Task Difficulty and Time Constraint in Programmer Multitasking: An Analysis of Prospective Memory Performance and Cognitive Workload

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ABSTRACT

The present study investigates how task difficulty and time constraint affect prospective memory (ProM) performance in programmer multitasking (N = 60). The results indicate that an increase in task difficulty and time constraint has a detrimental effect on ProM performance. Moreover, participants are able to successfully complete fewer difficult programs as compared to easier programs regardless of time constraint. Analysis shows that difficulty of the programming problems does not necessarily have a significant effect on cognitive workload (in short, workload) experienced by the programmers. Time constraint has a significant effect on workload experienced by the programmers. The results not only suggest a ProM performance decrement under high urgency (HU) as compared to low urgency (LU) but also show that time constraint has a significant effect on workload. Multiple regression analysis reveals that temporal demand is the most critical dimension of workload which explains 46% of the variation.

Keywords: Error, Human-Computer Interaction (HCI), Programmer Multitasking, Prospective Memory (ProM), Task Difficulty, Time Constraint, Workload Analysis

INTRODUCTION

This paper presents an experimental study of prospective memory (ProM) in a multitasking environment of programming. Particularly, the matter of focus under investigation is the role of task difficulty and time constraint in ProM performance with an emphasis on cognitive workload analysis. A ProM task is concerned with memory for activities that one intends to perform at an appropriate occasion in the future (McDaniel & Einstein, 2007; Meier, Zimmermann, & Perrig, 2006; Smith, & Bayen, 2004). ProM refers to remembering to perform a delayed intention. ProM has various aliases that include: everyday memory, remembering to do

DOI: 10.4018/jgc.2013010103
things, remembering intentions, remembering to execute planned or future actions, or simply remembering to remember. Konorski (1967) suggested that memory involving plans for future actions illustrate memory in its prospective aspect. The term prospective remembering was used by Meacham and Singer (1977) in reporting their naturalistic study. Then, the term ProM was introduced by Meacham and Leiman (1982). When the execution of an intended action is delayed, the very intention is stored in memory and at a later point retrieved and acted on; thus others prefer to talk about realization of delayed intention (Ellis, 1996; Ellis & Milne, 1996)—both task and processes—that begins with the decision to act in a particular way and ends with the evaluation of the outcome of that intention. The term ProM is not favored by some researchers because it implies that the task is purely a memory task. Nevertheless, as apparent from the literature, ProM involves a complex array of cognitive processes in addition to memory. Whatever the nomenclature is, the common agreement is that ProM task involves a delay of the intended action and is not inclusive of all kinds of intended actions.

Not every intention is associated with ProM task. Searle (1983) classified intentions into two types namely, prior intentions and intention-in-action. A prior intention involves forming an intention prior to action, whereas an intentions-in-action is the one in which there is no formation of a prior intention. However, prior intention can be further divided into immediate intention and delayed intention. When one begins to carry out a planned intention immediately after a decision is made about it, then it will be an immediate intention (one begins to carry out when a plan of action is formed and while the plan of action is in the focus of attention) (Kvavilashvili & Ellis, 1996; Smith, 2007). However, delayed intention involves a delay (separation in time) between formation of the plan and the designated moment of performing the action (see Figure 1).

Over a century ago, stating the complexity of cognitive processes in carrying out an intended action, William James (1890/1981, Vol. 2, p. 1130) proposed that an act of will involves an additional conscious element, in the shape of fiat, mandate or consent. It was not until the beginning of 1990s that ProM attracted a new line of experimental research (e.g., Einstein, Holland, McDaniel, & Guynn, 1992; Einstein & McDaniel, 1990; McDaniel & Einstein, 1993). This is despite the instances of early experiments on ProM which took place several decades ago (e.g., Birenbaum, 1930 in Kvavilashvili & Ellis, 1996; Loftus, 1971). The publication of the first book on this topic in 1996 was an important milestone (Brandimonte, Einstein, & McDaniel, 1996) in foregrounding the developments in the field. It is evident that there is an emergence of research efforts concerning ProM (Ellis & Kvavilashvili, 2000). Increasing interest in the investigation of ProM is evidenced in part by the development of new experimental paradigms and the rapidly growing body of literature. The topic represents as an emerging field of contemporary research concerning human cognition which has practical significance in real life work-settings. Thus, cognitive processes which underlie remembering and performing a delayed intention require important focus of empirical studies to resolve performance related issues and improvement of technological systems.

Cognitive workload (or simply, workload) refers to the information processing demands imposed by the performance of a task (Sanders & McCormick, 1993). Analysis of workload is crucial in multitasking. A particular issue about workload stems from the increase of potential errors in handling multiple tasks if the workload is not at the optimal level of an individual. A major concern of workload measurement is the evaluation of workload levels imposed by a task or system with the objective of identifying and eliminating workload related performance decrements (Wilson & Eggermeier, 2001). Wickens (1984) maintained that if adequate performance of a task demands more resources from an individual than are available, performance breaks down. On the other hand, Wickens further noted that if the supply exceeds the demand, the amount of this excess expresses the amount of workload.
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