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Time use behavior in single and time-sharing tasks

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Abstract

Human errors in aviation, process plants and other critical industries can result in dire consequences and hence it is essential to understand the operator behavior and task characteristics in order to improve task performance and safety. The time available and how it is used by the operator are important factors in multi-task situations. Polychrons are people, who favor doing multiple tasks at the same time, while monochrons prefer doing tasks in series. In this study, the strategy, performance and workload of monochrons and polychrons were evaluated in a single and dual control tasks. The task difficulty and multiple task priority were independent variables. Results indicated that polychrons switched between two tasks more than monochrons and achieved better performance when the tasks were equally important and difficult. When the priority between the tasks was different, monochrons changed their emphasis to the more important task even though polychrons did not change their strategy as dramatically as the monochrons. In addition, monochrons indicated significantly higher workload and difficulty than polychrons. Results of this study can be important for the development of training programs of personnel involved in time-critical operations.

Keywords: Complex control; Hill-climbing; Monochron/polychron; Time use; Control strategy; Performance; Task characteristics

1. Introduction

People play an important role in controlling complex systems such as air-traffic, airplanes and power plants (Hollnagel et al., 1988; Morris and Leung, 2006; Rasmussen, 1983; Sheridan, 1981). In these situations, monitoring and controlling multiple tasks is required. How one controls or monitors a task and the related outcome are very critical in complex situations with system faults, generally, attributed to human error (Reason, 1990) and in most cases caused by heavy workload (Morris and Leung, 2006) or "design" errors. Research has shown that people tend to use their self-designed methods to complete a task even though more efficient methods may exist (Coventry, 1989; Sanjram and Khan, 2011). This could be as a result of people achieving the same or similar results using personal strategies, which have been found to be beneficial in learning (Chen and Liu, 2011; Evans and Waring, 2011; Mampadi et al., 2011; Pretz et al., 2010), primarily because cognitive style governs the way a person processes and organizes information. Thus, Lewis (1990) suggested that the habitual responses of individuals be identified when controlling complex systems as they may not be very apparent or elicited verbally. In emergency situations, doing the right thing at the right time is very important since incorrect or non-optimal operations may result in heavy damage to plants, operations and personnel (Reason, 1990). Some operators show significant weaknesses while monitoring and processing multiple tasks under time pressure and limited resources (Reason, 1990). In a control task, when differing types of information are necessary and continuously available, it is essential that they be tracked in terms of the time available, and their priority (Iani and Wickens, 2007). In spite of the need for matching task demand with individual time usage preferences, little research has been carried out on individual preferences or the way people work, especially in complex control systems even though some individuals would

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perform better in multi-tasking situations (Bluedorn and Jaussi, 2007; Jansen and Kristof-Brown, 2005).

Time use is related to how people manage time while handling many things in multiple task situations. Hall (1959, 1989) characterized time systems as monochronic (M) or polychronic (P). When people perform multiple tasks, some people do one task at a time whereas others attend to do many tasks concurrently (i.e., in parallel). Hall and Hall (1990) defined ''Monochronic time (as) paying attention to and doing only one thing at a time. Polychronic time (refers to) being involved with many things at once''. These two types of task handling are called monochronic and polychronic behaviors and those exhibiting these two types of extreme behavior are known as monochrons and polychrons. Poposki and Oswald (2010) offered a definition of individual polychronicity indicating it was preference for shifting attention. König and Waller (2010) provided a more precise definition with polychronicity being the *preference* for doing many things at the same time while the *behavioral* aspect is referred to as multitasking. The usage of time has been studied by many researchers (Bowman et al., 2010; Branscome and Grynovicki, 2007; Francis-Smythe and Robertson, 1999; Harris and Wiggins, 2008; Ishizaka et al., 2001; Kaufman et al., 1991; König and Waller, 2010; König et al., 2005; Lindquist et al., 2001; Lindquist and Kaufman-Scarborough, 2004, 2007; Zhang and Goonetilleke, 2004; Zhang et al., 2005) to understand people's multitasking behaviors in many different fields such as management psychology, shopping behaviors, marketing and process control and in many different cultures. Some studies (Ishizaka et al., 2001; Branscome and Grynovicki, 2007; König et al., 2005) reported the results where they attempted to find a relationship among monochronicity, polychronicity and performance. However, they did not find significant differences between monochrons and polychrons. A study on dual process-control tasks (Zhang et al., 2005) showed that strategy and performance differ between monochrons and polychrons when the tasks had equal importance. In general, researchers believe that monochrons may be better suited for work with strict time constraints such as in transportation (Conte et al., 1999), while polychrons may be suited for work that needs rapid adaptation to changing demands and which requires doing many things at a time while 'balancing' time use, such as in firefighting and emergency room tasks (Kaufman-Scarborough and Lindquist, 1999).

As an individual factor, which relates to multitasking behavior and performance, the use of time appears to be an important issue in process control. Task characteristics of difficulty and priority might play an important interacting role in control strategy and performance (Hall, 1989; Ishizaka et al., 2001; North and Gopher, 1976; Wickens and Seidler, 1997). The various interactions among monochronicity/polychronicity, difficulty and priority have not been carefully investigated. Based on the current knowledge one may hypothesize, with two tasks, monochrons may focus more on the important task and ignore the other when the priorities change or may tend to focus on one task when difficulty levels of the tasks change; polychrons may attempt to perform both tasks irrespective of their importance. Furthermore, when there is mismatch between the inherent time characteristic of an individual with that of the task demands, it can be hypothesized that the mental workload (Hart and Staveland, 1988) of the individual to be higher or in the other extreme case, the individual would feel bored. Therefore, the main objective of this experiment is to investigate the strategy, performance and workload changes of monochrons and polychrons with different task difficulty and priority in a dual task situation. In addition, a person with superior performance in one task may have an effect when he/she performs multiple tasks. Thus, the differences between monochrons and polychrons when performing a single task were evaluated as well in order to validate the results of the dual tasks.

2. Methodology

2.1. Participants

Four hundred and sixty-five students from the Hong Kong University of Science and Technology were invited to complete the monochronic/polychronic questionnaire ''work and life survey'' (Plocher et al., 2002), which included two monochronic/polychronic scalesthe Modified Polychronic Attitude Index 3 (MPAI3) (Lindquist et al., 2001) and Inventory of Polychronic Values (IPV) (Bluedorn et al., 1999) scales. The monochronic/polychronic scores were then calculated based on the average value of all the items of each scale. There were 18.9% ($N=88$) in the monochronic group ($1 \leq$ MPAI3 score ≤ 3 and $1 \leq$ IPV score ≤ 3) 40.4% ($N=188$) in the neutral group ($3 <$ MPAI3 score < 5 and $3 <$ IPV score < 5) and 9.5% ($N=44$) in the polychronic group ($5 \leq$ MPAI3 score ≤ 7 and $5 \leq$ IPV score ≤ 7). Around 31% ($N=145$) had scores that were mismatched in their MPAI3 and IPV scores. Thirty-two Chinese (sixteen from monochronic group and sixteen from polychronic group) were then randomly selected to participate in the subsequent experiment. Each group comprised 8 males and 8 females. Ages of participants were recorded and each participant was paid HK$200 with an added bonus for performance at the end of the experiment.

2.2. Simulation software

A bivariate process control simulation software was developed in Visual C++. The hill-climbing task originally developed by Rigby (1972) has been used to study human behavior and performance in multivariate process control tasks (Berkowitz et al., 1983; Goonetilleke and Drury, 1989; Laughery and Drury, 1979). This type of task also represents supervisory control situations such as in air