Hand-Skin Temperature and Tracking Skill

Ravindra S. Goonetilleke, Chow Kin Wah, and Yeung Ying Chun
Department of Industrial Engineering and Engineering Management
Hong Kong University of Science & Technology
Clear Water Bay, Kowloon, Hong Kong

ABSTRACT

Even though manual tracking performance has been extensively investigated, there is little or no research related to the lower limit of temperature for unimpaired tracking performance. This study is an attempt to obtain temperature limits while investigating the effect of hand-skin temperature on manual tracking for the Hong Kong population. A total of 18 subjects were used in a within-subject design experiment. The hand-skin temperature investigated were 10, 20 and 30 degrees Celsius. Tracking performance was measured by the subject drawing a continuous line in-between two straight lines of length 20mm and width 1.5 mm, 2mm, 2.5mm, 3mm, and 4mm. Performance measures were the speed to draw a line of length 20mm with a given spacing (4, 3, 2.5, 2, 1.5mm) and the number of errors as determined by the cross-over points of the drawn line with the printed lines while drawing. Both performance measures were consistent and showed significant effects ($p < 0.05$) for line spacing and hand-skin temperature. Performance at 10°C was significantly worse from that of 20°C and 30°C. Tracking performance was best with the larger width line spacing. It can hence be concluded that at low temperatures, gloves or suitable protection be used, especially for the Hong Kong population.

Keywords: Hand-skin temperature, tracking, cold stress, climate

1. INTRODUCTION

Most office or manual work involves some form of tracking when using the hand. Even though the effect of temperature on tracking skill has not been investigated, there exists research related to tactile sensitivity. Tactile sensitivity is reduced when the temperature is low. Morton and Provins (1960) have found that tactile sensitivity is an L-shaped function of skin temperature and that each individual has a relatively sharp critical temperature at which performance deteriorates significantly. This reduction in sensitivity makes small object manipulation difficult. Hence assembly, typing, and small-repair tasks can be adversely affected by "cold" temperatures if no proper protection is used. Researchers have suggested the use of gloves or other forms of protection in cold temperatures. However, the dexterity associated with small part manipulations and assembly does reduce with the use of gloves. (Bishu et al, 1987). Hence it is important to find the lower limit for tracking skill without any covering or with the use of bare hands. Even though Sanders and McCormick (1992) states that the lower limit for unimpaired tracking is still uncertain, they suggest an ambient temperature of 4 to 13 degrees Celsius (39 to 55 degrees Fahrenheit).

This study addresses the effect of hand-skin temperature on manual tracking for the Hong Kong population. In addition to the temperature, the population tested is also important. Even though there exist some literature related to body temperature and motor performance, none is available for the Hong Kong population. It is important to be able to generalize the results based on other populations since the underlying structures of the body are different in different parts of the world. The primary objective of this study was to investigate the relationship between tracking performance and hand-skin temperature for the Hong Kong population.

2. METHODOLOGY

2. 1 Subjects

A total of 18 subjects were used in a within subject design experiment. None of the subjects had any hand defects.

2.2 Equipment

Three temperature controlled water beakers, stop watch, and pencil were used. The water temperature in the three beakers were maintained at 10°C, 20°C, and 30°C respectively.

2.3 Procedure

The 18 subjects were divided into 3 groups and a within-subject design was used. Each subject was asked to dip their hand in a temperature controlled water bath for 1 minute. The subjects were given a 5-minute break between each temperature evaluation. The temperature of the water bath was controlled to be at either 10, 20 or 30 degrees Celsius. The presentation order of each temperature is shown in Table 1 below. Tracking performance was measured by the subject drawing a continuous line in-between two straight lines from left to right. These lines are shown in Figure 3. After dipping the hand at a given temperature for 1 minute, each subject was asked to draw 5 lines of length 20 mm in-between two printed lines of different width. The width between the two lines were set at 4mm, 3mm, 2.5mm, 2mm, and 1.5mm. The order in which each width was presented to each subject was randomized. Hence each subject drew a total of 15 lines corresponding to the 3 water temperatures, i.e., 5 lines for each temperature. The subjects were asked to draw each line as fast as possible and as accurately as possible. The time to draw the line was one dependent measure. The number of cross-over points with the printed lines (also called number of errors) was the second dependent measure.

Table 1. Test Sequence

	Group A (N=6)	Group B (N=6)	Group C (N=6)
Test 1	10^0 C	20^0 C	30^0 C
Test 2	20^0 C	30^0 C	10^0 C
Test 3	30^0 C	10^0 C	20^0 C

3. RESULTS

Performance measures were the speed to draw a line of length 20mm with a given spacing (4, 3, 2.5, 2, 1.5mm) and the number of errors as determined by the cross-overs of the drawn line with the printed lines while drawing. All statistical analyses were performed using the SAS package on a personal computer (PC). The effect of temperature and line spacing on the two performance measures are illustrated in Figure 1 and 2.

The ANOVA showed significant effects for both performance measures at the $p < 0.05$ significance level. There was no interaction (temperature * line spacing) effect for either Movement Time or the Number of Errors at the $p < 0.05$ level. Hand-skin temperature and line spacing showed significant effects for both movement time and errors. The three levels of Temperature were significant for movement time, $F(2,255)= 6.03$; $p=0.0028$ and Number of errors, $F(2, 255)=8.95$; $p = 0.0002$. Line spacing was significant for Movement Time, $F(4, 255) = 21.99$; $p = 0.0001$ and Number of Errors, $F(4,255)=81.26$; $p = 0.0001$.

Student-Newman-Keuls (SNK) analysis showed no differences between the two temperatures of 20°C and 30°C for both the dependent variables, movement time and number of errors. However, the temperature of 10°C was significantly different from the other two temperatures for both the dependent variables. As far as line spacing, there were no significant differences between 2.5 mm and 3 mm as indicated by the SNK test for movement time as well as the number of errors.

4. DISCUSSION

The results show a significant decrease in tracking performance as measured by both movement time and the number of errors, when the hand-skin temperature is 10°C,. However, at the other two temperatures of 20°C and 30°C, there does not seem to be any significant difference in tracking performance.

The analysis also shows no significant difference in performance when the line spacing is 2.5 mm or 3 mm. However, the other line spacings do show a significant difference with "best" performance at the widest line spacing which is not too surprising. There is no doubt that the time restriction of having the hand immersed for 1 minute is a limitation in this study. However, the fact that performance was significantly poor at 10°C does indicate that even short exposure is detrimental to tracking skill at this temperature. Further research is needed to find the cold exposure duration before differences in tracking are seen between 20°C and 30°C.

Hence it may be concluded that at temperatures below 20°C, gloves or suitable protection be used as a safety measure. However, the effect of gloves or other hand protection on tracking skill needs further investigation.

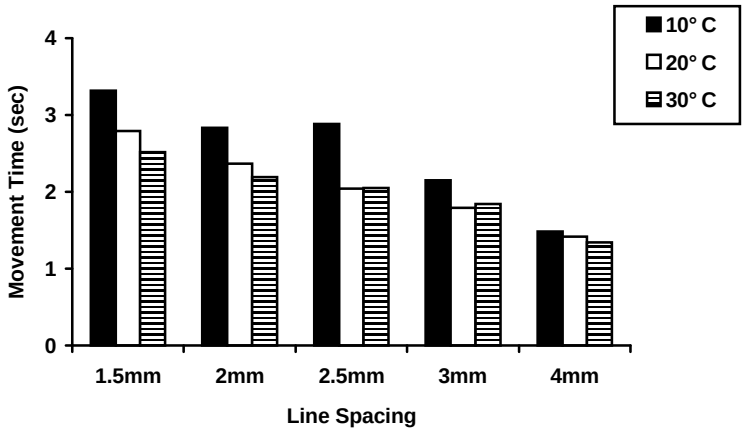

Figure 1. Movement time in seconds for varying hand temperature and line spacing

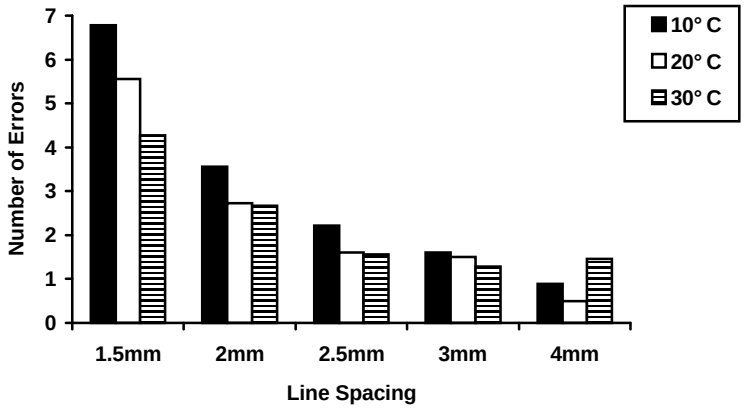

Figure 2. Number of errors for varying hand temperature and line spacing

5. REFERENCES

Bishu, R. R., Batra, S., Cochran, D. J., and Riley, M. W. (1987). Glove effect on strength: An investigation of glove attributes. Proceedings of the 31st Annual Meeting of the Human Factors and Ergonomics Society, 901-905.

Morton, R., and Provins, K. (1960). Finger numbness after acute local exposure to cold. Journal of Applied Psychology, 15, 149-154.

Sanders, M.S, and McCormick, E. J. (1992). Human Factors in Engineering Design. New York: McGraw-Hill.

Subject Number ____ Temp _____

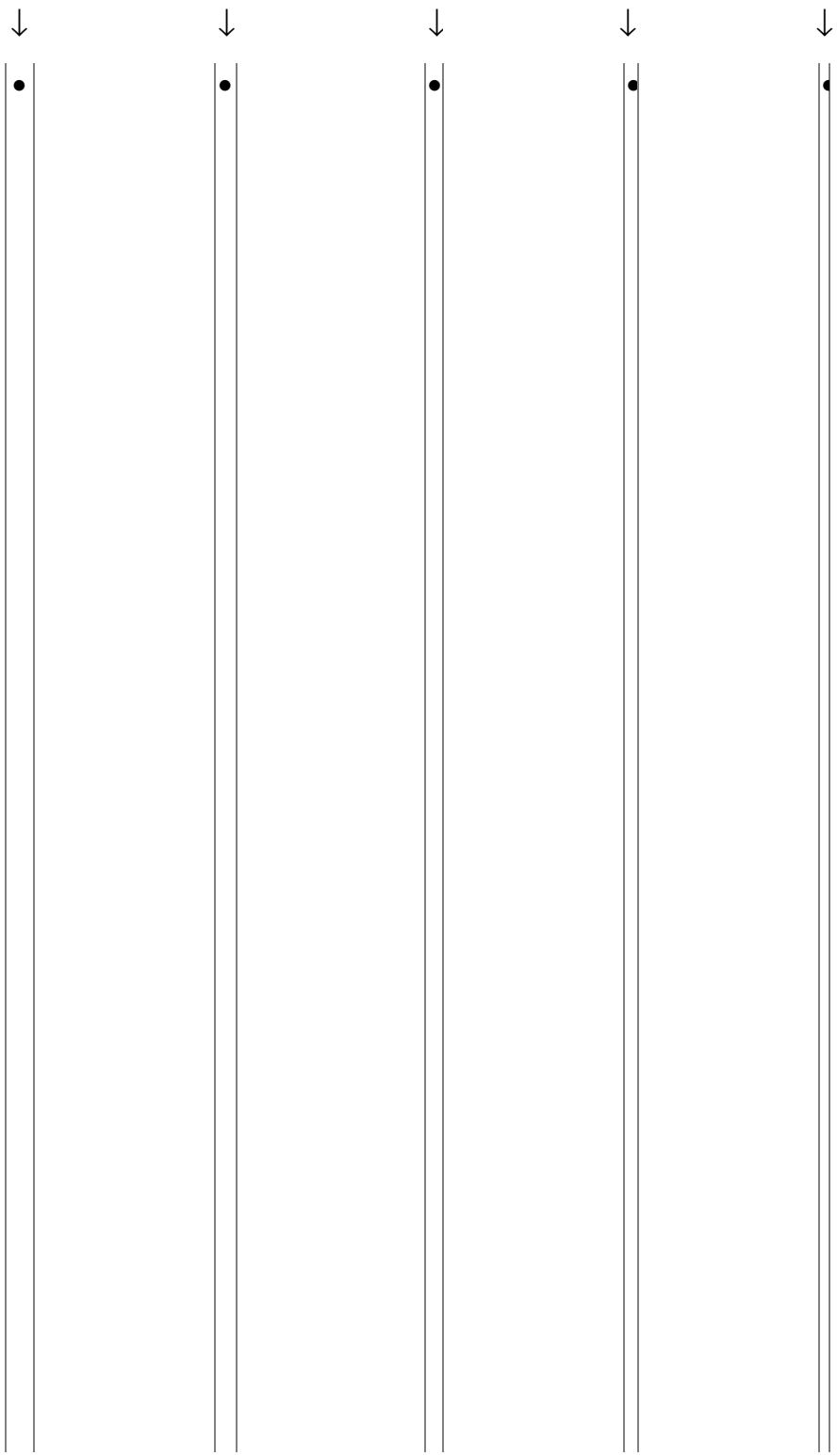

Figure 3. Tracking Performance Sheet