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Gender differences in mental workload during two computer-based tasks

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Abstract: The objective of this study was to examine the differences in mental workload to computer-based tasks between men and women. Twelve female and twelve male students participated in the study. They performed a modified mirror tracing task and a mental arithmetic task. Mental workload was measured by physiological variables, subjective measurement and behavioral performance. Results suggested the possibility that women have advantages over men with respect to mental workload tolerance.

Keywords: computer-based task, mental workload, gender difference

1. INTRODUCTION

Although a great deal of research has conducted to assess the mental workload during computer-based work, many such researches have often excluded women or included them relatively small numbers. Traditions, convenience and women's biological rhythms are likely expectations for the preference of males as subjects (Lundberg, 1998). However, considering that the number of women who use computer at work has increased rapidly, research is required to examine the mental workload in women during the computer-based work.

So far, most studies on mental workload haven't directly compare men to women. Therefore, the first purpose of this study was to examine the differences in mental workload to computer-based task between men and women by using physiological variables, subjective measurement and behavioral performance. Recent study has suggested that cardiovascular response pattern differ from task to task in the laboratory setting (Miyake, 1997). However, little attention has been paid to the gender differences in cardiovascular reactivity to different type of computer-based mental task. Therefore, the second purpose of this study was to examine the cardiovascular responses to different type of computer-based tasks in men and women.

2. METHOD

2.1 Subjects

Twelve female and twelve male undergraduate students participated in the study. On the initial screening interview, subjects were confirmed that they had no history of cardiovascular disease and were not smokers. Before enrolling in the study, written informed consent was obtained from all participants.

2.2 Experimental tasks

Subjects performed a modified mirror tracing task and a mental arithmetic task. Modified mirror tracing task was used to evoke substantial pressor responses. The subjects traced the pathway on the computer screen with a mouse. The horizontal and/or vertical axis controls of the mouse were reversed. Mental arithmetic task was used to elicit substantial heart rate responses. The task consisted of serial subtraction by 17's from a random 4-digit number presented on a computer screen for 5 minutes. Subjects were required to enter the answer by clicking the 10 numeric buttons displayed on the screen with a mouse.

2.3 Physiological measurements

Electrocardiogram (ECG) and respiration signals were monitored with a polygraph system and recorded on a digital tape recorder. Four blocks of ECG data were analyzed; 5 minutes before modified mirror tracing task (PRE), modified mirror tracing task (MT), mental arithmetic task (MA), and 5 minutes after mental arithmetic task (POST).

As it has been reported that power spectral analysis on heart rate variability (HRV) is useful to assess the mental workload (Sloan et al, 1995), ECG data were digitized at a sampling frequency of 1kHz and autoregressive model (AR) power spectrum from trendgram was calculated by the fixed tenth-order AR model. The power spectral density was divided into sum of spectral components by means of a spectral decomposition method, and the center frequency and the power of every spectral component were obtained. In this study, a spectral component with center frequency of between 0.05 and 0.15Hz was considered as the LF component, and a spectral component with the same cycle as the respiratory one and a center frequency of around 0.25Hz was considered as the HF component. Each spectral component was normalized (%LF, %HF) be dividing it by total power less the first-order component, if present. The LF/HF ratio was also calculated to assess the balance in autonomic nervous system. Heart rate (HR) was derived from calculating the number of R waves.

Respiration activity was transduced by a strain-gauge placed around the subject's abdomen halfway between the rib cage and navel.

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) was measured by an automatic blood pressure monitoring system via cuff placed on the left upper arm.

2.4 Subjective measurement and behavioral performance

Subjective metal workload was evaluated by the NASA-TLX. Weighted workload score (WWL) was obtained from rating for the six component scales of NASA-TLX. .

Behavioral performance of the modified mirror tracing task was calculated by dividing the total traced length on the pathway by the number of deviations from the pathway. As an instruction of the mental arithmetic task performance, the ratio of number of problems solved correctly divided by the number attempted were computed.

2.5 Experimental Procedure

On arriving at the laboratory, subjects were attached the electrodes and were instructed to rest seated quietly for 10 minutes. Then, blood pressure was measured. Following a 5 minute modified mirror tracing task period, blood pressure was measured again. Next, subjects rested for 5 minutes. Same procedure was used for the mental arithmetic task. Subjects controlled their respiratory frequency during the last 5 minutes of rest period before modified mirror tracing task, both tasks, and rest period after mental arithmetic task.

Repeated measures of analysis of variance (ANOVAs) were used to evaluate gender and block effects on physiological and subjective measurements. Where ANOVAs revealed significant effects, post hoc comparisons were made using Tukey's Honestly significant Difference (HSD) procedure. Student's t-test was used for analyzing the behavioral performance.

3. RESULTS

3.1 HR, HRV and BP

Figure 1 presents changes in HR for each block. Results showed that HR during mental arithmetic task (MA) were significantly greater than those during two rest periods (PRE, POST) and the modified mirror tracing task (MT) ($p<0.01$). Gender main effects and gender by block interaction were not significant for HR.

As for HRV variables, no significant main effects nor interaction were revealed for total power. Changes in %HF were shown in Figure 2. Results showed LF components increased during two tasks (MT, MA) than those during two rests (PRE, POST) and HF components during two tasks (MT, MA) were lower than during two rests (PRE, POST). HF components in males were marginally lower than those in females. No significant interaction of gender by block emerged for HF components. Changes in LF/HF ratio were depicted in Figure 3. Result showed that the LF/HF ratio were higher during two tasks (MT, MA) than during the rest before a modified tracing task (PRE) and greater during a modified tracing task (MT) than during the rest after a mental arithmetic task (POST). There was no significant gender by block interaction. No main effects of gender were found for LF, HF components and LF/HF ratio.

Changes in SBP and DBP were shown in Figure 4 and Figure 5, respectively. There were significant differences in SBP and DBP between pre and post tasks, indicating SBP and DBP after task were higher than those before task ($p<0.01$). SBP for man was higher than that for women ($p<0.01$) and DBP for man was marginally higher than that for women ($p<0.10$). A significant pre-post task by gender interaction was found for SBP ($p<0.05$).

3.2 Subjective measurement and behavioral performance

Changes in WWL were shown in Figure 6. There were no significant main effects of task, and gender, nor was there a gender by task interaction.

The performance of modified mirror tracing task and mental arithmetic task are shown in Table 1. No gender differences in index for the modified mirror tracing task. As for the mental arithmetic task, males showed a marginally higher correct rate as compared to females ($p<0.10$).

4. DISCUSSION

In this study, result from ANOVA showed there were no gender by task interaction on the physiological variables except SBP during two mental tasks, which suggest that the magnitude of physiological reactivity to the tasks were not significantly different between men and women. However, there was significant pre-post task by

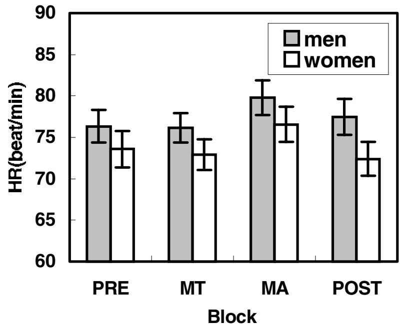

Figure 1 Changes in HR

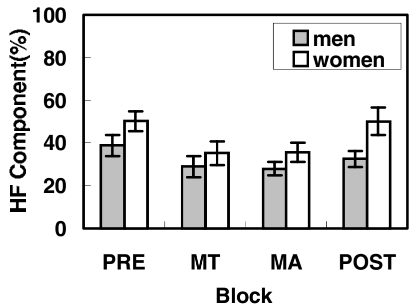

Figure 2 Changes in %HF

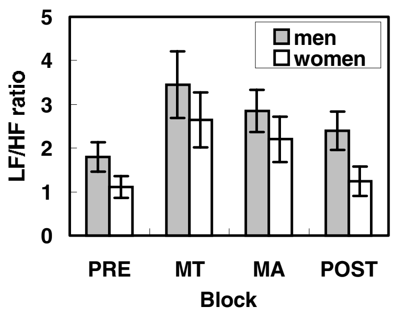

Figure 3 Changes in LF/HF

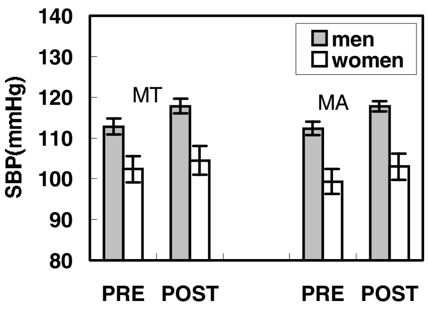

Figure 4 Changes in SBP

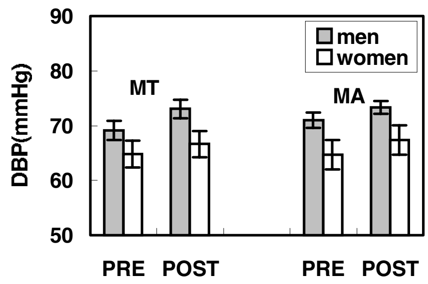

Figure 5 Changes in DBP

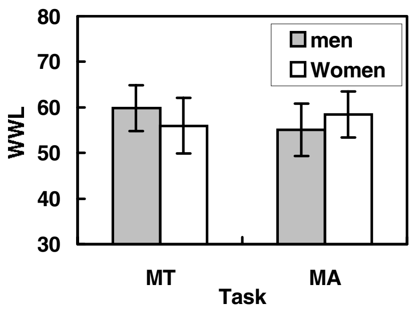

Figure 6 Changes in WWL

Table 1 Behavioral performance for each task

Task	MT	MA
Index	Traced length/the number of deviation (pixel)	Corerct rate (%)
Men	31.24 (2.39)	91.45 (1.50)
Women	35.46 (3.24)	86.35 (2.27)

gender interaction in SBP. Men exhibited greater SBP reactivity to the tasks than those in women. In addition, men had marginally lower baseline level of %HF and higher baseline levels of SBP and DBP than those in women. Power in the HF is widely recognized as a measure of vagal modulation of HR (Sloan et al, 1995). SBP and DBP are increased by sympathetic nervous activation. Therefore, together with our findings, it is possible women have advantages over men with respect to mental workload tolerance.

It has been suggested that the mirror tracing task activated alpha-adrenergic activity whereas the mental arithmetic task activated beta-adrenergic activity (Sherwood et al, 1995). In the present study, HR during the mental arithmetic task period was significantly higher than during the baseline and the modified mirror tracing task periods while HR during the modified mirror tracing task period were not significantly different as compared with those during two resting periods. The values of SBP and DBP after each task period were higher than before each task. Our results partly supported the previous study. However, we couldn't confirm the gender differences in physiological reactivity pattern to those two tasks in the present study.

In summary, our results suggested there are gender differences in mental workload to computer-based mental task. Additional study of gender differences in mental workload should be conducted by using various computer-based tasks under more real work environment in a larger sample in the future.

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REFERENCES

Miyake, S. (1997), Factors influencing mental workload indexes, *J UOEH*, 19(4): 313-325.

Lundberg, U. (1988), Work and stress in women. *Women, stress, and heart disease*. In: Orth-Gomer, K, Chesney, MA, Wenger, NK. Mahwah: IEA: 41-56.

Sherwood, A., Turner, J.R. (1995), Hemodynamic responses during psychological stress: implications for studying disease process, *Int J Behav Med(2),* 193-218.

Sloan, R.P. et al.(1995), Consistency of heart rate and sympathovagal reactivity across different autonomic contexts, Psychphysiology, 452-459.