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Integrating knowledge of multitasking and interruptions across different perspectives and research methods

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ABSTRACT

Multitasking and interruptions have been studied using a variety of methods in multiple fields (e.g., HCI, cognitive science, computer science, and social sciences). This diversity brings many complementary insights. However, it also challenges researchers to understand how seemingly disparate ideas can best be integrated to further theory and to inform the design of interactive systems. There is therefore a need for a platform to discuss how different approaches to understanding multitasking and interruptions can be combined to provide insights that are more than the sum of their parts. In this article we argue for the necessity of an integrative approach. As part of this argument we provide an overview of articles in this special issue on multitasking and interruptions. These articles showcase the variety of methods currently used to study multitasking and interruptions. It is clear that there are many challenges to studying multitasking and interruptions from different perspectives and using different techniques. We advance a six-point research agenda for the future of multi-method research on this important and timely topic.

1. Multitasking and interruptions: of theoretical and practical interest in many fields

How people deal with multiple tasks that are competing for attention has been an active area within the fields of human–computer interaction (HCI) and cognitive science. Researchers have been influenced by a variety of disciplines, from computer science, to experimental psychology, and social sciences. Each field brings its own theoretical perspective and methodological approach. The aim of this special issue is to facilitate the integration of results across these different perspectives and research traditions. In this article we argue for the necessity of this integrative approach.

Perhaps one of the core questions driving research into multitasking and interruptions is: how beneficial or harmful is it to multitask? For example, are interruptions disruptive? Researchers have attempted to answer this question using a variety of methods. For example, observational studies have shown that interruptions occur frequently in many workplaces (e.g., González and Mark, 2004), controlled experiments have shown that interruptions take time to recover from and increase the likelihood of errors being made on a task (e.g., Brumby et al., 2014; Li et al., 2008; Monk et al., 2008), modeling and theoretical work has provided detailed explanations of these effects (e.g., Altmann and Trafton, 2002; Salvucci and Taatgen, 2008), which in turn has informed the design of interactive systems to minimize the costs of interruptions (e.g., Böhmer et al., 2014; Iqbal and Bailey, 2010). Some of this work is presented to a dedicated community; other work is presented at interdisciplinary venues. Our aim is to stimulate debates across disciplines.

We start the rest of this article with some general background on multitasking and interruptions research. We then assert the need for multiple techniques and perspectives in the study of this important and timely research topic. We then introduce the papers in this special issue with a focus on how the variety in their approaches furthers our understanding. Finally, we advance a six-point research agenda for the future of multi-method research into multitasking and interruptions.

2. Costs and benefits of multitasking and interruptions

Multitasking and interruptions are ubiquitous. In some environments, such as offices (González and Mark, 2004), multitasking and interruptions affect productivity but are unlikely to have direct dangerous consequences. In other settings multitasking and interruptions can impact safety. For example, in aviation (e.g., Dismukes et al., 2001; Latorella, 1996; Loukopoulos et al., 2001; McFarlane and Latorella, 2002), healthcare (e.g., Li et al., 2012; Magrabi et al., 2010; Rajkomar and Blandford, 2012; Walter et al., 2014; Westbrook et al., 2010a, 2010b), and driving (e.g., Caird et al., 2008; Horrey and Wickens, 2006; Mccartt et al., 2006). There is a need to understand the potential risks (and benefits) that might arise from multitasking in these and other environments. This can provide insight into cognition and behavior, but also inform the design and evaluation of interactive systems that are frequently used by people in these settings.

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Engaging in multitasking behavior usually incurs some kind of cost; this is because switching between tasks requires people make changes to physical and mental states. The operations required to make these changes take time and resources and thereby affect performance. For example, in the case of interruptions, we know that when interruptions are particularly long or taxing, people find it harder to resume their original task (Mark et al., 2012; Monk et al., 2008); that people find it easier to recover after interruptions that are relevant to their current activity (Adamczyk and Bailey, 2004; Czerwinski et al., 2000; Gould et al., 2013); that interruptions have selective disruptive effects on different types of procedural errors (Li et al., 2008); and that interruptions are less disruptive when they occur at subtask boundaries (Bailey and Iqbal, 2008; Iqbal and Bailey, 2005; Janssen and Brumby, 2010; Janssen et al., 2012; Miyata and Norman, 1986; Monk et al., 2008; Payne et al., 2007; Salvucci, 2005). Research has made efforts to make these cognitive costs more quantifiable (e.g., Altmann and Trafton, 2002; Janssen et al., 2011; Salvucci and Taatgen, 2011).

In addition to the cognitive costs associated with multitasking, there are also emotional costs. For example, interruptions can increase feelings of stress and frustration by subjective (Mark et al., 2008) and physiological measures (Mark et al., 2012; Brumby et al., 2014). One approach to reducing these negative emotions is to stop interruptions from occurring, for example by looking at ways to encourage concentration (Shneiderman and Bederson, 2005). However, in practice it might not always be possible to avoid interruptions altogether. Simple changes to the timing of interruptions might then have a significant effect on the extent to which participants have negative feelings about interruptions (Adamczyk and Bailey, 2004).

Given the potentially negative costs of multitasking and interruptions, why then do people seem to exhibit a natural tendency to multitask and self-interrupt themselves (e.g., Dabbish et al., 2011)? In some settings multitasking and responding to interruptions can be considered adaptive and rational despite the costs incurred (e.g., Janssen et al., 2011, 2012). For instance, a medic moving from one patient to the next incurs a variety of costs (e.g., moving wards, changing of gloves, reading of charts) but such moving is entirely rational if a patient requires emergency attention. In other settings people might switch activities if they feel they are making insufficient progress on their current activity (e.g., Payne et al., 2007) or because switching tasks might reveal some new or useful information (e.g. information about a meeting being rescheduled). In yet other situations, people switch simply because they are bored (Jin and Dabbish, 2009). In monotonous tasks in particular, occasional multitasking can improve vigilance (e.g., Atchley and Chan, 2011).

All of these research findings have the potential to be used in the design of virtual, physical, and organizational interventions to help people manage tasks effectively. These range from preventing switching (e.g., Mark et al., 2012), to providing information about the context in which an interruption or distraction takes place (e.g., Grandhi et al., 2011; Janssen et al., 2014), to providing training so that people better manage interruptions (e.g., Relihan et al., 2010), to designing systems to mediate the interaction between users and other tasks demanding their attention (e.g., Arroyo and Selker, 2011; Iqbal and Bailey, 2010). Of course, despite the potential for the use of theory in practical settings, the link between theory and practice might not always be immediately obvious. For example, critical assumptions or abstractions that are made in a controlled study might not hold in a more applied context. Inversely, the context of a specific applied setting might interfere with generalizing theoretical insights. This tension between theory and practice further motivates a broad perspective on research and practice into multitasking and interruptions.

3. The need for multiple perspectives and techniques

Preceding work has investigated multitasking and interruptions using different perspectives and methodological approaches. This has also led to the development of interventions for reducing the disruptive effects of interruptions and frequent multitasking. However, more often than not, these interventions are motivated by a single theoretical perspective or research approach.

We argue that interventions can be improved by combining several approaches to produce more nuanced assessments of tasks, users, and environments. For example, could physiological measures of workload such as pupil dilation (e.g., Iqbal et al., 2005), skin conductance, and heart rate variability (e.g., Healey and Picard, 2005; Mehler et al., 2012) be combined with subjective measures (e.g., the NASA-TLX, Hart and Staveland, 1988) and objective measures (e.g., error rate, speed of performance), as well as predictive theoretical models (e.g., Hornof and Zhang, 2010; Howes et al., 2009; Janssen et al., 2011, 2012; Janssen and Brumby, 2010; Kieras and Meyer, 1997; Salvucci and Taatgen, 2008, 2011)? How can qualitative observations be quantified to a level that is useful for quantitatively oriented theoretical models?

Approaches that combine insights from different fields and methodological approaches, and that combine various methods and techniques in their own studies have two advantages. First, a broader perspective and study of multitasking and interruptions (e.g., using multiple methods) has the potential to yield a richer description of human multitasking behavior. Second, as multitasking and interruptions occur in a wide variety of settings, different techniques and methods might be more or less appropriate for each setting. Therefore, a heterogeneous approach to the study of multitasking can assist in understanding multitasking and interruptions in a wider range of settings.

Aggregating multiple approaches in this way is not a trivial task: it requires careful evaluation of how various approaches should be combined, particularly when they might conflict (see Gould et al. (2012)). Drawing conclusions even from methodologically similar studies can be made difficult by contextual effects. For example, laboratory work has shown that recovery after interruptions can be made more accurate by encouraging people to stop and think (Brumby et al., 2013). However, introducing enforced pauses in a setting free of experimenter oversight can induce *even more* multitasking (Gould et al., 2015). Making sense of results from disparate paradigms presents an even bigger challenge; how would one go about reconciling conflicts in data collected simultaneously through work shadowing and computer-based activity monitoring? Of course, it might be the conflicts in results that provide the real insight.

4. Overview of articles in this special issue

The aim of this special issue is to offer a platform to discuss how different approaches to understanding multitasking and interruptions can be combined to provide insights that are more than the sum of their parts. The articles in the issue cover various approaches and highlight the strengths and challenges that each method has. We will now provide an overview of the papers in this issue, clustered by the main methods that were used.

Three papers adopted questionnaire-based and interview studies. Mattarelli et al. (2015) employed a mixture of methods that consists of survey, diary, and semi-structured interviews to examine how individual perceptions and attitudes about a workplace influence one's multitasking behavior. Paul et al. (2015) adopted a user experience sampling method (User Experience Report) and semi-structured interviews to study the effect of interruptive notifications in desktop environments and to generate design