Investigation to Explore the impact of hand-skin temperature on performance

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Abstract

In this study, Our main objective was to determine if there was a relationship between tracking performance and hand-skin temperature. The study involved 11 participants, each of whom repeated the experiment 4 times. To measure hand skin-temperature, we used a thermometer placed in a water bowl. The experiments were conducted randomly, varying the ring diameters and water temperatures. Participants were instructed to submerge their hands (from the forearm to the fingers) in the water bowl for 1 minute before playing a game. We measured tracking performance based on the number of mistakes made and the time taken to complete the game. Participants were given a 10-minute break between different water temperatures. We analyzed the data using a factorial within-participants design to examine significant differences between the levels of each factor and their interactions. The results indicated that temperature had no significant effect on the time taken or the ring diameter, including their interaction. However, both temperature and ring diameter had a significant effect on the number of mistakes made. Interestingly, the interaction between temperature and ring diameter did not have a significant effect on the number of mistakes.

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Introduction

The study aimed to investigate the potential relationship between hand-skin temperature and tracking performance. It explored manual performance in relation to different rates of cooling during cold exposure and subsequent rewarming.[1] While there is limited research on the effect of temperature specifically on tracking ability, previous studies have demonstrated that low temperatures can reduce tactile sensitivity.[2] The study also recognized the health and safety concerns associated with exposure to a cold environment, such as pain, discomfort, numbness, and potential skin damage.[3]

Some Clarifications

In this study, we have chosen to set the warm temperature at 38°C and the cold temperature at 12°C based on the following justifications.

- These temperature ranges allow us to examine the impact of both warm and cold environments on tracking ability, providing a comprehensive understanding of the relationship between temperature and performance.

- The warm temperature of 38°C is within the range of normal body temperature for humans. This choice ensures that participants will not be exposed to excessively high temperatures that may pose health risks or discomfort.

- The cold temperature of 12°C represents a moderately cool environment.

- 12°C falls within a range that individuals may encounter in real-world settings, such as outdoor environments during colder seasons or in certain working conditions.

By selecting these specific temperature values, we aim to create controlled conditions that are relevant to real-life scenarios while minimizing potential health and safety risks associated with extreme temperatures.

Methodology

1. ***Participants***

Eleven participants, comprising six males and five females, were included in this study. All participants were in a state of good health and did not report any hand-related issues or concerns.

2. ***Equipment***

The equipment used in this study included the following:

- Timer
- Thermometer
- Two water bowls
- Buzz wire game

3. ***Procedure***

The procedure involved several steps as follows:

1. Water was poured into each bowl, and the temperature of the water was measured using a thermometer. Additionally, the skin temperature was measured using another thermometer, which was found to be very close to the water temperature.

2. The experiment was conducted randomly, varying the water temperature and the diameter of the ring. Two options were available for the ring diameter: a larger ring with a diameter of 1.08 cm and a smaller ring with a diameter of 0.88 cm.

3. Participants were instructed to submerge their hands (from the forearm to the fingers) in the water bowl for a duration of 1 minute before proceeding to play the game.

4. During the game, the number of mistakes, indicated by the sound produced when the ring touched the game's path, was counted. Additionally, the time taken by participants to complete the game was recorded.

5. A 10-minute break was provided between different temperature conditions.

6. Participants played the game again until they completed all four conditions, which were assigned randomly.

7. Data from the experiment was recorded and subsequently analyzed using Minitab software.

4. Data Analysis

To assess the significance of differences between the levels of each factor and the interaction between the factors, we employed a factorial within-participants design on the collected data.

Results and Discussion:

Two measures were used to measure the performance which are time to finish the track and how many mistakes were done during the trial. We choose 95% confidence interval in our study.

Time to finish:

The investigation aimed to explore the potential relationship between tracking performance and hand-skin temperature. The normality test, with a p-value of 0.429 (> 0.05), indicated that the collected data are normally distributed. Additionally, an assessment for outliers revealed that there are no outliers. The null hypotheses which are that the levels of factors, namely temperature, ring diameter, and their interaction, would not impact the recorded time, while the alternative hypotheses proposed the opposite.

Table 1: (Time to finish the track in seconds)

Participant	**D=1.08cm**		**D=0.88cm**	
	Warm	Cold	warm	cold
1	36	29	32	31
2	39	44	35	39
3	33	24	37	40
4	48	42	41	38
5	36	45	33	27
6	45	31	40	44
7	52	38	39	32
8	54	43	45	38
9	37	30	33	40
10	41	37	43	38
11	48	54	45	43

The application of ANOVA yielded non-significant p-values for temperature ($p = 0.150$), ring diameter ($p = 0.238$), and their interaction ($p = 0.348$), all exceeding the significance threshold of 0.05. These results suggest that variations in hand-skin temperature and ring diameter do not show a statistically significant influence on tracking time.

Despite the statistical analysis showing no significant effects, participants displayed a slight speed increase when the environment was colder, and the ring diameter was smaller. More precisely, the speed rose by 7% and 8.5%, respectively. While this change isn't statistically significant, it hints at subtle behavioral adaptations to environmental conditions. Although these adjustments don't noticeably impact the total tracking time in a statistical sense, they highlight the intricate relationship between external factors and participant performance.

It is crucial to acknowledge that the controlled nature of the experiment, where participants' speed directly influenced tracking time, may contribute to the lack of observable effects. Future research endeavors may benefit from exploring additional variables or task designs to further elucidate the intricate relationship between physiological factors, such as hand-skin temperature, and tracking performance.

Number of mistakes:

After analyzing the normality of the data (p-value = 0.522 > 0.05), it is evident that the dataset conforms to a normal distribution. Outlier tests confirmed the absence of outliers, indicating normality and randomness. The hypotheses posited that the levels of factors, including temperature, diameter, and their interaction, would not influence errors. Conversely, the alternative hypotheses proposed that these factors would indeed impact error rates.

Table 2: (number of mistakes)

Participant	**D=1.08cm**		**D=0.88cm**	
	Warm	Cold	warm	cold
1	9	14	16	24
2	7	16	16	22
3	13	19	18	25
4	11	15	17	23
5	9	18	20	29
6	10	14	19	23
7	12	18	21	27
8	8	16	17	25
9	7	13	15	26
10	9	15	19	28
11	11	17	17	24

The application of ANOVA revealed a statistically significant effect of both temperature and diameter on the occurrence of errors (p-value = 0 for both), suggesting that variations in these factors do influence the number of mistakes made. However, the interaction between temperature and diameter did not exhibit a statistically significant effect (p-value = 0.369 > 0.05) (see Appendix II). Notably, the number of errors increased significantly by 46.5% in different temperatures. Considering this finding, it is recommended that workers in cold environments wear insulated gloves to enhance dexterity and reduce the likelihood of errors. Additionally, task designers should consider allowing more tolerance for mistakes, especially considering that a decrease in diameter led to a substantial 68.7% increase in errors. These insights underscore the practical implications of environmental conditions and equipment specifications on task performance.

Limitations

During the course of the study, several limitations were encountered. These included constraints relating to the length of the buzz wire's path. Furthermore, the participants' speed, which determined the time taken, could potentially impact the number of mistakes made. Additionally, the experiment involved four conditions, each of which required considerable time. Consequently, the recruitment of a larger number of participants became challenging.

Conclusion

In conclusion, this study aimed to investigate the potential relationship between hand-skin temperature and tracking performance. While variations in hand-skin temperature and ring diameter did not have a statistically significant impact on tracking time, participants displayed slight speed increases in colder environments and with smaller ring diameters, suggesting subtle behavioral adaptations. The number of mistakes made, however, was significantly influenced by temperature and diameter, indicating that these factors affect error rates. The findings suggest the importance of considering environmental conditions and equipment specifications in manual tasks. Future research should explore additional variables and task designs to further understand the relationship between physiological factors and tracking performance. The study faced limitations related to the experimental design and participant recruitment, which should be taken into account when interpreting the results.

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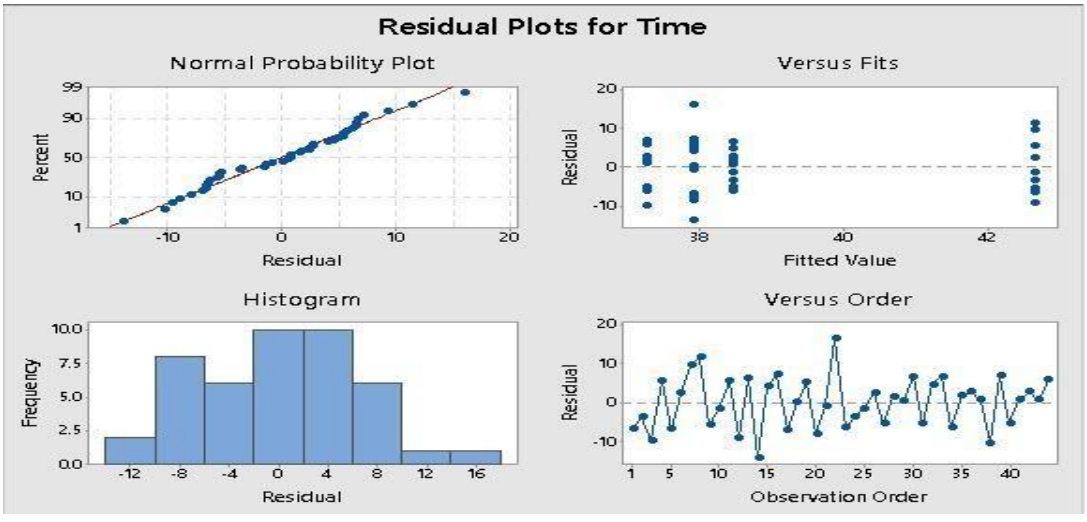
APPENDIX

I. Analysis of Variance for Time:

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Diameter	1	63.84	63.84	1.43	0.238
Temp	1	96.02	96.02	2.15	0.150
Diameter*Temp	1	34.57	34.57	0.78	0.384
Error	40	1782.36	44.56		
Total	43	1976.80			

II. Residual plots for time:



III. Analysis of Variance for Mistake:

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
D	1	820.45	820.455	207.00	0.000
T	1	511.36	511.364	129.01	0.000
D*T	1	3.27	3.273	0.83	0.369
Error	40	158.55	3.964		
Total	43	1493.64			

IV. Residual plots for Mistake: