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Research Commentary

A Call for Engaging Context in HCI/MIS Research with Examples from the Area of Technology Interruptions

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This paper contributes to the discussion on future directions of Human-Computer Interaction in Information Systems (HCI/MIS) research by explicating the role of task- and social context. We show that context has not been sufficiently engaged, and argue why it is important to pay more attention to it in theory and design of future HCI/MIS research. Drawing on examples from the core HCI area of technology interruptions, we formulate a set of general research questions and guidelines, which allow us to represent the context of multiple users in continuous collaboration with multiple tools while working on tasks that are intertwined within business processes. These guidelines will generate new insights for HCI/MIS research and allow us to develop research that captures the changing nature of the computing environment.

INTRODUCTION

This research commentary contributes to the discussion on future directions of Human-Computer Interaction research in Information Systems (HCI/MIS), which was spawned by the keynote panel discussion at the 2009 SIG HCI workshop. Specifically, this paper explicates the concepts of task context and social context as critical factors to be considered in both HCI/MIS theory development and design, and develops a set of guidelines that can be used to frame a research agenda. To achieve this objective, the paper first briefly discusses the state of HCI/MIS research. Then, to make the analysis more concrete, it draws upon the core HCI area of technology-based work interruptions (hereafter referred to as technology interruptions) to show how such research can gain from explicating the complex context, in which multiple individuals are simultaneously interacting with multiple technologies to perform a set of intertwined tasks. With help from this analysis, the paper concludes with a set of research questions and guidelines for future HCI/MIS research.

THE NEED FOR CONTEXT IN HCI/MIS RESEARCH

What is HCI/MIS research?

HCI research is multidisciplinary by nature, incorporating a vast number of efforts from fields such as computer science, psychology, sociology, anthropology, ergonomics, and engineering, among others. In this paper, we restrict our focus on HCI research from an IS perspective (HCI/MIS), which is mostly published in IS journals, IS conference proceedings, and specialized HCI journals. We adopt Zhang and Li's definition of HCI/MIS research as research that is "concerned with the ways humans interact with information, technologies, and tasks, especially in business, managerial, organizational, and cultural contexts" (Zhang and Li, 2005, p. 228). This definition distinguishes HCI/MIS research from other HCI research areas by virtue of its focus on business tasks, and particularly their meaningfulness from an organizational perspective (Galletta et al., 2003, Zhang et al., 2002). As Zhang and Galletta stated, "The MIS researcher's perspective affords special importance to managerial and organizational contexts by focusing on analysis of tasks and outcomes at a level relevant to organizational effectiveness. The two distinguishing features of MIS from other 'homes' of HCI are its business application and management orientations" (2006, p. 5). Consequently, the analysis in this paper does not include other types of HCI research – such as HCI research from a CHI perspective – that delineate the context of human-computer interaction but pay little attention to the organizational meaningfulness of such interactions (Grudin, 2006).

What is context in HCI/MIS research?

We define context as situational factors exhibiting cross-level effects in which a stimulus or phenomenon at one level of analysis has an impact at another level (Johns, 2001). Situational factors can include both phenomena and temporal conditions that surround the focal constructs of interest. Such situational factors can directly influence lower-level phenomena, condition relations between one or more variables at different levels of analysis, or be influenced by phenomena nested within them (Bamberger, 2008). *Task context* reflects situational factors related to characteristics of the task or portfolio of tasks in which an individual (or group) is involved. *Social context* involves situational factors that arise from individuals' interactions with each other as they perform their tasks (Johns, 2006).

This definition binds the concept in several ways. First, it ascribes to a positivist view that represents context as a stable social object which can be captured and delineated, and which is separable from the activity that occurs within it (e.g., Bamberger, 2008, Johns, 2006). This definition is in contrast to phenomenological perspectives of context as an occasioned social object that is defined dynamically, emerges from activity, and is inseparable and particular to the activity (e.g., Dourish, 2004, Orlikowski, 1996, Suchman, 1987). Second, our conceptualization of context focuses on how context directly influences underlying HCI phenomena, rather than how it provides contextual information that illuminates the underlying phenomena (Bamberger, 2008).

Our conceptualization of context is also influenced by the changing environment of human-computer interactions (Lyytinen, 2010). In a recent write-up following the keynote panel discussion at the 2009 SIG HCI workshop, Kalle Lyytinen emphasized the pressing need to understand richer and more complex patterns of human-computer interactions and to move away from the single-user/ single-tool paradigm that has dominated the HCI/MIS literature. Particularly, he conjectured that a key way to move forward is to "understand and take more seriously what defines and constitutes the environment of computer use. This concern needs to permeate both our theory building and our research design" (Lyytinen, 2010, p. 23). Several dynamics characterize the context in this changing environment. First, technology is much more geared toward collaborative, rather than independent use. This is supported by a networked computing platform which enables real-time communication, and provides a digitized knowledgebase available to all. Traditional tools such as decision-support systems and expert systems are being complemented by collaborative tools such as email, chat, text messaging, web conferencing, social networking, and knowledge management systems. Rather than being external tools that are adapted by users, such tools now also come in the form of web-based services that permeate every business process, and that enable as well as constrain users as they perform those processes.

Second, the social and task environments in which users interact with technology are also changing. Most organizational work is now done by multiple users who are continuously interacting across a wide set of computing tools in rich social contexts. Such users typically work on tasks that are not isolated, but rather intertwined within a portfolio of business processes (Law and Chuah, 2004).

The changing environment of computer use has implications for some dimensions of task and social context that are expected to be salient in such an environment. Johns (2006) identified the following examples of task context: task autonomy, uncertainty, accountability, and resources. Similarly, he identified social density, social structure, and social

influence as important dimensions of social context. In the changing computing environment, we expect task interdependence, task uncertainty, and time resources to be especially salient dimensions of task context. First, due to the nature of task subdivision and the intertwining of tasks within larger processes, users are often organized in groups working on tasks that exhibit various forms of interdependencies (Dabbish and Kraut, 2004). Second, in fast-changing work environments where tasks are intertwined (e.g., new product development), technological changes trigger increases in task uncertainty, which in turn influences underlying human-computer interactions, such as requiring the use of IT for rapid communications (Pavlou and El Sawy, 2006). Third, as technology pervades work (and personal) space and interrupts work tasks, time becomes more and more fragmented. Hence, time resources act as a constraint on user actions, often contributing to enhancing subjective workload and hampering task performance (McFarlane, 2002).

With respect to social context, we expect social structure and social influence (e.g., norms, persuasion, and communication) to continue to be important. However, social density (e.g., network position and context awareness) is expected to be a particularly salient dimension of context. For example, network centrality may trigger more use of IT (Wasko and Faraj, 2005). Further, as studies in pervasive computing and mobile computing have shown, context awareness may play a role in shaping underlying HCI behaviors, both with respect to computers becoming sensitive to their use context (Dey, 2001), and users becoming sensitive to other users' use contexts (Dabbish and Kraut, 2004).

Is there a gap in studying context in HCI/MIS research?

Over the past several decades, we have witnessed an increasing emergence of HCI/MIS research. As an indication of this trend, 45% of articles published in top-tier IS journals in 2008 focused on HCI issues, and this number increased linearly since 1990 (Zhang et al., 2009). Additionally, HCI research has a place in major IS conference tracks (e.g., ICIS; AMCIS; HICSS), is promoted by special interest groups (e.g., ACM SIGCHI; AIS SIGHCI), appears in special issues of major IS journals (e.g., *Journal of MIS*: 2005; *Journal of the AIS:* 2004, 2006, and 2007), and has its own dedicated journals (e.g., *Human Computer Interaction*; *AIS Transactions on HCI; ACM Transactions on CHI; International Journal of HCI; International Journal of Human Computer Studies*).

Despite this widespread diffusion, the relative focus of HCI/MIS research has remained somewhat narrow. In particular, while the overall body of literature has yielded significant theoretical and empirical insights, the roles of task- and social context have not been sufficiently engaged, despite being part of the definition of HCI/MIS research. Indeed, the state of HCI/MIS research reveals the need for a deeper and more systematic engagement of context. In particular, we argue that the role of context in extant HCI/MIS research has either been (1) excluded from investigation, (2) present in name only, (3) present in a limited form, or (4) focused on contextualization rather than on contextual effects that directly influence underlying phenomena. While research in each of those areas has significantly advanced our understanding about important HCI/MIS issues, it does not best represent the notion of context, as it is defined here.

1. Research where context is excluded

Early HCI/MIS research – which was mostly experimental in nature (e.g., the Minnesota experiments) – deepened our understanding about how material features of the technology facilitated or constrained user cognitions and behaviors, and how this in turn influenced task performance (Benbasat and Schroeder, 1977, Chervany and Dickson, 1974, Dickson et al., 1977). However, context was mostly absent in this type of research, which focused on a single user working on a single task, and using a single decision-making tool. Essentially, studies in this category excluded or implicitly controlled away context by narrowing their focus on observable chunks of phenomena in order to better understand the relationships between technology features and individual attributes.

2. Research where context is present in name only

Subsequent areas of HCI/MIS research – such as research on group support systems (GSS), computer-mediated communication (CMC), and computer-supported cooperative work (CSCW) – expanded the scope beyond interactions between individual characteristics, system characteristics, and decision environments. Those streams shifted the perspective from the individual to the group level and thus seemed better armed to more deeply engage context in their research efforts. However, much of the research in this category invokes context mostly in name only. Here, context represents a boundary around all research that falls within those areas. Context serves as a major assumption or constraint in the area itself, but it does not typically come to the foreground. It is something that just exists or that is salient "out there." However, as noted by Johns (2006), "situational salience is neither sufficient nor necessary to ensure contextual impact on organizational behavior" (p. 387). In other words, research in this category rarely examines the nature of such contexts, manipulates it, or directly investigates the ways by which it influences

the underlying phenomenon under investigation (e.g., how task and social contexts shape interactions between users and technologies placed within such contexts).

Group norms are one example of many contextual factors that are present, but not directly explored in this category of research. Group norms develop in all functioning groups (Feldman, 1984), including the groups studied in GSS and CSCW research. They regulate the behaviors of group members, and are likely to be influential in shaping group members' interactions and outcomes. However, group norms have rarely been explicitly examined as a contextual factor of importance in GSS research (e.g., Bui and Sivasankaran, 1990, Gallupe et al., 1988, Vogel and Nunamaker Jr., 1989). In one study of GSS use where norms were not explicitly studied, the norms of one of the groups were such that the group members even refused to use the system (Dennis et al., 1990a, Zigurs et al., 1988). Further, Dennis et al. (1990a) conjectured that the discrepancies in results between experimental and field study GSS research can be partly explained by unexplored differences in contextual group norms that arise between experimental and real organizational groups.

Similarly, traditional theories of CMC such as social presence theory (Short et al., 1976) and media richness theory (Daft and Lengel, 1984) have long considered CMC tools to be inherently poor transmitters of context cues such as non-verbal cues and other aspects of the physical environment (Walther, 1995). Consequently, much of the CMC literature influenced by those theories underplayed the role of context, especially social context (Connolly et al., 1990, Hiltz et al., 1986). Despite context being inherently implied in the overall area of CMC, such research has traditionally "disallow[ed] any effects of extrinsic factors such as relationships or context, and any dynamics within or across conversations such as development or change across time" (Walther, 1995, p. 188).

Finally, in much of HCI/MIS research on social computing – which focuses on technology-mediated social relations such as those in online communities – context has served as an overarching background that has not explicitly come to the foreground. For example, Parameswaran and Whinston (2007) noted that online communities differed from real-life communities by virtue of members keeping anonymous identities. Subsequently, they pointed out that existing social science theories that would attribute members' motivations to participate to factors such as bonding and forming relationships did not apply well in online communities. To better predict cooperative behavior, social computing research would need to explicitly theorize about contextual factors unique to online communities that motivate members to participate in social action.

3. Research where context is present in limited form

Much of GSS research has actually considered some contextual effects, such as the fit between task and GSS technology (Zigurs et al., 1999), the effect of group size and member proximity on system configuration (DeSanctis and Gallupe, 1987), and the moderating effects of reward structure on group outcomes (Benbasat and Lim, 1993). Overall, this research has enhanced our understanding of GSS features, usage and performance impacts. However, while these studies explicitly examined cross-level effects and thus took some stock of contextual issues, the nature of the research setting in much of the GGS literature limited deeper engagement with context and questioned whether contextual factors were in fact methodological artifacts rather than real situational phenomena (Benbasat and Lim, 1993).

In particular, the experimental approach taken in this stream produces social contexts that are different from and more limited than their real-life counterparts (e.g., with respect to representing social interactions, past or future group history, and interdependence among group members). Also, the task contexts addressed in this literature has mostly involved singular, isolated, brief, and artificially manipulated tasks. Finally, experimental research in CMC has often confounded the temporal aspect of context by limiting the time given to CMC and F2F groups, and by giving equal time to both groups which reduced the message exchange rate for the CMC group (Walther, 1995).

4. Research that focuses on contextualization

The research that falls into this category – while explicitly incorporating context – has dealt with a different conceptualization of context than the one we use in this paper. Specifically, there is a wide body of HCI/MIS research that has emphasized the contextual information related to some underlying phenomena, but without explicitly capturing the role of such context in directly shaping relationships between the underlying phenomena. Hence, such research conceptualizes context in terms of a sensitizing device that contextualizes observations by linking them to facts and events, while our conceptualization directly examines how contextual factors exhibit cross-level effects on the variables of interest. Bamberger (2008) referred to the former conceptualization as context that *illuminates* phenomena, and to the latter conceptualization used in this paper as context that *affects* phenomena.

The practice-based perspective, which was adopted in the HCI field by Suchman (1987) in her pioneering theory of

situated action, and later imported by Orlikowski (1996, 2007) into HCI/MIS research, has followed this *contextualization* conception of context. Rather than examine how broad task and social contextual factors directly influence user interactions, studies adopting this perspective are concerned with describing the context (stimuli or phenomena) that exists in the environment external to the IT artifact. The goal is then to understand how the IT artifact can be made sensitive to the context of its use (Suchman, 1987), or how users can change their practices based on such contexts (Orlikowski, 1996). For example, in Suchman's (1987) study of expert help systems, the system's behavior was not only based on the designers' intent, which was coded into the system, but also on how the system inferred the user's actions by sensing changes made to the system by the user. In other words, the system's behavior was situated in the context of users' everyday actions. Orlikowski (1996) took a broader approach – and one that fits more with HCI/MIS research – by looking at how changes in organizational structures and practices were situated in the context of users' everyday interactions with a system. CSCW research on context-aware computing draws on the work of Suchman (1987), and also uses the contextualization conception. It defines context as relevant information (e.g., location, identity, and state) about the system, the group, group members, group tasks, and so forth (Dey, 2001, Dourish and Bellotti, 1992, Pinheiro et al., 2003). Such information can then make the system's and/or group members' behaviors more relevant to the group's activity.

Another stream of HCI/MIS literature, based on the socio-technical systems approach, also follows this contextualization perspective. The main premise of this approach is that joint optimization of the technical and social subsystems are likely to improve system success (Bostrom and Heinen, 1977). However, the use of this approach has largely been confined to the examination of how providing contextual information about the technical and social elements improves system design (e.g., Hirschheim and Klein, 1994, Iivari and Hirschheim, 1996, Whitworth and De Moor, 2003).

Summary

In summary, this paper does not claim that there is *no* HCI/MIS research that has accounted for context, nor that there is no value in the ways context has been studied previously. Indeed, extant research has significantly advanced our understanding about HCI dynamics and contextual issues. For an example of one valued approach, some CSCW researchers have focused on directly integrating the role of the broader organizational contexts in which groupware technologies are used, e.g., Grudin and Palen's (1995) study of the impacts of organization infrastructure and peer pressure on the use of online meeting scheduling systems. Similarly, some studies in CMC have explicitly accounted for temporal context and examined whether relational intimacy takes longer to develop in CMC groups (Chidambaram, 1996). Some social computing studies based on network theory have also directly integrated context. For example, Wasko and Faraj (2005) studied whether social capital motivated individuals to share knowledge in electronic networks. They found that an individual's positional centrality in the network enhanced his or her willingness to use the system to contribute knowledge, as well as the quality of such contributions.

Notwithstanding the previous examples, we argue that the type of context which we define here is under-represented and not systematically examined in extant HCI/MIS research. A review of the past 30 years of HCI/MIS literature found that most research to date has focused on user-technology interactions, while downplaying the other two components in the definition of HCI/MIS research: task context and social/organizational context (Zhang et al., 2009). In particular, the review found that fewer than 10% of HCI/MIS studies have focused on social issues and interpersonal relationships. Also, over 80% of the literature has focused on the individual level, and less than 8% has considered cross-level effects (Zhang et al., 2009). Although today it is not uncommon for studies to incorporate some contextual factors in their research models, context – when not entirely ignored – is still either downplayed, focuses on description rather than causal relationships, or is studied in a piecemeal fashion. As an example of the latter, a study on the impacts of CMC use – while explicitly accounting for social context by distinguishing between groups with and without past history – was focused on a singular, isolated, and contrived decision-making task, and thus downplayed the task context (Yoo and Alavi, 2001). By-and-large, there are no guidelines in the HCI/MIS literature that allow us to systematically understand the various mechanisms by which context can shape the underlying HCI phenomena, especially in the changing environment of computer use.

Why is it important to fill this gap?

Following Lyytinen (2010), we argue that there is a need for a more dynamic representation of HCI/MIS research which captures the changing environment of computer use by engaging the role of context. First, paying more attention to context in HCI/MIS research will allow us to more accurately represent the changing computing environment described earlier, which is characterized by collaborative tools, networked computing, and continuous multi-user interactions on intertwined tasks composing larger processes.

Second, engaging context in HCI/MIS research can enhance our understanding of important HCI issues and explain

seemingly conflicting results. For example, a study on the use of electronic meeting systems (EMS) noted that previous research, which introduced no or small variation in group size (a social context variable), exhibited mixed results on group member satisfaction (Dennis et al., 1990b). Indeed, Dennis and colleagues found that variations in group size resulted in differences in member satisfaction with EMS-supported group meetings.

Third, a better understanding of context can generate new insights. For example, we will show later how a deeper engagement of context in our research on technology interruptions allowed us to unearth a new type of interruption which did not surface in earlier research that focused on interruptions in isolated task contexts.

Finally, explicating context allows us to suggest new directions for HCI/MIS research. In summary, we propose a shift of focus from how IT supports individual/group decision-making, to how IT enables/constrains collaborating individuals organized around business processes. As Zhang and colleagues suggested, "[w]ith the focus of HCI moving from individual-based productivity to communication, collaboration, socialization, and holistic human experiences, [social and interpersonal] topics may and should receive more attention in the future" (Zhang and Li, 2005, p. 254). Below, we propose guidelines that allow us to represent human-computer interactions embedded in rich task- and social contexts. To more concretely illuminate those guidelines, we ground the following analysis in the area of technology interruptions, which – as we argue below – provides a fertile opportunity to develop a context perspective.

THE CASE OF TECHNOLOGY INTERRUPTIONS

Interruptions play a key role in human-computer interactions today. First, research on general work interruptions shows that the average cluster of uninterrupted work time is just 11 minutes (Mark et al., 2005), and that managers spend over 10 minutes per hour engaged in unplanned, interruptive activities (Hudson et al., 2002, O'Conaill and Frohlich, 1995). Alarmingly, 41% of the time those interrupted tasks are not even resumed (O'Conaill and Frohlich, 1995).

Second, with the fusion of IT into most work activity, we are especially witnessing the emergence of technology interruptions, defined as perceived, IT-induced or IT-mediated events that capture cognitive attention and break the continuity of a focal task (Addas and Pinsonneault, 2010a). Whereas firms use IT to provide continuous interactions across spatial and temporal boundaries, the very usage of such tools to streamline work processes creates an opportunity for interrupting the work of individuals. For example, most individuals receive more than 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 immediately (within six seconds) and individuals take on average over a minute to recover from such interruptions (Jackson et al., 2003). Not all such technology interruptions are negative; in fact, some are anticipated and desired. Based on Jett and George's (2003) taxonomy of work interruptions, we have shown elsewhere that some technology interruptions (intrusions) exhibit negative effects on individuals by diverting their attention from the focal task, while others (interventions) exhibit positive effects by redirecting their attention and efforts toward sources of performance discrepancy (Addas and Pinsonneault, 2010a).

Technology interruptions are a particularly important area of HCI research. McFarlane's seminal paper touted technology interruptions as "a central HCI design problem for the future" (2002, p. 65). By definition, technology interruptions are situated phenomena that involve interactions between user, technology, task, and context. They provide a unique opportunity to develop a context perspective of HCI/MIS research, since "[t]he interaction experience is relevant and important only when humans use technologies to support their primary tasks within certain contexts" (Zhang and Li, 2005, p. 232).

However, much of what we know about technology interruptions comes from individual-level studies that focused on contrived, isolated tasks (e.g., Cutrell et al., 2001, Cutrell et al., 2000, McFarlane, 2002, Speier et al., 1997). Yet, most technology interruptions do not occur in a vacuum, but rather in the context of users collaborating on interdependent tasks embedded in larger projects/processes. Indeed, much organizational work occurs in group-settings and is organized around projects (e.g., Edmondson and Nembhard, 2009, LePine et al., 2008, McGrath et al., 2000), to the extent that project teams have become the "building block of organization" (Law and Chuah, 2004). Hence, there is a need to complement the individual level literature with a focus on the contexts in which technology interruptions take place.

WHAT DO WE KNOW ABOUT TECHNOLOGY INTERRUPTIONS & CONTEXT?

A summary of what we know about context in technology interruptions research is shown in the Appendix. This summary is meant to be illustrative of the categories that emerge, rather than an exhaustive coverage of the interruptions literature. Regarding research objectives, three broad categories were found: 1) studies that describe patterns of interruption, 2) studies that examine interruptibility and interruption response strategy, and 3) studies that examine the performance effects of interruptions. Studies falling into the first category relied on rich observation techniques to identify patterns of interruptions in social contexts, such as time parameters (Chong and Siino, 2006, Rukab et al., 2004), interruption frequencies and durations (Chong and Siino, 2006, Rukab et al., 2004), and likelihood of task resumption (O'Conaill and Frohlich, 1995). Most studies in the second category used experimental approaches to examine interruptibility and response strategies for interruptions (intrusions) in social settings. A main finding is that providing an interruptor with context awareness about the interruptee's state leads to less frequent and better-timed interruptions, given a team condition and outcome interdependence (Dabbish et al., 2007, Dabbish and Kraut, 2004, Dabbish and Kraut, 2008). Also, the social context of interruptees (location and social surrounding) helps determine their interruption readiness (Avrahami et al., 2007). Finally, relational context, such as the interruptor's identity (Grandhi and Jones, 2010) and interruption content (Dabbish et al., 2007, Grandhi and Jones, 2010) has been shown to be important.

Studies in the third category were mostly experimental, and focused on the effects of technology interruptions in social contexts. This category shows implicitly that different interruptions have distinct performance effects. Whereas interventions exhibit positive effects, such as enhancing team decision-making accuracy (Hollenbeck et al., 1998), intrusions exhibit negative effects such as increased decision time (Miller, 2002) and reduced decision quality (Heninger et al., 2006). Performance effects can also vary with respect to a social structure dimension of context (Johns, 2006) that considers the different perspectives of the interruption source and target. For example, IT-mediated communication benefits interruptors by providing information that reduces their delays, but harms interruptees by disrupting their work (Rennecker and Godwin, 2005). Also, using context awareness systems to control interruption timing may mitigate negative effects of interruptions on interruptees, but may increase cognitive load for interruptors (Dabbish and Kraut, 2004).

Overall, most studies on technology interruptions and context have adopted the level of analysis of the individual within a dyad (see Appendix). Less common were studies – mostly on the effects of interruptions – that focused on the individual within a group (Heninger et al., 2006, Miller, 2002, Schultze and Vandenbosch, 1998, Weisband et al., 2007). A single study explicitly examined the group level, and found positive effects of interventions on team decision-making accuracy (Hollenbeck et al., 1998). In fact, theirs was a cross-level study because it modeled the effects of individually-experienced interruptions on overall group performance. Also, a single study included multiple levels of analysis by comparing interruption patterns in groups of paired programmers to those in groups of solo programmers (Chong and Siino, 2006). In sum, the small sample of studies summarized in the Appendix considered context in one of two ways. First, almost all studies examined the dynamics of individual interruptions for individuals within dyads and groups. Second, a single study examined the effects of individual interruptions on group outcomes (Hollenbeck et al., 1998). To a large extent, the studies reviewed above ascribed to the *contextualization* view of context, which focuses on an individual's experience of interruptions within the context of a larger social setting, rather than explicitly integrating context into the theoretical models. Also, task context was still mostly limited to singular, isolated tasks that were of brief duration, rather than longer-term task interactions and tasks that were intertwined within larger processes.

WHAT DO WE NOT KNOW? GUIDELINES FOR FUTURE HCI/MIS RESEARCH

There is much to be discovered about contextual dynamics in technology interruptions and in HCI/MIS research in general. In this section, we develop a set of research questions and guidelines that allow us to engage context more fully. While the questions are general enough to apply to HCI/MIS research overall (which, as previously argued, is characterized by a similar need of context), we make the analysis more concrete by showing examples of how such questions can be answered in the HCI sub-area of technology interruptions.

Research Question 1 (RQ1): How can human-computer interactions be explained when they take place in richer contexts with intertwined tasks?

This question reflects a shift of focus from the singular task level to a business process level, where tasks are interdependent and embedded in larger processes. In technology interruptions research and in general HCI/MIS

research, task contexts typically involve singular, isolated, brief, and mostly contrived tasks. A shift to the process level is likely to enhance our understanding – and bring new understanding – of HCI/MIS phenomena. For example, we explored the different types of technology interruptions in a project team environment where tasks were intertwined, and found that in addition to intrusions and interventions, a new technology type emerged that was a hybrid of those two types of interruptions (Addas and Pinsonneault, 2010a). More specifically, hybrid interruptions reflected interruptions (e.g., email information updates) that were unrelated to a project team member's current task (hence, intrusions to the current task), but related to their overall project portfolio of tasks (hence, interventions that provided useful information on other project tasks). In fact, this type of interruption was shown to be detrimental to productivity, beneficial to learning, and both beneficial and detrimental to the quality of project team members' work (Addas and Pinsonneault, 2010a). Had we adopted a single-task lens, such hybrid interruptions would not have surfaced, or may simply have been identified as intrusions to the current task. Hence, an important future direction for HCI/MIS research in general is to model and explain interactions that take place in this broader context. To implement this approach in HCI/MIS research, researchers need to be sensitive to factors that may trigger various forms of task interdependence, which may in turn affect underlying human-computer interactions. Examples of such factors include: how task resources are distributed among team members, how tasks are partitioned, the processes by which team members perform their tasks, and whether tasks are rewarded individually or collectively (Wageman, 1995). Process modeling techniques can be used to better understand task interdependencies (see RQ6).

Research Question 2 (RQ2): What are the various forms of cross-level contextual effects that can be examined in HCI/MIS research?

This question relates to the various ways in which contextual effects can manifest across levels. Our analysis of technology interruptions studies revealed that much of the research examined the effects of interruptions on individuals within dyads and individuals within groups. Very little is known about effects at the dyadic or group levels of analysis. For example, what is the impact of interrupting an individual group member on group performance? While the HCI literature in general is more advanced than the technology interruptions literature in considering the group level (e.g., research on GSS and CSCW), it would still be useful for future research to distinguish among the following types of cross-level contextual effects: a) effects of individual-level HCI phenomena on individuals that are within groups (or within dyads), b) effects of individual-level HCI phenomena on groups (or dyads), and c) effects of collective-level HCI phenomena on individuals within groups (or within dyads). By making these distinctions in our research, we can become more sensitized to various forms of contextual effects. Table 1 summarizes the various types of cross-level contextual effects and provides an example of each from the extant literature. Note that while most of the time contextual effects are conceptualized as flowing from the top down, the direction can also flow in the opposite direction, because "individuals can sometimes provide contextual influence for organizations" (Johns, 2001, p. 32).

Table 1: Various Forms of Cross-Level Contextual Effects

Type of effect	Example from the literature
Effects of individual-level HCI phenomena on individuals within groups (or within dyads)	Effects of interruptions on individual programmers organized in dyads (Chong and Siino, 2006)
Effects of individual-level HCI phenomena on groups (or dyads)	Effects of individual process interventions on group decision quality (Hollenbeck et al., 1998)
Effects of collective-level HCI phenomena on individuals within groups (or within dyads)	Effects of group size on group member satisfaction with EMS use (Dennis et al., 1990b)

Research Question 3 (RQ3): How can the temporal aspect of context be incorporated in HCI/MIS research?

As indicated by our definition of context, a deep engagement of context in HCI/MIS research focuses not only on objective contextual phenomena, but also on temporal conditions that shape the underling interactions. Indeed, in conducting our technology interruptions research it became clear that interruptions are, by nature, temporal events that are situated in particular contexts. By explicitly focusing on the temporal nature of such events, their impacts can take on new meanings. For example, our research on technology interruptions revealed that some interruptions were first experienced by project team members as intrusions to their current work, but that at later times the same interruptive events were actually perceived as providing relevant feedback to the task at hand, and thus classified as interventions. The significance of such variations in perceptions is that they were accompanied by divergent emotional reactions and performance implications. For instance, an interruptive event may elicit negative emotions such as stress and annoyance when experienced as an intrusion, but such emotions may be absent when the same event is perceived as a task intervention. Also, the event may be detrimental to productivity and interfere with the quality of task work when experienced as an intrusion, but enhance quality when experienced as an intervention. In one of the interviews we conducted, the chief of a small engineering team working on developing semi-conductor testing equipment described the temporal effects of technology interruptions as follows:

The story starts a couple of years ago when we began to create our product from scratch and we decided that we were going to implement this Trac system [a bug-tracking tool that interrupts developers to address the bugs] in-house. But what we discovered was when you start to use a tool like this very early on in the process it becomes chaos. We were still very early on in the design process and I am designing a piece and my partner is designing another piece and we are working together, and instead of talking to each other on something that is very far from being released we keep getting interrupted. We found that people will go on the system and log a bug for example on something that is neither released nor ready nor complete. So what happened is that you ended up with a huge list on this tracking document, hundreds of items that maybe real, may not be real, there is duplications, there was all kinds of things. So that was the first effect of that interruption; it was frustrating and counter-productive. That is what we realized later on so we essentially abandoned the system. After a while, the product developed in processes further along and was almost maturing now, and we were starting to release the product in the field, and starting to get real bugs. Then we realized that now is the time to go back to the Trac system. Now when the developers get interrupted by the system, they are dealing with real bugs for a product that is in release. This is actually now helping us improve the product rather than distracting us from our work.

Hence, the bug notifications from the tracking system intruded on the work of developers when the system was used too early on in the process, while the same notifications represented an important source of feedback intervention later on, closer to product release. We suggest that we need to pay particular attention to such temporal context effects in HCI/MIS research in order to better understand how they shape underlying human-computer interactions. For example, Chidambaram (1996) used social information processing theory to show that over time, group member exchanges over GSS (CMC) evolved from initially constraining group interactions to eventually allowing members to form strong relational linkages. In turn, such electronic exchange of social information over time changed group members' attitudes toward the system – as well as their performance – from negative to positive. Similarly, Grudin and Palen (1995) showed that collaborative meeting scheduling systems were successfully adopted, whereas they were largely resisted in similar settings a decade earlier when users were less networked and derived fewer benefits from using the schedulers.

To implement the temporal aspect of context in future HCI/MIS research, we need to explicitly model how human-computer interactions unfold over time, and/or how such interactions are contingent upon time variables. For example, we should be attentive to whether individual or group attitudes, behaviors, and outcomes change with extended use of a system. This calls for more longitudinal research.

Research Question 4 (RQ4): What is the process by which human-computer interactions emerge at higher levels?

This question examines how context can manifest through a bottom-up process of emergence from lower-level phenomena. This aspect of context has received very little research attention (Bamberger, 2008, Goodman, 2000), and has been dubbed a "missing organizational linkage" (Goodman, 2000). In our sample of technology interruptions studies discussed earlier, we identified mostly individual-level interruptions influencing individuals embedded within dyads or groups. Applying this aspect of context, we can now consider how HCI phenomena, such as technology interruptions, may actually emerge at higher levels through interactions at lower levels (cf. Kozlowski and Klein, 2000). According to Tyre and Orlikowski (1994), interruptions manifest at the group level if an event that interrupts an individual affects the task-flow of other group members. Today, much organizational work is organized as a sequence of interdependent group tasks that comprise higher-level processes (McGrath et al., 2000). Because of the contextual effects of task interdependence, individual-level technology interruptions can manifest at the group level. This is consistent with Kozlowski and Klein (2000), who argued that contextual factors, such as task flow and social interactions, shape emergence.

To illustrate, consider new product development (NPD), which can be seen as a higher-level, technology-intensive process comprising a sequence of interdependent group tasks from idea generation to product commercialization (Cooper, 2001). Figure 1 illustrates the component tasks of NPD, and presents a hypothetical scenario in which each task is shared among two or more NPD workers. As shown in Figure 1, there are at least three processes by which technology interruptions manifest at higher levels (see also Table 2 for descriptions and examples of those processes). First, an individual technology interruption (e.g., system breakdown) for a single NPD worker performing a given task can spill over and affect that same worker on another interdependent task. Second, interrupting an NPD worker on a given task (e.g., via an email information request) may affect other group members working concurrently on the same task. Third, interruptions may also exhibit ripple effects across interdependent tasks (e.g., the interruption of a product design task may cause testing & validation to be delayed until the former task is completed).

While rarely studied, this process of contextual emergence has strong implications for HCI/MIS research. It allows us to understand whether and how changes in human-computer interactions and outcomes at one level translate to higher levels. For example, one of few studies using this approach examined how individual resistance to electronic

medical records in hospital settings emerged to the group level (Lapointe and Rivard, 2005). Research on IS impacts can especially benefit from this approach by explicitly examining the conditions in which and mechanisms by which an implemented system that improves the productivity of users will impact the unit or the organization as a whole. To implement this approach in HCI/MIS research, a technique such as Goodman's (2000) linkage analysis can be used, where researchers identify the factors that may affect whether the outcomes of cognitive, affective, and behavioral characteristics of human-computer interactions will translate across levels. Such factors include: 1) outcome coupling (e.g., are outcome metrics similar across the levels? What forms of interdependence exist? What is the nature of connections?), 2) limiting conditions (e.g., what constraints may prevent positive outcomes from translating to higher levels?), 3) feedback mechanisms (e.g., are there initial conditions in the system that may facilitate or hinder emergence?), and 4) compensatory mechanisms (e.g., is there a common focus or a common objective across the levels?).
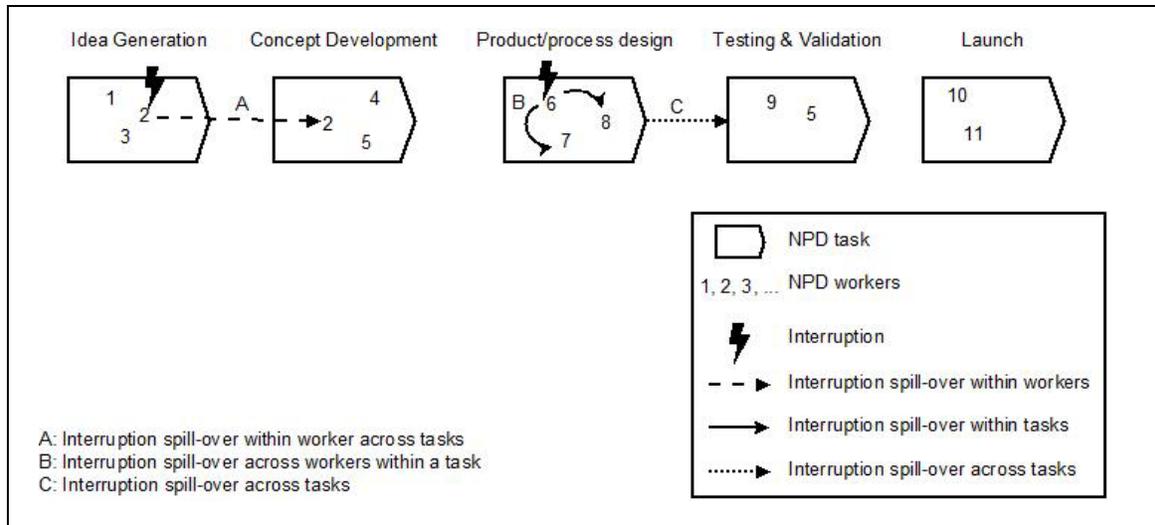
Figure 1: Interruption Spillovers across the NPD Process

Table 2: Examples of Technology Interruption Spillovers

Item	Scope of technology interruption	Example
A	Interruption spill-over within workers across tasks	NPD worker #2, who is involved in an electronic brainstorming group activity (idea generation task), faces a system breakdown intrusion. This interruption may have spill-over effects that delay worker #2 in another group activity involving development of the project plan (concept development task).
B	Interruption spill-over across workers within a task	NPD worker #6, who collaborates with other process designers (product/process design task), is frequently interrupted during group meetings by email requests for information. These intrusions may also affect the other group members by forcing them to wait for input from worker #6, and/or through secondary disruption effects.
C	Interruption spill-over across tasks	A task switch interruption that delays group members in the product/process design task may also affect the subsequent testing and validation task which depends on input from the former.

Research Question 5 (RQ5): What are the moderating and mediating contextual effects that influence human-computer interactions?

This question suggests a top-level view of context as situational factors that enable, constrain, and mediate organizational behavior (Johns, 2006). For example, in our research on technology interruptions we identified the following set of factors: a) constraints that amplify the adverse effects of intrusions, b) opportunities that mitigate the adverse effects of intrusions, c) opportunities that leverage the positive effects of interventions, and d) factors that mediate the effects of intrusions and interventions. First, task interdependence was identified as a contextual constraint that amplifies the effects of intrusions and, as discussed above, makes them emerge at the group level. This mitigating effect can become substantial when interruptions affect interdependent tasks that are on a project's critical path.

Second, we identified three contextual effects representing opportunities that mitigate the adverse effects of intrusions. Context awareness display, which was discussed earlier, is an especially important factor with design implications for HCI/MIS. Such systems provide sufficient contextual information that allows interruptors to initiate interruptions at opportune moments during which the interruptee has a lighter workload, while not overloading the interruptors with information that is too detailed (Dabbish and Kraut, 2004). Furthermore, we identified experienced work unit polychronicity (Slocombe and Bluedorn, 1999) as a mitigating force when group members prefer, expect, and are used to juggling multiple tasks and therefore can better take on various technology interruptions. Resource substitution is another contextual mitigating effect, which allows interruptees to draw upon other resources to offset the effects of the interruption (e.g., Ren et al., 2008).

Third, source credibility was identified as an opportunity that enhances the positive effects of interventions. Based on the literature on knowledge adoption (Mak and Lyytinen, 1997, Sussman and Siegal, 2003), it was expected that the perceived credibility of the interruptor would influence whether the interruptee would attend to and integrate the content of a feedback intervention, and thereby achieve its objective of reducing performance discrepancy.

Finally, context may reflect higher-level factors that mediate between interruptions (that are experienced individually) and group performance. Contextual factors that mediate between intrusions and group performance include group workload, defined as a shared perception among group members of mental demand, time pressure, and stress (Bowers et al., 1997). Subjective group workload is increased by intrusions as a result of group members' limited attentional capacity. In turn, this decreases the group's performance since workload has been associated with resorting to simpler, more rigid, and more independent information processing (Zellmer-Bruhn, 2003) and to quick-fix efficiencies rather than innovative group solutions (Kelly and McGrath, 1985). Also, our technology interruptions research revealed that collective mind (Weick and Roberts, 1993) is a contextual factor that mediates between interventions and group performance, since discrepancies identified by interventions trigger mindful reflection and interrelating of actions among group members, which in turn enhances group performance (Addas and Pinsonneault, 2010b). Overall, we propose that future HCI/MIS research explicate contextual effects in the form of constraints, opportunities, and mechanisms that drive human-computer interactions. To be able do so, it would be useful for HCI/MIS researchers to think of context in terms of a "tension system" that exhibits both facilitating and constraining influences, and to identify such forces (Johns, 2006). For example, Pinsonneault et al. (1999) identified a set of countervailing contextual factors – labeled as process losses and process gains – that shaped the productivity effects of using electronic brainstorming systems (EBS). Consequently, for task context they identified the separation of ideation and evaluation tasks as a factor that increases productivity, and cognitive interference between ideas as a factor that impairs productivity from EBS. Similarly, they identified social recognition as a social context factor that increases productivity and evaluative apprehension as a social context factor that impairs productivity in EBS groups.

Research Question 6 (RQ6): What research designs are suitable for more fully engaging context in HCI/MIS research?

Context typically appears in HCI/MIS research designs as cross-level moderating and mediating effects in variance models (Zhang and Li, 2005, Zhang et al., 2009).Our definition of context as situational factors that exhibit cross-level effects is consistent with such a variance orientation. However, it has also been suggested that a process perspective and "[r]esearch designs that examine how behavior unfolds over time or how organizations configure themselves to deal with recurrent problems especially reveal context" (Johns, 2006, p. 401).We concur with this call, and propose a process perspective for HCI/MIS research designs to complement the overwhelmingly dominant variance perspective. In particular, we propose that a process design may provide additional insights into the nature of context as situational factors (e.g., how such factors unfold), and that such a process perspective may later be used in variance models to test the specific cross-level effects of such situational factors. This is consistent with Mohr's (1982) notion that variance and process models can mutually inform one another (albeit without confounding the two): "Variance-type predictions [   ] may often be based on process theory and may serve to test it" (p. 69).

To implement this approach, we propose the use of graphics-based process modeling as a way to engage context in HCI/MIS research designs. In line with the business process focus presented earlier, which views human-computer interactions as occurring in the context of specialists collaborating on interdependent subtasks that compose higher-level processes, process modeling can be used to better model such task- and social contexts. Various techniques for process modeling exist that focus on different perspectives of the process such as the informational elements (informational modeling), organizational resources (organizational modeling), and task sequences (transaction modeling) (Curtis et al., 1992). For example, Beyer and Holtzblatt's (1998) contextual design approach introduced five process models explicitly aimed at capturing the informational, organizational, transactional, as well as the cultural and physical context of a given business process. However, Basu and Blanning (2000) highlighted two limitations of most graphically-based process modeling techniques, such as those just discussed: 1) they implement the various process modeling perspectives separately, and 2) they provide representational, but not analytical, capabilities.

By contrast, metagraphs are a process modeling technique that presents an integrated view of the resources (users, computers, etc.), tasks, and informational elements that compose a higher-level business process (Basu and Blanning, 2000). They allow one to visually represent and model process relationships and interdependencies, and thereby better observe how contextual effects unfold. But metagraphs also go beyond visual representation of task and social context by leveraging the mathematical properties of graphical structures (e.g., connectivity, bridges, cycles, etc.). Thus, they enable formal analytical operations that allow us to make inferences about how changes in context will affect other components of a business process (Basu and Blanning, 2000). For example, metagraphs allow us to focus on how resources interact in a process (users with computers, and with other users) while representing the task- and informational contexts of the interactions. Hence, one can answer questions such as: How does a resource failure (e.g., a system interruption) affect other elements within the network of interdependencies? Alternatively, with metagraphs one can focus on task interactions and examine which tasks fall on the critical path, or which tasks can still function in the absence of specific informational elements, and so forth. This approach allows us to capture context and retain some of the complexities inherent in HCI/MIS phenomena. Indeed, Basu and Blanning (2000) showed how context – in the sense of limits on the range of values that input variables and other exogenous factors could take – could be represented by metagraphs both visually and analytically. Also, they enable us to observe the process of emergence addressed in RQ4.

CONCLUSION

HCI/MIS research has come a long way in the IS field. Its importance continues to increase as a result of the evolving context of computer use. In his write-up following the SIG HCI 2009 workshop keynote panel discussion, Lyytinen highlighted the importance of capturing such changes in the computing environment in both our theory-building efforts and our research designs. He urged researchers to study interactions that occur in specific environmental niches, and where interactions are shaped by device- and service convergence. While HCI/MIS research commonly includes facets of context in extant research models, we have presented in this commentary a set of research questions and guidelines to facilitate a deeper engagement of context in theory and design. These guidelines allow us to better understand some of the specific environmental niches as promoted by Lyytinen, especially when we think of them as contextual effects that shape HCI/MIS phenomena. Also, device convergence and service convergence can be better explained by the use of metagraphs that represent relationships between resources (e.g., multiple users using multiple devices and tools to perform a given function). Together, this richer representation of context in the theory and design of HCI/MIS research should provide us with research opportunities to pay more attention to the "combinatorial explosion of use situations and their complexity" (Lyytinen, 2010, p. 23).

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APPENDIX (Summary of Literature on Technology Interruptions & Context)

Study	Research objectives *[Category]*	Type of interruption	Findings	Method	Level of analysis
(O'Conaill and Frohlich, 1995)	Examined interruption patterns among professionals working together *[Interruption patterns]*	Intrusions	While in most cases interruptees gained some personal benefits from interruptions, 41% of the time they did not resume the interrupted primary tasks	Case study of two communication engineers working on unspecified tasks (video-taped observation)	Individual within dyad
(Hollenbeck et al., 1998)	Examined the impact of process feedback interventions on team decision-making performance *[Interruption effects]*	Interventions	Process feedback interventions positively influenced team decision-making accuracy	Experiment with students working on a simulated naval command & control task; n = 95 four-person groups	Group
(Schultze and Vandenbosch, 1998)	Examined the effects of groupware use, information load, and information control on information overload *[Interruption effects]*	Not specified	Groupware use increased both information load and control over information, leaving no net effect on information overload	Longitudinal field study of a large US insurance company (interviews and surveys)	Individual within group
(Miller, 2002)	Examined the impact of interruptions on decision making in a team setting *[Interruption effects]*	Intrusions; interventions	Interruptions lengthened decision time, especially when goal rehearsal intrusions were given. No effect on accuracy	Experiment with students working on a team decision-making task; n = 24 individuals in simulated groups	Individual within group
(Dabbish and Kraut, 2004)	Examined the impact of using awareness display systems on regulating interruptions and influencing performance outcomes of interruption source and target *[Interruptibility & response strategies; interruption effects]*	Intrusions	Lower interruptions rate in team condition. Use of awareness system by interruptor improved interruptee's performance, but too much information in the system overloaded interruptor's attention	Experiment with students working on a problem-solving task; n = 36 dyads	Individual within dyad

Study	Research objectives [Category]	Type of interruption	Findings	Method	Level of analysis
(Rukab et al., 2004)	Developed a framework of interruptions at the system level for a distributed team environment using an Activity Coding System *[Interruption patterns]*	Intrusions; interventions	The framework of interruptions at the system level included the following attributes: time parameters, types of interrupting stimuli, interrupted and interrupting tasks, prioritization among tasks, interruption handling strategies, as well as interruption frequency, modality, and duration.	Case study of two Biomedical Engineers at NASA's mission control center (video-taped observation)	Individual within dyad
(Chong and Siino, 2006)	Examined differences in interruption patterns between paired versus solo programmers *[Interruption patterns]*	Intrusions; breaks; distractions	Paired programmers initiated interruptions that were more functional and of shorter durations, responded faster to interruptions, possessed situational awareness to determine importance of interruptions, monitored each other's work during interruptions, were more flexible in ending interruptions, relied on each other as cues for interrupted tasks, and used resource sharing to recover more quickly	Case study of two software development teams in a mid-sized Californian company (ethnographic observations)	Individual within group; dyad
(Heninger et al., 2006)	Examined the impact of dual task interference on information processing and decision quality in synchronous GDSS interactions *[Interruption effects]*	Intrusions	Dual task interference is negatively associated with information processing and decision quality	Experiment with students working on a decision-making task; n = 102 individuals in simulated groups	Individual in group
(Avrahami et al., 2007)	Examined the impact of providing contextual awareness on response strategy for interruptor and interruptee (placing/receiving a call vs. leaving/receiving a message *[Interruptibility & response strategies]*	Intrusions	Willingness to interrupt/be interrupted, and choice of interruption modality (call vs. message) changed depending on location (home/office) and availability of others around interruptee (alone/not alone). Interruptors were more likely than interruptees to perceive their interruptions as urgent.	Two experiments with individuals not working on a specific task; n_1 =78 Individual within dyads; n_2 = 12 individuals in dyads	Individual within dyad
(Dabbish et al., 2007)	Examined the impacts of control over interruption timing, displaying interruptions urgency, and common team identity on response strategy and performance of interruption source and target *[Interruptibility & response strategies; interruption effects]*	Intrusions	Interruptee's response likelihood and speed was increased by interruptor control over interruption timing, display of interruption urgency, and common team identity. Interruptor control over interruption timing also increased interruptor's performance.	Two experiments with students working on a problem-solving task; n_1 =12 dyads; n_2 = 9 dyads	Individual within dyad

Study	Research objectives *[Category]*	Type of interruption	Findings	Method	Level of analysis
(Weisband et al., 2007)	Examined the impact of interruption notifications on performance in critical work environments *[Interruption effects]*	Intrusions; interventions	Interruption modality (silent delivery to messaging board rather than screen pop-up) increased task switching and enhances task performance	Experiment with students working on a simulated operating room scheduling task; n = 39 individuals in 13 groups	Individual in group
(Dabbish and Kraut, 2008)	Examined the impact of using awareness display systems on regulating interruptions and influencing performance outcomes of interruption source and target *[Interruptibility & response strategies; interruption effects]*	Intrusions	In team condition (common social identity and outcome interdependence), awareness display led to interruptions at moments with lower interruptee workload, improving interruptee performance. Too much information in display harmed interruptor's task performance	Two experiments with students working on a problem-solving task; n_1 =36 dyads; n_2 = 33 dyads	Individual within dyad
(Grandhi and Jones, 2010)	Examined the impact of relational context (interruption source; message context) on interruption response strategy *[Interruptibility & response strategies]*	Not specified	Interruption response depended more on who was calling and the content of the call than on location setting and cognitive context of interruptee	Longitudinal field study of 40 students and individuals; n = 1201 incoming cell phone calls (experience sampling surveys)	Individual within dyad

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