How Temperature and Time Affect Reaction Time

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ABSTRACT. *This study compared the reaction time of individuals after submerging their hand in different temperatures of water, for different amounts of time. We looked to test whether or not the temperature of the water the individuals submerged their hand in and the amount of time their hand was submerged in water would have an effect on the reaction time of the individual. Results indicated that the reaction time of an individual after submerging in Cold (32℉) water was significantly different from submerging in both room-temperature (70℉) and luke-warm (110℉) water. Overall, our findings confirmed that the temperature of water an individual submerges their hand in prior to taking the test does have an impact on the reaction time of the individual, however, we failed to find evidence that the amount of time submerged had a significant impact.*

1. INTRODUCTION

Reaction time is a measure of how quickly a response is elicited by a stimulus. Thus, reaction time is prevalent in many fields, such as biology, sports science, and cognitive psychology. Reaction time can be used to gauge an individual's sensorimotor skills, and improving reaction time strengthens parts of the brain. Multiple factors can influence reaction time. In our study, our goal is to analyze how submerging one's hand in different water temperatures for different lengths of times affects reaction speed. In the context of our study, we expect varying temperatures and varying lengths of time to affect how our bodies react to stimuli.

Previous studies have looked at how temperature affects reaction time, indicating that hot temperatures result in faster reaction time, while cold temperatures result in slower reaction time.[1,2]

2. MATERIALS & METHODS

To test each subject's reaction times by their body temperature, we used two factors. The first of which was the temperature of the water that the subject submerged their hand in. The levels of this factor are room-temperature (~70℉), ice-cold (~32℉), and luke-warm (~110℉). Each subject placed their hand in each of these temperatures of water for 60 and 30 seconds. This makes the treatment structure of this experiment a three-by-two factorial. Table 1 describes each treatment combination.

Table 1. Treatments

Levels	32℉ (Cold)	70℉ (Control)	110℉ (Hot)
60 (Sec)	60/32	60/70	60/110
30 (Sec)	30/32	30/70	30/110

In order to test each subject's reaction time with each treatment, we used a website that measured reaction time in milliseconds (up to 3 decimal places). The website worked by having the subject click on the screen once to start the procedure, then click again when the screen turns green.

The subjects were Cal Poly students living in the Cerro Vista Apartments. They all volunteered to be in this experiment.

To reduce variability, we had each subject complete each treatment. We randomized the order of the treatments using a random number generator, without replacement. We waited 2 minutes between treatments to ensure that the effects of the previous treatment had completely worn off. The subject also was given five practice attempts before the treatments started in order to familiarize them with the test.

To test the significance of the resulting data, we completed an effects test in JMP. We did have a significant effect of one factor, so we carried out a Tukey test of multiple comparisons. There was no need to adjust for non-normality or non-consistent variances. The Shapiro Wilk's test produced a p-value of .018, which is not significant at an alpha level of .01. This means that there is not enough evidence to claim that the data is not normal. The Brown-Forsythe test produced p-values of .338 and .211 for the water temperature and time factors respectively. Neither of these p-values are significant at an alpha level of .01, meaning that there is not enough evidence to claim the levels within the respective factors have unequal variances.

3. Results and Discussion

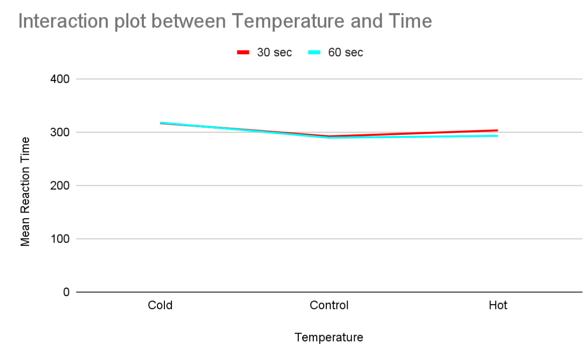
Based on the large F-statistic (9.9071), with 2 numerator degrees of freedom and 80 denominator degrees of freedom, and small p-value (0.0001), we have strong evidence that temperature has a main effect on mean reaction time. However, based on the small F-statistic (0.6173) with 1 numerator degree of freedom and 80 denominator degrees of freedom and large p-value (0.4344), we don't have enough evidence to say time has a significant main effect on mean reaction time. Lastly, based on a small F-statistic (0.4314), with 2 numerator degrees of freedom and 80 denominator degrees of freedom and a large p-value (0.6511), we don't have sufficient evidence to say there's a significant interaction effect between temperature and time on mean reaction time.

Table 2. Main Effect Means and Standard Deviations

Factor	Level	Mean (ms)	SD (ms)	Letter
Temp	Cold	317.294	40.235	A
	Control	290.676	29.541	B
	Hot	298.059	32.116	B
Time	30 sec	303.990	39.321	
	60 sec	300.029	32.059	
Levels not connected by the same letter are significantly different				

We found that using cold water resulted in a mean reaction time of 317.294 ms, which is significantly different from the means of the other two levels. The level of temperature that resulted in the fastest mean reaction time is Control (about 70℉) with a mean of 290.676 ms. However, this mean is not significantly different from the Hot level, which has a mean reaction time of 298.0590 ms. When looking at the levels for time in Table 2, we can see that the 60 second level had a faster mean reaction time (300.029 ms), but this mean was not significantly different from the mean reaction time of the 30 second level (303.990 ms).

Figure 1. Plot of the effect of temperature within levels of time.



From Figure 1, we can see that time does not significantly modify the effect of temperature on mean reaction time.

Table 3. Treatment Means

	Temperature (ms)		
Time	Cold	Control	Hot
30 sec	316.852 (46.907)	291.912 (32.108)	303.205 (35.624)
60 sec	317.735 (33.737)	289.441 (27.670)	292.912 (28.319)
Note: Standard deviations are in parentheses			

From table 3, the treatment group with the fastest reaction time was the Control / 60 sec group, with a mean reaction time of 289.441 ms. However, the mean reaction time of this group is only significantly different from the mean reaction times of the Cold / 30 sec group and the Cold / 60 sec group.

4. Conclusions

Our study aimed to find the combination of temperature and time that resulted in the fastest reaction time. We found that the treatment group with the fastest reaction time is the control temperature for 60 seconds. Overall, we recommend four treatment combinations that yield fast mean reaction times: Control at 30 seconds, Control at 60 seconds, Hot at 30 seconds, and Hot at 60 seconds. The treatments that yielded the slowest mean reaction times are the Cold at 30 seconds and Cold at 60 seconds. Specifically, we found that the Control and Hot temperatures result in faster reaction times. However, we did not find that hot temperatures yield better reaction times than the control. Moreover, we did not see that one time resulted in a better reaction time overall.

These results bolster the notion that at lower temperatures, our reaction time is slower. This phenomenon is due to our muscles contracting at a slower rate, making our reflexes slower. The conclusions of this study exemplifies how temperature affects reaction time.

Since we did not randomly select the participants, we treated the participants as fixed. Consequently, the results of our study can only be applied to the participants in our study.

5. References

[1] Rammsayer, T H et al. "Effects of cold on human information processing: application of a reaction time paradigm." *Integrative physiological and behavioral science : the official journal of the Pavlovian Society* vol. 30,1 (1995): 34-45. doi:10.1007/BF02691388

[2] Vasudevan, Madhan Kumar & Anbuchelvan, Ashwath & Muniyandi, Manivannan. (2022). Effect of Elevated Finger Temperature on Active Force JND. 10.1007/978-981-16-9539-1_32.

6. Appendix

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
Temperature	2	2	80	9.9071	0.0001*
Time	1	1	80	0.6173	0.4344
Temperature*Time	2	2	80	0.4314	0.6511

Least Squares Means Table

Level	Least Sq Mean	Std Error
Cold	317.29412	7.1824355
Control	290.67647	7.1824355
Hot	298.05882	7.1824355

Level			Least Sq Mean
Cold	A		317.29412
Hot		B	298.05882
Control		B	290.67647

Level	Least Sq Mean	Std Error
30	303.99020	6.7256166
60	300.02941	6.7256166

Least Squares Means Table

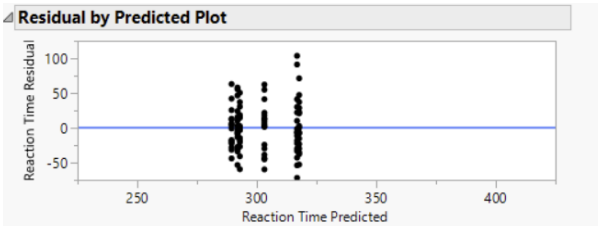
Level	Least Sq Mean	Std Error
Cold,30	316.85294	8.4052223
Cold,60	317.73529	8.4052223
Control,30	291.91176	8.4052223
Control,60	289.44118	8.4052223
Hot,30	303.20588	8.4052223
Hot,60	292.91176	8.4052223

Level				Least Sq Mean
Cold,60	A			317.73529
Cold,30	A	B		316.85294
Hot,30	A	B	C	303.20588
Hot,60	A	B	C	292.91176
Control,30		B	C	291.91176
Control,60			C	289.44118

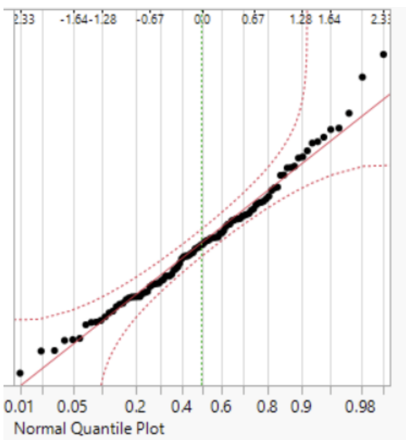
	Temperature		
	Cold	Control	Hot
	Reaction Time	Reaction Time	Reaction Time
Time	Std Dev	Std Dev	Std Dev
30	46.90707726	32.108329962	35.623929292
60	33.73662589	27.67042778	28.319182597

Temperature		
Cold	Control	Hot
Std Dev	Std Dev	Std Dev
Reaction Time	Reaction Time	Reaction Time
40.234750103	29.540645433	32.115974668

	Time	
	30	60
	Std Dev	Std Dev
	Reaction Time	Reaction Time
	39.321176254	32.059072314



In the Residual by Predicted plot above, we can see that the spread is similar throughout, indicating that the constant variance assumption is satisfied.



In the Residual Normal Quantile plot above, we can see that the residuals follow the line and are all similarly spread across the plot, so the assumption of normality is also satisfied.