Title: Caffeine Effects on Short Term Memory Recall

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ABSTRACT

Caffeine is known for its physiological effects on the body that include increased heart rate, blood pressure, and metabolism. Caffeine is used regularly by students to increase their alertness for early classes and especially to stay focused for an exam or quiz. However, not much research has been conducted regarding caffeine and short-term memory, which can be important for success in school. The purpose of this study was to investigate the effect caffeine and a placebo have on short-term memory recall performance. Ten male participants were recruited and performed the Rey Auditory Verbal Learning Test while either consuming eight ounces of a caffeinated or decaffeinated Bang energy drink unknowing to which one. Percent difference from the baseline test to the experimental test was measured. Our results explained that caffeine and the placebo did not have a statistically significant impact on the performance of the Rey Auditory Verbal Learning Test.

INTRODUCTION

Caffeine is the most widely used stimulant globally and is consumed by a large percentage of the world's population (4,10). Caffeine's popularity is partially due to its wide accessibility in stores in the form of soda, energy drinks, and chocolate. Caffeine delivers a significant sympathetic response to consumers through increased blood pressure and heart rate (9). The sympathetic response generated by caffeine can improve physical performance by decreasing reaction time and increasing alertness (1,2). Caffeine's stimulatory effects can improve sport and weightlifting performance (1,2). Along with exercise performance, caffeine can be important to students who utilize caffeine's effects to become less tired for morning classes.

Many studies have examined caffeine's effects on physiology; however much less research has been conducted involving caffeine and cognitive memory. Some studies that present the topic of caffeine and memory have produced widespread results (3). Caffeine has shown to improve explicit memory recall during the non-optimal or morning-time of day and its effects on memory

were not significantly different from exercising (10). Caffeine has also been shown to reverse the adverse effects of sleep deprivation and successive days of minimal sleep on cognitive performance, learning, and memory (5,7). These findings could prove vital to students who struggle to sleep at night or stay up late studying for a test. Even though caffeine has shown to have effects on the adverse effects of sleep deprivation, it is no replacement to sleeping (8).

The purpose of this study is to examine the effect of caffeine and a placebo have on short-term memory recall. Students often have quizzes at the end of class to test their knowledge of either what was covered in class that day or previous days. It can be difficult for students to stay awake for early classes and focus the entire time and still have the mental capacity to take a graded quiz. Human short-term memory has the capacity to recall 7±2 elements of information presented to them (6). Studies have shown that caffeine can enhance cognitive function; this study hopes to test the possible correlation between the 7±2 postulate and caffeine. We hypothesize that caffeine will have a positive statistically significant difference than the placebo in terms of short-term memory recall performance.

METHODS

Participants

This study was approved by the Institutional Review Board of Franklin College, Indiana. Participants will include 10 college males between the ages of 18-23. All participants were asked to abstain from ingesting caffeine 12hrs before the day of the study. Participants were enrolled in the study if they ingested minimal amounts of caffeine daily (estimated less than 100mg per day) and did not take any medication that would affect resting heart rate. Participants were excluded if they consumed excess amounts of caffeine daily (estimated more than 200mg per day), or have a heart condition which caffeine ingestion would be detrimental. These heart conditions include arrhythmias, cardiomyopathy, or a previous myocardial infarction. All participants were screened for COVID-19 signs and symptoms prior to each testing day, and were required to abide by the designated guidelines of the institution. All enrolled participants were briefed on the details, and possible discomforts and risks of the experiment protocol and informed consent were obtained. All participants had the right to step away from the experiment at any time, with no repercussions and their results discarded immediately.

This was an in-person study so participants had an increased chance of being exposed to individuals that have or have been exposed to someone with COVID-19. Participants were not allowed to participate if they had been in contact with someone who has COVID-19 or they display symptoms. All researchers and participants were required to wear masks and researchers were wearing gloves to decrease the chance of exposure. All research areas were disinfected

between participants' time slots. Each participant was also required to display their Campus Clear results before participation.

Protocol

Upon arriving at the testing facility, participants were given a consent form containing information on the study as well as a pre-test survey that was approved by the Franklin College Institutional Review Board (#11240). This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science. On the testing day, the participants performed a baseline test to obtain results under normal physiological conditions. The baseline consisted of the Rey Auditory Learning Test, and contained a different set of words used for the experimental test to minimize participants memorizing words. After baseline testing, the participants were randomly assigned into a placebo or experimental group. The experimental group consumed 8oz of Bang (1600 N Park Dr, Weston, FL 33326), and the placebo group consumed 8oz of Decaffeinated Bang (1600 N Park Dr, Weston, FL 33326).

Participants were advised to not consume any caffeine 12 hours before testing day, and all were given information on common foods containing caffeine. The participants' height and weight were recorded using a Detecto stadiometer (102 East Daugherty St.Webb City, MO 64870), and were fitted with a H10 Polar Heart Rate Monitor (Polar USA, Bethpage, New York) to wear for the duration of the study. Subsequently, each participant was given either an 8oz regular Bang Shot or 8oz of Decaffeinated Bang Shot in a single blind fashion. The drinks were administered in white Dixie cups. Once all 8oz was consumed, participants were given a one hundred-piece jigsaw puzzle to work on for 30 minutes while the caffeine was digested. The participants were not required to complete the puzzle in the 30 minutes, and if completed before the 30-minute time frame was over, another one hundred-piece jigsaw puzzle was administered. The puzzle was used to ease any anxiety during the pre-test period. After 30 minutes, the subjects performed a Rey Auditory Verbal Learning Test. This test consisted of the participants being recited a list of 15 words, and were given 90 seconds to write down as many words as possible in no specific order. This test was repeated three times with three different word lists. Following testing, all equipment was sanitized following the designated guidelines of the institution.

Statistical Analysis

An independent sample *t*-test will be conducted to determine whether there is statistically significant difference between the means of the caffeine and placebo groups in the pre and post-test scores. JASP will be used for statistical analysis with an alpha-level of .05.

RESULTS

Table 1

Table 1: Means, Standard Deviations, and Standard Errors of the Placebo and Caffeine Groups on the Rey Auditory Verbal Learning Test

	Group	N	Mean	SD	SE
Percent Difference	Placebo	5	33.800	25.712	11.499
	Caffiene	5	27.551	12.976	5.803

Table 2: Independent Samples T-Test

Independent Samples T-Test

	W	df	p	Hodges-Lehmann Estimate	Rank-Biserial Correlation
Percent Difference	14.000		0.834	5.519	0.120

Note. For the Mann-Whitney test, effect size is given by the rank biserial correlation.
Note. Mann-Whitney U test.

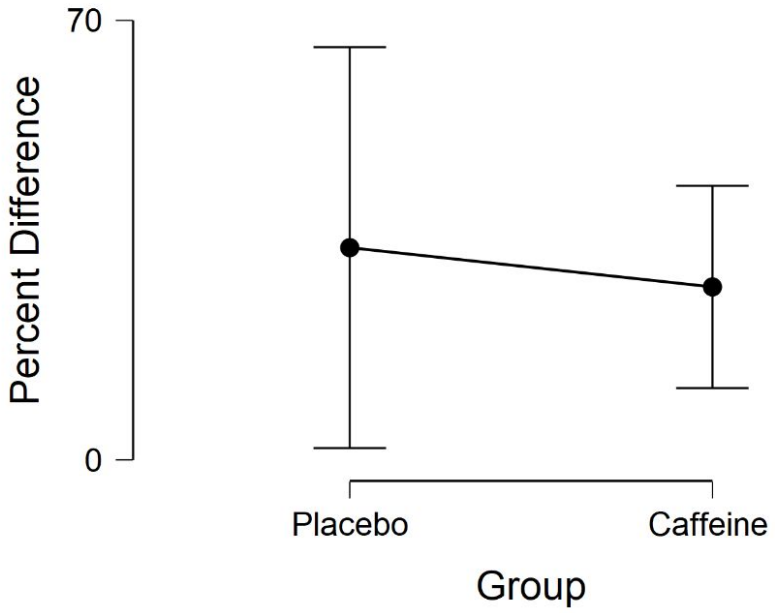

Figure 1

Percent difference of the placebo and caffeine groups from the baseline

There was no significant effect for the caffeine and placebo group, $t(16)$, $p = 0.834$, despite the placebo ($M = 33.80$, $SD = 25.71$) and the caffeine ($M = 27.55$, $SD = 12.98$) reaching higher scores than the baseline. Our effect size, or Rank-Biserial Correlation, was 0.120.

DISCUSSION

The purpose of this study was to test whether caffeine can aid in the participants ability to recall information from their short-term memory. The results of this experiment did not support the predictions. It was predicted that the caffeine group that was administered 150 mg of caffeine in the form of an 8 ounce Bang Energy Drink would have a positive statistically significant difference compared to the placebo group in terms of short-term memory recall performance. The results of this experiment were not statistically significant.

In this experiment, the Placebo group had a slightly higher percent difference from test 1 (the baseline test) to test 2 (post dosage test) compared to the caffeine group. At the same time, the caffeine group had a much smaller standard deviation compared to the placebo group. From this data this implies that caffeine did not improve performance significantly but had a tighter spread of data. A similar study performed by Mednick, S. C. also demonstrated that a moderate dosage of caffeine did not significantly improve short-term memory (8). A possible reasoning for this could also be explained by research performed by Kamiński, J (6). In this research, it is stated that the number of items that can be held in human short-term memory is limited to 7 (±2) elements (6). Therefore, given that the subjects were exposed to word lists of fifteen words a piece as well as a moderate dosage of caffeine that allowed their body to reach a heightened state, they were not able to perform the short-term memory recall effectively. After grading the results, we found that many of the correct answers were the first and last few of the words read aloud. This could indicate a primacy and recency effect that may have limited the amount of words remembered in the middle of the order.

The results with our study are consistent with some previous research that have found that caffeine does not have an impact on memory recall in the afternoon, but can improve performance in the morning (10). Previous research has also discussed that caffeine's effects on arousal do not directly influence performance on memory recall (8,10). This is consistent with our results because none of the participant's heart rates increased dramatically to show arousal and their performance was not significant. We believe that this is due to a low dose of caffeine (150 mg). Our results are consistent with other research regarding a higher performance in the placebo group compared to the caffeine group (8). This could be because the placebo group expected to receive caffeine and therefore improved their performance with memory recall. Some research has shown that caffeine can improve memory performance during high stress and

low sleep (7). However, this research was heavily based on motor movement, suggesting that caffeine may improve motor memory better than cognitive memory.

The results of the study could be explained by numerous factors. The first possible explanation is that the participants did not follow our instructions to not consume caffeine 12 hours before the test day. This could have limited caffeine's ability to have a significant impact on memory because the participants already had consumed caffeine prior to the test. Another factor that could have played a role in the results is that each participant only received one dose of caffeine that was a relatively low amount. The experiment involved only one dose of 150 mg of caffeine that may not have elicited a large enough response in the body to affect memory. The caffeine administered may have enhanced focus of the participants that did not transfer to performance on the test. The participant's knowledge of the possibility of receiving caffeine could have caused a placebo effect that improved the placebo group performance compared to the caffeine. The time of day could have also influenced the results of the study. Most individuals consume caffeine in the morning which is the most likely time to take a quiz or an exam. Caffeine could have a greater effect on performance in the morning since the body has not consumed nutrients since the night previous. This could then cause caffeine to have a greater effect due to faster metabolism and also increased alertness compared to the afternoon after lunch. Another possible explanation of the findings is that the second word list used during the experiment had highly related words compared to the first list. This could have caused an increase in recall compared to the baseline test.

Though the results were not expected for the placebo and experimental groups to perform similarly on the memory tests, there were many influences that could have led to this conclusion. Due to COVID19 protocols, only10 participants were recruited for the study, limiting our ability to obtain an accurate amount of data to find any trends or outliers within our study. The small number of participants did not allow a full range of data to be analyzed and interpreted which will further limit our results. The inability to obtain a large amount of participants also hindered our ability to fully control the daily caffeine intake of participants. Although a minimum caffeine daily intake was set, the range of participants' caffeine intake still ranged drastically with some reporting on one soda daily and others reporting three to four cups of coffee daily. Caffeine affects everyone differently, with only 8oz being administered during the study, some participants may not have been affected at all due to their already high tolerance for caffeine which could influence our results. The time of day might have also limited the findings of our study with all of the testing being administered late in the afternoon. It is difficult to control, even with recommendations, what each participant ate/drank throughout the day of testing without being in a completely controlled environment. The memory test administered to the participants after consuming the placebo or the caffeine was deemed to be easier due to the words on each list being more similar than words used in the baseline test. This would influence our results by first allowing participants to get a better score regardless which group they were

placed in, and it would further hide any results on whether the caffeine aided the participants memory.

This study provides a glimpse into the different effects of caffeine, many studies have tested the effects of caffeine on performance, reaction time, and hand-eye-coordination but not many have tested its effects on memory. Further research should include a memory component, with different amounts of caffeine administered to participants. This study used a minimal amount of caffeine, future studies should use more caffeine and allow more time between administration of caffeine and testing. This can be done by a gradual increase in caffeine or a large amount all at once. Other cognitive components such as focus and attention span would be intuitive add-ons to studies to help aid and further advance the field of caffeine consumption benefits. These two cognitive functions can be tested along with memory in a consecutive fashion, and some tests provide the ability to test for multiple at a single time. The ability to control for the weight and caffeine consumption of participants will be crucial in further studies in order to get as accurate results as possible. Other forms of caffeine such as pre-workout supplements, caffeinated chewing gum, or caffeine pills should be explored. Many past studies have used these forms of caffeine and obtained results that show caffeine improves performance and reaction time.

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