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Studying interruptions and multitasking in situ: The untapped potential of quantitative observational studies



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ABSTRACT

Much of the large and growing body of literature on interruption and multitasking is motivated, in part, by a desire to reduce their negative effects in occupational settings, particularly those that are safety critical. Much of the existing knowledge has come from experimental studies, however, these do not necessarily generalize to non-experimental contexts. By virtue of being in situ, the results of observational studies are more generalizable, but internal validity remains an issue. Since many of the quantitative observational studies of interruption or multitasking to date have been largely descriptive, their full potential to contribute knowledge that informs practical improvements has been underutilized. We discuss ways to address threats to internal validity in quantitative observational studies through appropriate analysis with particular reference to workflow time studies, a form of direct observation. We also discuss the potential for more sophisticated analysis methods to both address some of the threats to internal validity and to provide more nuanced insights into the role and impacts of interruption and multitasking. In this way observational studies can contribute unique evidence to facilitate practical improvements to work practices and systems.

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1. Introduction

A key motivation to understand interruptions and multitasking is to improve the accuracy and efficiency of work in occupational contexts. This is particularly true in safety critical settings such as air traffic control, aviation, healthcare, industrial process monitoring, and driving where error and inefficiency can have injurious or costly repercussions. In-depth knowledge of the role and impacts of interruptions and multitasking can inform improvements to workplace safety, practices and systems. Due to the complexity and heterogeneity of workflow and individuals in such settings, studying aspects of human work processes, such as interruptions or multitasking, present many challenges for quantitative study design and analysis.

Several approaches can be employed to study work processes including controlled experiments, computer simulation studies, and observational studies. Both experiments and simulations can be designed to control known and unknown sources of bias and thus achieve a high level of internal validity. However, the generalizability of results is limited by their similarity to non-experimental

occupational settings, that is, they can lack sufficient external validity (Shadish et al., 2002). Some experimental studies have attempted to replicate interruptions or multitasking in contexts of interest, such as an office environment (Mark et al., 2008), cockpit (Latorella, 1999), motor vehicle (Watson and Strayer, 2010) or operating room (Liu et al., 2009); however, this becomes increasingly difficult for more complex and unpredictable settings such as hospital emergency departments (ED). Computer simulation studies provide a means to model interruptions or multitasking in more complex scenarios in a controlled way [see for example: (Lebiere et al., 2001; Sierhuis et al., 2007)], but this approach is limited by the accuracy of the necessary assumptions and, as with experiments, it can also be difficult to capture all the complexities of an uncontrolled setting. To date simulation studies of work in complex settings like EDs have focused on aspects such as patient flow and staffing, but not on interruptions or multitasking – an exception being a study (Gunal and Pidd, 2006) that simulated the effect of multitasking, in the sense of concurrent patient management, on departmental performance.

There are many types of observational studies that can be applied to investigate interruption and multitasking. Qualitative observational studies can provide insights about relationships, social dynamics and individual motivations and thought processes in a way that quantitative studies cannot, and this can be valuable when studying complex socio-technical settings. Nugus and Braithwaite (2010) used an ethnographic approach in an ED to understand the seemingly opposing

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factors of quality and organizational efficiency: a question which encompasses issues around multitasking and interruptions. Colligan and Bass (2012) used a combination of semi-structured interviews and direct observation to examine strategies that nurses used to handle interruptions.

While all types of study can contribute important knowledge about interruption and multitasking, in this article we focus on quantitative observational studies for several reasons. They can be conducted in the setting of interest, hence making their results generalizable to at least that context or others that are similar (Black, 1996). For example, a study of medication administration errors found that the risk and severity of error increased with the number of times the administration was interrupted (Westbrook et al., 2010b). Observing interruptions of nurses in situ provides a more accurate assessment of their potential impact on nurses' work than results from experiments or simulations. There may also be ethical constraints on conducting experiments or interventions in safety critical settings where the effect of unintended negative consequences could be serious. The same restriction is less of an issue for observational studies where the data collection process aims to have minimal impact on the context under study. However, a major drawback to the quantitative observational approach is that it can be difficult to establish internal validity and to date this has proven restrictive to the rate of knowledge generation about interruption and multitasking, particularly in healthcare.

The majority of quantitative observational studies of interruptions or multitasking are situated in medical contexts and, as noted previously (Coiera, 2012; Grundgeiger and Sanderson, 2009), most of these have essentially taken a "counting" approach by simply summarizing counts, rates and proportions. A select few healthcare studies have taken a more advanced approach. The previously mentioned medication administration study used a multivariate analysis to find an association between interruption and error (Westbrook et al., 2010b), while another study of intensive care unit staff used eye tracker technology and a multilevel multivariate model to analyse resumption lag following an interruption (Grundgeiger et al., 2010).

While the quantitative observational approach is well suited to healthcare, it is also applicable in other domains. Several studies of information workers have used this approach to examine concurrent task management (Czerwinski et al., 2004; Gonzalez and Mark, 2004), and Loukopoulos et al. (2001) conducted a study of interruption and task interleaving among pilots by observing their activities from the cockpit jumpseat. In an observational study of drivers, Strayer and Drews (2006) assessed the association between concurrent hand held cell phone use while driving and failure to stop at an intersection.

The need to advance the research agenda for interruptions and multitasking in healthcare has been recently noted (Westbrook, in press), and there is clearly considerable scope for more rigorous observational studies to contribute practically useful knowledge to occupational domains, whether healthcare or otherwise. In this paper we aim to expound the ways in which the design, data collection and analysis of quantitative observational studies of interruption and multitasking can be improved from current practice. In particular we discuss fundamental issues with the internal and external validity of observational research in reference to interruption and multitasking, and the ways in which these issues can be mitigated through the application of existing statistical techniques. We also point out areas in which new statistical developments are needed and outline ways forward for each. Where possible, we illustrate these points via a hypothetical case study.

2. Workflow time studies

There are many approaches that can be employed to record an individual's work process, as discussed at length by Lopetegui et al.

(2014). The workflow time study approach (Lopetegui et al., 2014) is a type of time and motion study that offers many advantages over other non-experimental methods applicable to work processes. It involves an external observer shadowing a participant and recording time-stamped information about their tasks and interactions to create a continuous record of the work process. It has its roots in Mintzberg's structured observation method (1970) and is also similar to systematic direct observation used in timed-event sequential analysis in psychology (Bakeman and Gottman, 1997; Chorney et al., 2010) in that it involves recording behaviour in an uncontrolled setting according to predefined operational definitions. The additional emphasis in workflow time studies is on capturing a continuous record of behaviour. It is distinct from an ethnographic approach where observed interaction or behaviour is categorized during the analysis phase (Atkinson and Hammersley, 1994). Workflow time studies have been applied to interruption and multitasking in the domains of healthcare (Weigl et al., 2011; Westbrook et al., 2010a), aviation (Loukopoulos et al., 2001) and human-computer interaction (Gonzalez and Mark, 2004; Mark et al., 2012; Su and Mark, 2008).

The continuous recording of data increases the potential to capture work complexity compared to work sampling or self-report approaches such as diary studies (Mintzberg, 1970). It is also less prone to bias than work sampling (Finkler et al., 1993) or self-report. While audio or video recording can provide an accurate continuous record of a work process, these can easily capture non-participants and the need to seek consent from all those recorded can be prohibitive. In addition, workflow time studies open up the analysis possibilities to a wide range of existing techniques, each of which has the potential to provide innovative insights. Hence we focus on this observational approach and the ways in which it can minimize threats to internal validity and can broaden the scope for statistical analyses applicable to observational data on interruptions and multitasking.

3. Internal validity

One of the main challenges in quantitative observational studies is to generate internally valid results, that is, results that are not biased. This is particularly so in complex settings where there is a network of intertwined factors at play and separating out the influences of particular factors requires addressing the many threats to internal validity. In this section we outline some of those threats and how they can be mitigated with reference to workflow time studies.

3.1. Defining interruptions and multitasking

There is much heterogeneity in the definitions of interruptions and multitasking. Many studies provide no explicit definition, while others attempt to bring some precision to particular terms, such as Trafton et al. (2003) often cited 'anatomy of an interruption' (Fig. 1). The study of interruption and multitasking is now beset with inconsistency, with some terms having been defined to have several different meanings, and some concepts described by several different terms. For example, with reference to Trafton

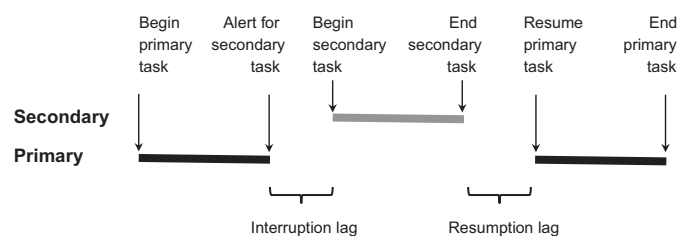


Fig. 1. Trafton et al.'s anatomy of an interruption.

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