW interruptions on the work domain. In particular, as our data suggests, NTW interruptions significantly jeopardize work performance but do not induce NTW conflict. Future research could examine what aspects of work-related and nonwork-related interruptions account for their distinct effects (e.g., duration, intensity, urgency, societal or organizational norms, etc.). Moreover, whether an interruption is externally generated (focus of the current study) or self-initiated represents an interesting aspect that future research could assess to further our understanding of the interruption phenomenon. Individuals may have greater control over the frequency, duration, and nature of an interruption if the interruption is initiated by themselves rather than by other people, which may lead to distinct outcomes of other-initiated and self-initiated interruptions in people's work and personal life.

Third, follow-up studies could extend our research by adopting objective measures of the variables in our research model. Although it may not be feasible to collect communication logs of all the communication media examined in this study (i.e., phone, email, IM, and texting across devices), future research could focus on a single device to collect objective measures across applications or on a single application to collect objective measures across devices. Likewise, it would also be worthwhile, yet challenging, to collect objective data on performance such as human resources evaluation records or assessment by other people such as the respondents' family members or supervisors.

Fourth, further research is needed to understand how knowledge workers can manage interruptions. The seemingly effortless use of the technology has brought a challenge: how to maintain proper focus on the tasks while responding to the demands delivered via a large diversity of devices and applications. Therefore, how to manage the constant technology-mediated interruptions represents a major challenge faced by knowledge workers. Interruption management mechanisms could be developed by individuals to cope with the negative outcomes of technology-mediated interruptions. They could be based on technologies, social norms, and self-discipline, and each of these may be differentially efficacious in mitigating negative effects of interruptions (Chen, 2011). Future research on this topic would be beneficial. Specifically, future research could identify the various types of interruption management mechanisms, how they develop, and how they mitigate the negative effects of interruptions.

## 8. Contributions and Implications for Research and Practice

This study contributes to research and practice in several ways. The contribution to research is threefold. First, this study examines the negative effects of information communication technologies. Recent literature has started to assess the unintended negative outcomes of technology use (Ayyagari et al., 2011; Cameron & Webster, 2011). In response to the call for research on problematic use of technologies (Weber, 2004), we hypothesized and tested negative effects of technology-mediated interruptions.

Second, it represents one of the first studies that offer a nuanced view of technology-mediated interruptions in that it differentiates WTN and NTW interruptions and examines their effects on people's work and personal life. The increasingly pronounced consequences associated with ubiquitous technologies have generated a body of research on technology-mediated interruptions. However, prior research focuses predominantly on interruptions that are generated and occur in the work domain. We

focus on two types of cross-domain interruptions—those that originate from work but occur in personal life and those that originate from personal life but occur at work—and provide empirical evidence of their distinct outcomes. Moreover, making the distinction based on the direction of an interruption also enriches the research on individuals' technology use in that diverse outcomes can emerge from using the same technology across the domains of work and personal life.

Third, the research contributes to the work-life literature by examining technology-mediated interruptions as a transitory form of role transition as opposed to institutionalized ones such as telecommuting and flextime. Modern technologies have greatly shaped how knowledge workers define work and personal life and how they demarcate boundaries between the two domains. Although telecommuting and flextime represent important arenas where work and personal life interact, more and more such interaction occurs during transitions between work and personal life that occur on the fly through such technology-mediated interruptions. Therefore, we need to understand technology-mediated interruptions in the context of how the new generation of knowledge workers dynamically interweaves their work and personal life domains.

Our study has important implications for practice. First, the study highlights the detrimental effects of cross-domain interruptions. Specifically, WTN interruptions turned out to be more detrimental than NTW interruptions, with the former having negative effects on both WTN conflict and nonwork performance but the latter only adversely affecting work performance and to a lesser extent than the former's effects on nonwork performance. Work and personal life are two interdependent life domains. Recovery experiences during off hours such as detachment from work and relaxation play a crucial role in allowing knowledge workers to recuperate and get ready for the next working day (Sonnentag, Binnewies, & Mojza, 2008). As such, organizational norms surrounding work-related technology-mediated interruptions during time off work should be consciously developed to facilitate knowledge workers' recovery experiences during their restorative downtime. But, equally importantly, knowledge workers, who are also more prone to technology-mediated interruptions, should have interruption management tools available to erect boundaries when they deem necessary. Application and device designers could develop functionality that enables intelligent interruption management (e.g., iPhone's "Do Not Disturb" functionality). Knowledge workers should also be made aware of different ways in which interruptions can be managed. Identifying effective interruption management mechanisms would be an important direction for future research in this domain.

Moreover, it requires the efforts of both communication partners to mitigate the negative effects of WTN interruptions. People who initiate interruptions should minimize the number of unnecessary communications (e.g., combining related topics to generate fewer messages, or flagging emails with exclamation marks or red flags only when necessary). People who receive interruptions should actively engage in some interruption management techniques to keep interruptions under control (e.g., color-coding email senders as a filter tool, or simply resisting the temptation to check IM messages every time there is a new message alert).

Given that cross-domain technology-mediated interruptions are unavoidable for today's knowledge workers, a concerted effort is needed by technology designers, organizations, and knowledge workers to provide tools and techniques to alleviate negative effects. This appears to be a more severe issue for work-related interruptions in one's personal life than for personal interruptions at work.

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