

Room Temperature and Task Effects on Arousal, Comfort and Performance

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ABSTRACT

The effects of room temperature (58-60°, 67-68°, 72- 73°, and 78-80° F) on performance, arousal, and comfort in different tasks (reading, mathematics, and memorization) were examined. Participants arrived at one of four temperature conditions and completed all three tasks and a survey regarding subjective measures of physical comfort, task difficulty, and physiological arousal. Although participants' physical comfort was dependent on ambient temperature, no performance differences based on temperature were found for any of the tasks. Interestingly, males outperformed females in both the math and reading tasks. Changes in heart rate were also related to changes in performance on word-recall and math tasks for males but not for females.

INTRODUCTION

Ambient temperature has been the subject of hundreds of studies. Previous research has examined variables associated with room temperature, including arousal, performance, and attention. Despite numerous empirical studies, research has yielded inconsistent results. While some studies have yielded performance decrements in hot and cold temperatures, others have found no decrements or even performance gains (Griffiths & Boyce, 1771; Ramsey, 1995; Fox, 1967). Allen and Fischer (1978) had 65 freshman students in introductory psychology courses learn a 9-item paired association list (e.g. Box/chair) in thermally controlled rooms at temperatures of 52°, 62°, 72°, 82°, or 92° F. They found that male college students recalled best on a word list at 72° F, while performance declined at successively lower and higher air temperatures.

Aluciems (1972) collected data from 23 classes of children, drawn from 19 secondary schools. Aluciems opened the windows of the classroom and recorded the temperature before, during, and after the completion of the task and found the temperature remained constant across all classes. Although temperature was not directly manipulated, differences were still found in task performance based on room temperatures. Aluciems discovered that lower temperatures were associated with better performance. School children (11-16 year olds) performed best at temperatures between 58-62° F for a variety of mental tasks involving mathematical problems of continuous addition and subtraction.

Similarly, Nelson, Nilsson, and Johnson (1984) had participants write stories to accompany pictures in ambient temperatures of 55.4°, 73.4°, and 86° F. They also measured changes in participants' subjective fatigue and mood using the Feeling Tone Check List and Mood Adjective checklist. Interestingly, Nelson et al. found that participants' wrote more words and stories in a cooler temperature (55.4° F).

Researchers have theorized that several factors may be able to account for the difference in task performance across ambient temperatures. Some of these factors include fatigue, comfort, arousal, and the nature of the task itself (Green & Bell, 1980; Nelson, Nilsson, and Johnson, 1984). Research on arousal reveals some classic results on performance. In general, human performance is best with a medium level of arousal. Too little arousal fails to increase performance, and too much arousal appears to curtail performance by limiting the amount of information one processes (Schwartz, 1991), causing a narrowing of the "range of attention." Perhaps temperature-performance effects are mediated arousal level.

Task complexity also affects the relationship between arousal and performance. Generally, tasks that are more complex or more cognitively demanding are more sensitive to arousal affects. Clements and Turpin (1995) found that the type of task itself could increase arousal. Consequently, one reason that different performance effects have been found across tasks and temperatures may be due to a combination of temperature and task complexity. Unfortunately, in the primary studies on temperature and cognitive performance, researchers did not compare types of cognitive tasks across temperature conditions. The majority of research examined one task in various ambient temperature conditions. Even so, Sharma and Panwar (1987) investigated various cognitive tasks across moderately

cold ambient temperatures and found significant impairment of simple cognitive functions beginning at 59° F. They did not investigate moderately hot room temperatures, nor did they examine factors such as comfort and physiological arousal. Pilcher, Nadler, and Busch, (2002) performed a recent meta-analysis, which suggested that variables such as level of personal arousal, physical comfort, and type of cognitive task might impact performance under moderate to extreme temperature conditions.

The present laboratory study was therefore undertaken to investigate a number of cognitive tasks in moderately hot and cold room temperatures, while measuring performance, arousal, and comfort. Gender, much overlooked in prior research, was also investigated.

METHOD

Participants

One-hundred-and-seventy-four UW-Lacrosse undergraduates (140 women and 36 men, mean age 19.8 years) participated for extra credit. All participants were asked to wear a t-shirt, and long pants to the study. Participants were additionally informed that they would be required to wear a heart rate monitor. One participant's data was omitted because he/she was not fluent in English.

Materials

Heart rate monitors were used to measure physiological arousal. The tasks consisted of previously used quantitative and verbal GRE sections, and two word lists, each consisting of 20 words. A survey regarding demographic information and a survey regarding subjective measures of arousal, task difficulty, and physical comfort were also administered. A Hygrometer was used to measure ambient temperature and humidity.

Design

A 4 (temperature condition; 58-60°, 67-68°, 72- 73°, & 78-80° F) X 3 (task; math, reading, word-recall) mixed-design was used with task as the within-subjects independent variable.

Procedure

Participants arrived at one of four temperature conditions (58-60°, 67-68°, 72- 73°, or 78-80° F), read a brief description of the tasks, whereupon they read and signed informed consent. Participants were then given instructions on how to properly wear their heart rate monitors. Once participants were finished putting on their heart rate monitors, they began one of three tasks. All tasks were counterbalanced across sessions. All room temperatures were maintained within 1 degree Fahrenheit of the desired temperature for the duration of each session. Relative humidity was between 11%-20% for all temperature sessions.

Math Task: The math task consisted of a sample quantitative (math) GRE section. Participants were given ten minutes to do as many of the problems as they could. The task entailed 30 multiple-choice questions concerning geometry, algebra, and statistics. Participants were informed that they could skip around in the packet; however, they were told they should begin on the first page. Directly before beginning and directly after the math task, participants were asked to record their heart rate.

Reading Comprehension Task: The reading comprehension task consisted of a sample verbal (reading comprehension) GRE section. Participants were given ten minutes to do as many of the problems as they could. The task entailed 38 multiple-choice questions concerning reading comprehension, analogies, and vocabulary. Participants were informed that they could skip around in the packet, however, they were told to begin on the first page. Directly before beginning and directly after each task, participants were asked to record their heart rate.

Word-Recall: Participants were given a list of twenty words. In each word list, participants had 90 seconds to review the list. Following that time, participants were asked to stop, turn over their paper, and record their heart rate. They then had to count out loud upwards by three for 15 seconds. After 15 seconds, participants were given 60 seconds to write down as many words from the list as they could remember.

Similar to the math and reading comprehension tasks, participants were asked to record their heart rate directly before beginning and directly after each word list. Participants repeated this sequence for two word lists.

Following each task, participants were asked to fill out a brief survey measuring subjective levels of physical comfort, physiological arousal, and task difficulty. Upon completing all three tasks, participants completed a survey requesting demographic information.

RESULTS

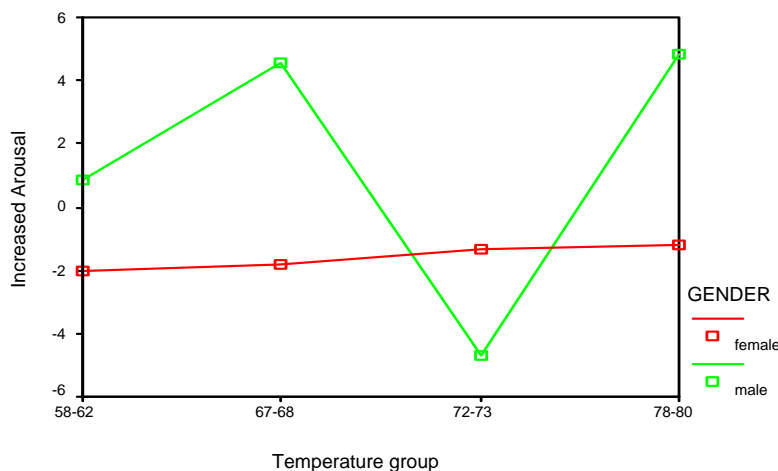
	Mean (SD)		
	Reading	Mathematics	Word-recall
Male	7.63 (3.17)	7.22 (3.28)	11.69 (2.83)
Female	6.04 (2.48)	6.46 (2.57)	12.47 (2.83)

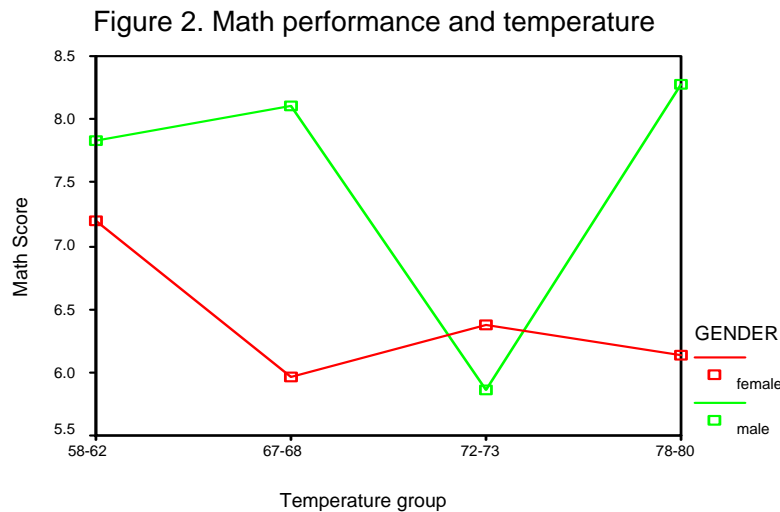
Table 1. Mean Task Scores Between Gender

A 2(gender) X 3(task) X 4 (temperature condition) multivariate ANOVA was conducted, indicating a number of main effects. There was a main effect of temperature on subjective physical comfort across all tasks: reading ($F(3, 174)= 4.99, p < .01$), mathematics ($F(3, 174)= 9.02, p < .01$), and word-recall ($F(3, 174)= 6.13, p < .01$). Specifically, participants rated the 58-60° temperature conditions less comfortable than all other temperature conditions. There was no main effect of temperature on performance in any of the tasks. While physical comfort scores varied as a function of temperature, performance did not. There was also a main effect of gender on math and reading. Specifically, males outperformed females on both math ($F(1, 174)= 4.10, p < .05$) and reading scores ($F(1, 174)= 10.00, p < .05$). For mean scores see Table 1.

Analyses of gender and physiological arousal indicated a temperature x gender interaction for all tasks, ($F(3, 174)= 3.67, p = .01$), mathematics, ($F(3, 174)= 7.08, p < .01$), word-recall and ($F(3, 174)= 3.67, p = .01$) for reading. Specifically, increased arousal during mathematics ($r(36)= .45, p < .01$, see Figures 1 & 2) and word-recall ($r(36)= .36, p < .01$) are related to increases in performance for males but not for females.

Figure 1. Increased arousal during math and temperature





DISCUSSION

The main purpose of this study was to investigate possible explanations for prior researchers' inconsistencies. Theorized factors, such as arousal, comfort, and task-type were examined within one study. Proposed explanations of ambient temperature discrepancies, including geographic location, time of year, and time of day were controlled.

Although room temperature affected subjective physical comfort, it had no impact on performance in mathematics, reading comprehension, or word recall. These results suggest that although performance has been found to correlate strongly with comfort (Griffiths & Boyce; Rohles, 1974), comfort is not a prerequisite for performance. Wyon, Fanger, Oleson, and Pederson (1975), similarly, concluded, "While participants tend to prefer warmer temperatures (66-73.4°F) than cooler temperatures, warmer temperatures may not improve task performance."

Although males' performance correlated with increased arousal for the math and word-recall tasks, it did not appear to be related to performance in the reading task. The relationship between performance and arousal may depend upon the type of task one engages in. Furthermore, the relationship between performance and arousal may additionally depend upon the gender of the participant. Gender and task-type need further consideration when examining arousal-performance relationships.

Results from the current study also suggest that further research is needed to look at the effects of room temperature on arousal between genders. One study found that heart rate was significantly elevated only by a condition that paired cognitive activity with cold exposure (Thomas, Alhers, House, Schrot, Van Orden, Winsborough, Hesslink, & Lewis, 1990). However, almost all research in this area has only used male participants (Van Orden, Benoit, & Osga, 1996).

In summary, although room temperature affected subjective physical comfort, it had no impact on performance in mathematics, reading-comprehension or word recall.

Also, physiological arousal does appear to be related to performance in mathematics and word-recall tasks. This relationship appears to exist for males only. Prior inconsistencies in examinations of arousal and performance in temperature research may in part be due to a failure to consider gender as a variable of interest.

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