TIME ORIENTATION AND MULTI-TASKING

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Abstract: The concept of time orientation that classifies people as monochrons (M) or polychrons (P) is not new. Hall has extensively discussed time orientation differences among differing cultures. However, time orientation has not been explicit in the human-machine systems literature. Two experiments are presented in this paper. The first shows the effect of time orientation on human performance in a dual process control task. Polychrons switched more often between the two processes and had significantly better performance overall. The second experiment was a means to understand the underlying differences between monochrons and polychrons and it showed that there were no differences between M and P in the cognitive style analysis, perception, judgement and memory tests. However, there were differences between the two groups in the attention test. Overall, the concept of time orientation seems to be quite promising as an individual difference characteristic.

Keywords: cognitive ability, cultural aspects of automation, human supervisory control, process control, time orientation

1. INTRODUCTION

In his book, Society and Solitude, Ralph Waldo Emerson (1882) quotes, "(the days) come and go like muffled and veiled figures sent from a distant friendly party; but they say nothing, and if we do not use the gifts they bring, they carry them as silently away". The importance of doing the right thing at the right time is well known to many of us. Executive training programs also emphasize the importance of time management and the necessity of scheduling important activities and events. However, are all people capable of handling many different activities simultaneously and effectively? In order to answer such questions, one may resort to the concept of time orientation proposed by Hall (1959, 1989, 1990). The two extremes of time orientation have been labelled as monochronicity (doing one thing at a time and a person who is inclined to do one thing at a time is known as a monochron) and polychronicity (doing many things at once and a person having such behaviour is known as a polychron).

The extent to which a person exhibits monochronic or polychronic behaviour can be quantified using scales such as the Modified Polychronic Attitude Index 3 (MPAI3) score (Lindquist, et al., 2001) or the Inventory of Polychronic Values (IPV) proposed by Bluedorn, et al. (1999). The mean score of the scale items of both MPAI3 and IPV range from 1 to 7 with 1 indicating monochronic tendencies and 7 indicating polychronic tendencies. Differences among differing cultures have already been documented. Recent data using an on-line questionnaire (Plocher, et al., 2002) are shown in table 1. This questionnaire can be accessed at http://143.89.20.170/introduction01.html.

The concept of time orientation has appeared extensively in the area of management psychology, but research is quite sparse in relation to human performance in human-machine systems. Even though Human Factors researchers have emphasized the importance of time-sharing abilities, this ability has not been quantified and linked to human performance in a systematic way. Frei, et al. (1999) have discussed the potential relationship between polychronic behaviour and time-sharing ability and indicated that polychrons might perform multiple tasks better than monochrons. But, the underlying differences between the two groups are somewhat unclear. Could the differences be due to differing abilities in relation to sensory processing, perception, cognition, memory, response selection, response execution and attention? In this paper, two experiments are presented to get more insight in relation to time orientation. The first experiment is an attempt to evaluate the effect of time orientation on human performance in process control tasks and the second experiment is aimed at identifying the underlying differences between monochrons and polychrons.

Table 1 Time orientation scale values of people of different birth nationalities.

Country of Birth	Sample Size	MPAI3 scale value	IPV scale value
UK	24	4.64	4.45
USA	132	4.64	4.32
Sri Lanka	50	4.37	4.24
Malaysia	21	3.86	3.58
China	70	3.82	3.53
Hong Kong	88	3.77	3.47

2. EXPERIMENT 1

2.1 Participants

Forty-two Hong Kong Chinese (25 males and 17 females) participated in the experiment. The MPAI3 scale was used to determine the M/P score using an online questionnaire. The age of participants was 20 to 25 years (mean = 21.9, SD. = 1.34).

2.2 Experimental design

The Control Station software (Cooper and Dougherty, 2001) was used to simulate a two-process control task. Participants were required to control the two processes such that the output of each process was within a predetermined set limit. The two processes were both either first or second order. A 2 (process order) * 5 (trial) full factorial experiment was used and the sequences of the two conditions were balanced. Participants underwent process and simulator training for about an hour prior to the start of the actual test. Each experimental trial was set to be approximately 6 minutes and each participant was given five trials in each condition. The control strategy and control performance were evaluated using the number of switches (N_{switch}) between the two processes, number of input magnitude changes (N_{mag}) within the two processes, overall mean error (E_o) and Root-Mean-Square error (E_{rms}).

2.3 Results

All statistical analyses were performed using SAS. Analysis of variance revealed significant differences among the five trials. A *post-hoc* Duncan test demonstrated that trial 1 was significantly different from other trials for the variables, overall mean error and RMS error. Hence, trial 1 was eliminated in all subsequent analysis. Correlation analysis showed significant correlations between M/P score and the strategy measure and performance measure. Figures 1 and 2 show the linear regression ($R^2 > 0.8$) of the performance and strategy measures with the M/P score. It is clear that a higher M/P score (a polychron) is associated with a higher number of switches (or switching frequently) and a lower overall RMS error (or better performance in both tasks).

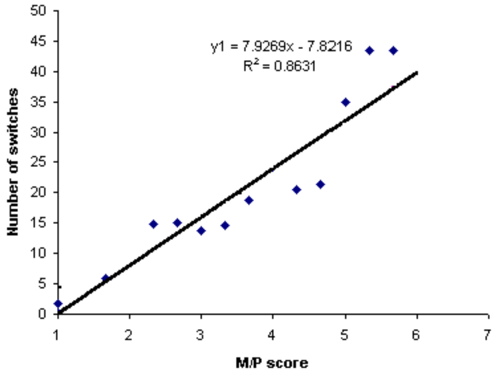

Fig. 1. The relationship between M/P score and number of switches for first order system (N=39).

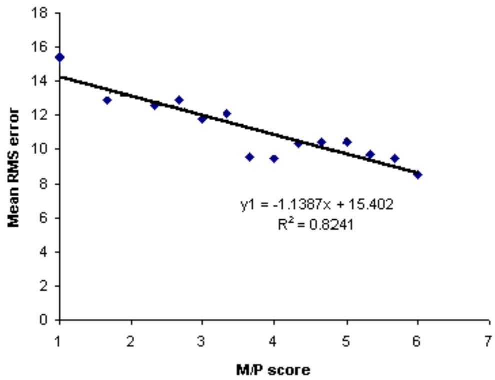

Fig. 2. The relationship between M/P score and mean RMS error for first order system (N=39)

In order to further investigate the differences between monochrons and polychrons, twenty-two participants were assigned to two groups (11 in each group) based on their M/P score: monochrons ($1 \leq$ MPAI3 score ≤ 3) and polychrons ($5 \leq$ MPAI3 score ≤ 7). The three-way ANOVA (M/P group, order and trial) showed that monochrons had significantly different strategies and performances compared to polychrons: N_{switch} ($F(1,160)= 218.59$, $p<0.0001$) N_{mag} ($F(1,160)= 106.33$, $p<0.0001$), E_o ($F(1,160)= 41.26$, $p<0.0001$) and E_{rms} ($F(1,160)=54.50$, $p<0.0001$). Monochrons generally had a tendency to control the processes serially. In other words, monochrons switched from one process to another only when the first process was somewhat within control. On the other hand, polychrons attempted to control both processes at the same time and switched much more between the two processes. As a result, the number of switches (N_{switch}) was significantly larger for polychrons (mean = 34.16) than monochrons (mean = 13.80). Since the polychrons controlled both processes at the same time, they were able to achieve a lower error as indicated by E_o and E_{rms} when compared to monochrons (mean E_o was 7.45 for polychrons and 10.69 for monochrons).

There were no significant differences between the two process orders. Since the second order process was a second order system with an exponential lag, it did not result in any degradation in performance (Wickens, 1986).

3. EXPERIMENT 2

Since time orientation has significant effects on the strategy and performance measures, the objective of the second experiment was to determine the underlying differences between the two groups.

3.1 Participants

Potential participants completed a MPAI3 and IPV online questionnaire. Based on the online survey, 24 monochrons whose MPAI3 and IPV scores were between 1 and 3 and 24 polychrons whose MPAI3 and IPV scores were between 4.9 and 7 were selected to participate in this experiment. Twenty-five males and 23 females were participants in this experiment. The age range of participants was 19 to 30 years with a mean age of 23.77 years and a standard deviation of 2.77 years.

3.2 Stimulus materials

The perception, memory and judgment tests of Industrial Psychology International (IPI) were used. In addition to the IPI tests, cognitive style, attention and digit memory span of participants were evaluated.

IPI Perception, memory and judgment tests. The perception test had 54 questions that had to be completed in 6 minutes and it tested the ability of a person to perceive details in words and numbers and to recognize similarities and differences quickly. The Memory test is designed to check one's ability to remember visual (recognize faces), word (recall words) and number (recall numbers) stimuli. The judgement test checks the ability to deduce solutions to abstract problem and measures the aptitude to think logically.

Cognitive style. Cognitive Style Analysis (CSA) (Riding and Rayner, 2000), which measures the two dimensions, Wholist-Analytic (WA) and Verbal-Imagery (VI) was also used. The Wholist-Analytic dimension determines "whether an individual tends to organize information in wholes or parts" (Riding and Rayner, 2000) while the Verbal-Imagery dimension determines "whether an individual is inclined to represent information during thinking, verbally or in mental pictures" (Riding and Rayner, 2000).

Digit memory span test. A total of 18 numbers comprising 5 to 13 digits were displayed on the computer screen at 500 msec/digit (modified from Goonetilleke, et al., 1999). Participants were required to memorize and input the number when requested.

The attention test. This test was a modified form of the Hirshkowitz, et al. (1993) multiple vigilance test (MVT). The participant's attention span was measured for a period of 15 minutes while each participant listened to English news through headphones. The participants were told that their main task was to respond correctly to the attention test and they were told that they would not be questioned on the news that they heard. A total of eight targets or non-targets were presented during each minute and the number of hits, misses, correct rejections and false alarms were recorded automatically.

3.3 Experimental design and procedure

The test sequence was the same for every participant: i.e. CSA, judgment, digit span, memory, perception and attention test. Participants read the instructions and were given a short practice prior to each test. The participants were allowed to take a short break between tests.

3.4 Results

There were no significant correlations between the M/P score and the various cognitive tests (table 2).

Table 2 Correlation coefficients between M/P score and cognitive tests (N=48). The probability values are given in brackets.

Test and Measure		MPAI3	IPV
Cognitive style analysis	WA Ratio	0.0818 (0.5803)	0.0659 (0.6561)
	VI Ratio	-0.1192 (0.4198)	-0.1179 (0.4249)
I.P.I. Aptitude Tests	Perception	0.1265 (0.3915)	0.1275 (0.3879)
	Judgment	0.0838 (0.5712)	0.1146 (0.4380)
	Memory	-0.0705 (0.6340)	-0.1203 (0.4153)
Attention	Number of Hits	-0.2787 (0.0551)	-0.2642 (0.0695)
	Number of False Alarms	0.1305 (0.3766)	0.1245 (0.3991)
Digit span		0.0688 (0.6423)	0.0714 (0.6297)

Moreover, the analysis of variance also did not shown any significant differences between monochrons and polychrons for the perception, judgment, memory, digit span and cognitive style ($p>0.05$) scores. However, the attention test showed a significant difference ($F(1,44)=4.11$, $p=0.0488$) between monochrons and polychrons with monochrons having a higher number of hits (mean=43.5, SD. = 1.93) when compared to polychrons (mean number of hits = 41.33, SD. =4.80). In other words, monochrons concentrated on the main task while polychrons were distracted and switched attention to the news, sometimes, during the test. Wickens and Hollands (2000) have used resource allocation to explain such differences in performance in multi-task situations. When an operator divides differing amounts of resource to different tasks, performance may be different. Performance differences between monochrons and polychrons in the attention test may be related to such a resource allocation difference.

4. DISCUSSION

The results of the first experiment clearly show that polychrons are able to take care of two things at once compared to monochrons who attend to one thing at a time. The second experiment showed that there were no differences between monochrons and polychrons in many cognitive components but had differences in attention. This suggests that monochrons might be putting more attentional resources on the primary task while polychrons can be distracted by disturbances or other tasks resulting in performance degradation in the main task. These results are in line with Hall's (1989) claims that monochrons are focussed on a primary task and ignore unimportant things. Since attention allocation strategy can be affected by task characteristics such as task priority (North and Gopher, 1976; Wickens, 1977) and task difficulty (Andre and Heers, 1993), more research needs to be done to identify how the attention allocation strategies of monochrons and polychrons change with such task situations. Such an understanding will help train and aid operators to improve performance in complex control tasks even though their time orientations may be different.

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