Caffeine and College: The Perceived Effects of Caffeine on Heart Rate and Alertness

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ABSTRACT

This study measured the effects of coffee (caffeinated, decaffeinated) and expectancy (told caffeinated, told decaffeinated) on heart rate, maze reaction time, and subjective alertness. A 2x2 ANOVA indicated a main effect of expectancy on heart rate [F (1, 100) = 4.41, $p < .05$]. Overall, participants who were told they drank caffeinated coffee showed higher heart rates than those told they were drinking decaffeinated coffee. We also found a main effect of coffee and expectancy on subjective alertness [F (1, 100) = 7.90, $p < .05$; F (1,100) = 5.97, $p < .05$, respectively]. Generally, participants who drank caffeinated coffee demonstrated more alert Revised Stanford Sleepiness Scale (RSSS) scores than participants who drank decaffeinated coffee. Also, participants who were told they drank caffeinated coffee showed more alert RSSS scores than participants who were told they were drinking decaffeinated coffee. There were no significant interactions or main effects for participant's maze task reaction times. In sum, participant heart rate and perceived arousal depended on what the participants were told they were consuming, while this expectancy had no impact on maze task reaction time.

INTRODUCTION

Approximately 80% of the U.S. population consumes caffeine on a daily basis with an average intake equivalent to 280 mg (Brice & Smith, 2002; Hughes & Oliveto, 1997). Caffeine is found in food, beverages, headache medicine, diet pills, and many medications (Finnegan, 2003). Although the effects of caffeine have been debated, research suggests that caffeine normally results in an increase in blood pressure and perceived attention (Mikalsen, Bertelsen & Flaten, 2001; Stine, O'Connor, Yatko, Grunberg & Klein, 2002). Health psychologists have increasingly studied the effects of caffeine on performance.

Studies have demonstrated that the amount of caffeine consumed affects performance both negatively and positively. For instance, Stine et al. (2002), found that participants who reported consuming low levels of caffeine ($\leq$135 mg/day) performed better at predicting actual time than participants who reported that they consumed either no caffeine or high levels of caffeine (>135mg/day). On the other hand, Jarvis (1993) examined the relationship between daily consumption of either coffee or tea and cognitive performance and found that the best performances (reaction time, verbal memory, and visuo-spatial reasoning) were from participants who consumed a high dose of caffeine (400 mg).

Not all researchers believe outcomes after caffeine consumption are necessarily on behalf of the caffeine. The results may be compensating for previous caffeine consumption. James (1994) reported that caffeine consumption offsets negative caffeine withdrawal effects, thus causing the participant to appear to have improved performance when in actuality the participant is performing at their normal or baseline potential. Therefore, James argues that caffeine results in no positive effects. However, Christopher, Sutherland, and Smith (2005) studied non-withdrawn volunteers and found that actual positive effects of caffeine exist beyond the negativity of the withdrawal effects. One reason why these studies may have yielded such different results is that they only measured pharmacological effects and did not measure participants' perceptions of the effects of caffeine. Participants expecting positive effects from caffeine on performance may be more likely to show the expected results.

Researchers have long known about results of double-blind studies called placebo effects. The placebo effect occurs when participants believe they are being exposed to a particular drug or treatment and, due to this belief, show improved or expected behavioral outcomes. These participants show the expected results regardless to whether or not they were exposed to the actual treatment or drug (Mikalsen et al., 2001). For example, a study done by Kirsch, Moore, Scoboria, and Nicholls (2002) on selective serotonin reuptake inhibitor (SSRI) antidepressants demonstrated that the effectiveness of a pill placebo was almost as effective as the antidepressant.

Researchers have offered two possible types of placebo effects in these studies, classical conditioning and expectancy theories. According to Mikalsen et al. (2001), the classical conditioning theory is based on the idea that personal experience with a specific drug influences behavior not only regarding that drug, but also with stimuli

associated with that particular drug. The expectancy theory states that physiological influences are based on a participant's knowledge and pre-assumed effects of a specific drug (Mikalsen et al., 2001).

In relation to caffeine, findings suggest that placebo effects may be a factor in increased physiological states of participants after consuming what was thought to be a caffeinated beverage. Mikalsen et al. (2001) reported an increased alertness in individuals consuming caffeine-associated stimuli, as well as in participants that were told they were drinking a caffeinated beverage. Also, previous studies found that participants who were told they were drinking a caffeine-containing beverage exhibited increased psychological and physiological arousal regardless of the actual stimulant content in the beverage. Flaten, Aasli, and Blumenthal (2003) for example asked general public participants, who have consumed at least one cup of coffee per day for the last six months, to rate their expected arousal after consuming one or two cups of coffee. They found that participants assumed that two cups of coffee would have more of an effect; however, the actual caffeine effect was not dose dependent. Also, a decreased heart rate was found after consuming caffeine. Overall, the expected arousal was positively correlated with actual arousal; thus, demonstrating that believed caffeine consumption increases arousal regardless of actual caffeine consumption. According to Mikalsen et al. (2001) the discovery of decreased heart rate found in caffeine studies may be due to physiological factors related to the participants' simultaneous increase in blood pressure. However, others have found a slight increase in heart rate after caffeine intake (Carrillo & Benitez, 2000; Mikalsen, et al., 2001). Yet, multiple studies have found no significant effects in heart rate (Flaten & Blumenthal, 1999; Walach, Schmidt, Bihr, & Weisch, 2001; Botella, & Parra, 2003).

Our study will examine both the real and expected effects of caffeine consumption on heart rate, maze reaction time and subjective alertness. We hypothesized that participants who *consumed* caffeinated coffee, as well as those who were *told* that they consumed caffeine, would have higher heart rates, faster reaction time, and more alert RSSS scores than those who *consumed* decaffeinated coffee, or were *told* that they consumed decaffeinated coffee.

METHOD
Participants

One hundred and four undergraduate students (26 participants in each condition) from the University of Wisconsin-La Crosse participated in our study. Of the 104 participants, thirty-three were men and 71 were women. The ages of the participants ranged from 18 to 31 years of age, and the mean age of the participants was 20.43 (*SD* = 2.05). In terms of race, 93.3 % of participants identified themselves as Caucasian, 3.8% identified as Asian, 1.9% identified as Hispanic, and 1% identified as African American. Participants were primarily from a general psychology course, and received class credit for participating in this study.

Materials

We used a revised version of the Stanford Sleepiness Scale (RSSS) (Pivonka & Grunewald, 1990) (see Appendix A). The RSSS is a Likert ranking scale from one to eleven (1= Feeling active and alert to 11= Foggy; losing interest in remaining awake) was used to measure participant's self-reported alertness. Participant's heart rate was measured via a heart rate monitor watch. Participants consumed twelve ounces of either caffeinated (148 mg. of caffeine), or decaffeinated (3.8 mg. of caffeine) Folgers Instant Coffee. Three increasingly difficult paper-pencil mazes were given to participants (samples of which can be viewed in Appendix B). Participants watch a thirty-minute episode of the television show *Seinfeld*.

Procedure

We randomly assigned participants into one of four conditions based on actual consumption (caffeine or decaffeinated) and expectancy (told caffeine or told decaffeinated). Participants consumed 12 ounces of coffee, and we measured their baseline heart rate. We then continued to measure the heart rates of the participants every ten minutes. Participants self-reported their alertness via a revised version of Pivonka & Grunewald's (1990) Stanford Sleepiness Scale every fifteen minutes. Participants watched a half an hour of Seinfeld while waiting for the caffeine to have an effect. After watching Seinfeld, participants completed a timed series of increasingly difficult mazes.

RESULTS

We analyzed the data using a 2x3 factorial ANOVA regarding actual consumption (caffeinated, decaffeinated) and expectancy (told caffeinated, told decaffeinated) on heart rate, maze task reaction time, and self-rated alertness (RSSS). Results indicated that there was a significant main effect of expectancy (what participants were told they consumed) for all heart rate measures (see Table 1). Thus, participants that were told they consumed caffeine had an overall greater heart rate than participants that actually consumed caffeine.

For heart rate measure 4, we also found a significant consumption x expectancy interaction [F (1, 100) = 6.24, p = .01]. Post hoc analysis indicated that those who actually drank caffeinated coffee and were told they drank caffeinated coffee had higher heart rates than any other combination of actual consumption and told consumption (see Figure 1). The same interaction was marginally reliable for heart rate 5.

There were no significant interactions or main effects for participant's maze task reaction times, although for maze task 2 we found a marginally reliable main effect for expectancy [F (1, 100) = 3.54, p = .06]. Thus, participants that were told they consumed caffeine had a faster reaction time in maze task performance than participants that actually consumed caffeine.

We also found significant main effects of actual consumption for participant's RSSS scores (see Table 2). The main effect for expectancy (told consumption) was also significant for RSSS2 and RSSS3 [F (1, 100) = 7.27, p = .01; F (1, 100) = 5.97, p = .02, respectively]. Thus, both actual consumption and told consumption had an influence over participants RSSS scores.

For the fourth measure of the RSSS (RSSS4), we also found a significant consumption x expectancy interaction [F (1, 100) = 5.64, p = .02]. A post hoc analysis indicated that those who actually drank caffeinated coffee and were told they drank caffeinated coffee had more alert RSSS scores than any other combination of actual consumption and told consumption (see Figure 2).

Table 1. Means and Standard Deviations of Told Caffeine Consumption on Participant's Heart Rates

Told	Consumed								
	Caffeinated				Decaffeinated				
	Caffeinated		Decaffeinated		Caffeinated		Decaffeinated		
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	M.E. F
HR baseline	84.62	15.98	75.08	12.94	80.65	13.58	78.96	14.07	4.07
HR1	88.65	13.94	79.08	13.65	83.42	13.12	80.65	11.01	5.88
HR2	84.00	13.37	75.38	12.87	82.38	15.78	80.69	10.94	3.88
HR3	86.31	11.41	75.23	13.17	80.92	12.04	77.65	10.38	9.62
HR4	84.46	11.46	72.88	14.27	80.46	12.99	81.46	12.47	4.41
HR5	84.73	14.57	75.04	11.10	80.19	14.10	80.23	10.85	3.72

Notes. $p \leq .05$ for all comparisons. Degrees of freedom were 1, 100 for all analyses.

Table 2. Means and Standard Deviations of Actual Caffeine Consumption on Participant's Self-Rated Alertness

Told	Consumed								
	Caffeinated				Decaffeinated				
	Caffeinated		Decaffeinated		Caffeinated		Decaffeinated		
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	M.E. F
RSSS1	5.04	1.61	5.27	1.43	6.00	1.52	5.58	1.81	4.08
RSSS2	4.54	1.50	5.42	1.30	5.81	1.39	6.38	1.33	16.94
RSSS3	4.73	1.51	6.04	1.40	6.15	1.83	6.38	1.65	7.90
RSSS4	4.15	1.76	5.04	1.11	5.96	1.97	5.27	1.80	9.43

Notes. $p \leq .05$ for all comparisons. Degrees of freedom were 1, 100 for all analyses.
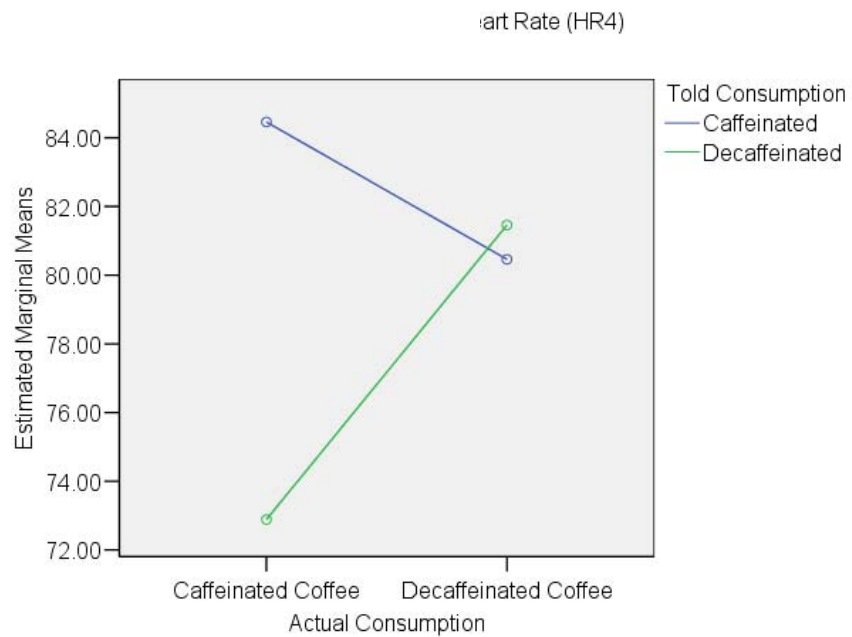
Heart Rate (HR4)

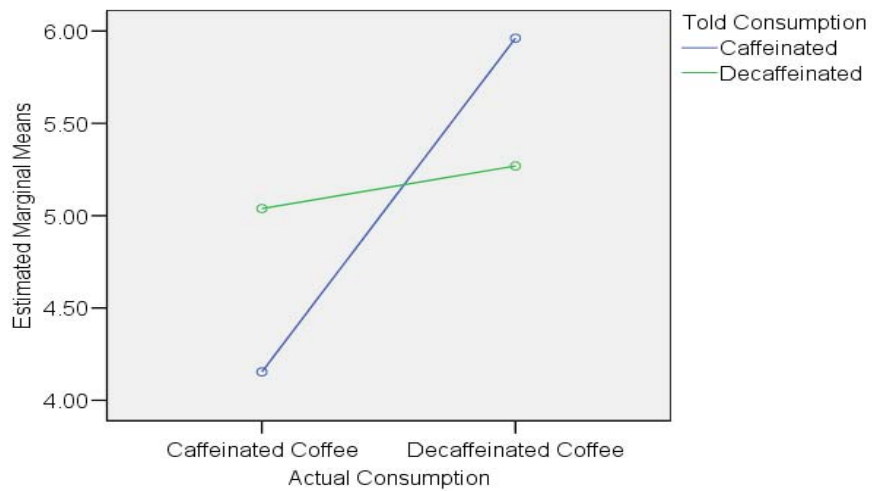**Figure 1.** Participant's Mean Heart Rate (HR4)

Figure 2. Participant's Mean Self-Rated Alertness (RSSS4)

DISCUSSION

Our hypothesis, that expectancy of consumption (told caffeinated, told decaffeinated) will have a greater influence over participants heart rate, maze task reaction time, and subjective alertness (via the RSSS) than actual consumption (caffeinated, decaffeinated), is supported in this study. Results suggest the 'placebo effect' exists regarding consumption of caffeine. Participants that were told they consumed a caffeinated beverage yielded higher overall heart rates as well as faster maze task reaction times. Although all the subjective alertness scores had a main effect of actual consumption, two RSSS measures were found also to have an expectancy main effect. This suggests that physiological and psychological arousal can be influenced by suggestion and expectation. Reasons for this may

be due to a common belief in our society about the effects of caffeine, possibly leading to an expectancy effect of increased physiological functions such as heart rate and psychological subjective alertness.

Improvements for this experiment include better standardized techniques when gathering data. Since data was collected from two different researchers at separate times, procedures were not always consistent. Specifically, during some trials, Seinfeld continued playing while the subjects performed the maze task, which may have distracted the participants thus affecting their reaction time. Additionally, regarding how the maze tasks were measured, the mazes could have been more consistent. In order to record all participants reaction time we needed to time each maze separately and wait for all participants to complete the same maze. This could have caused anxiety and pressure on the participants, especially if they were the last to finish the task. Also, a few participants seemed particularly frustrated with the third maze, to the point where they were unmotivated to finish the task effectively. As for the RSSS, instructions for how to complete the scale could have been placed on the top of each RSSS sheet to ensure participant understanding. Also, the scale may have elicited various interpretations or meanings for each level of the 11 point Likert scale. For example, each participant may have a differing definition of 'hyper.' Furthermore, heart rate is difficult to measure since it can fluctuate from moment to moment. By using heart rate monitors, we only collected data representing their "at that moment" heart rate every ten minutes versus measuring participants mean heart rate throughout the experiment. However, we did not have funding or access to this technology for our study. Also, it is possible that each participant did not consume the exact milligrams amount of caffeine, but rather an amount in close proximity. In future studies, a more precise measurement of caffeine could be used to improve the study.

Caffeine also may have varying effects from one person to the next due to differing age, lifestyle, or personality (Brice & Smith, 2002). If an individual is a regular caffeine drinker, his or her body may react to caffeine differently than a non-caffeine drinker. Thus, we should have included only participants in the study that consumed similar levels of caffeine in order to lessen this extraneous variable. In addition, because we found many of our significant effects toward the end of our study, perhaps not enough time was given for us to see the peak effects of caffeine. Therefore, further research should extend the amount of time for caffeine to have an effect.

Future research could also examine the effects of caffeine on heart rate, reaction times, and perceived alertness, using different amounts of caffeine to identify the effects depending upon the amount of caffeine consumed. Also, research could expand on participants varying individual caffeine intake levels; allowing researchers to gather in depth data regarding possible caffeine withdrawal effects. In addition, these findings could be further studied to other situations and generalized to other populations. Overall, the effects of caffeine have many applications to understanding the behavior of caffeine consumers; therefore, further attention through continued research is needed.

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APPENDIX A

Revised Stanford Sleepiness Scale:

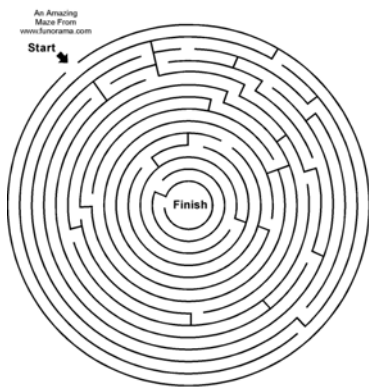| Degree of Sleepiness	Scale Rating
Hyper, can't stop fidgeting, super motivated	1
	2
Feeling active, vital, alert, or wide awake	3
	4
Functioning at high levels, but not at peak; able to concentrate	5
	6
Awake, but relaxed; responsive but not fully alert	7
	8
Somewhat foggy, let down	9
	10
Foggy; losing interest in remaining awake; slowed down	11

Revised from Pivonka, E. E., & Grunewald, K. K. (1990). Aspartame- or sugar-sweetened beverages: Effects on mood in young women. *Journal of the American Dietetic Association*, *90*(2), 250-254.

APPENDIX B

Maze 1

Maze 2

Maze 3