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Caffeine's Effect on Short Term Memory

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The Effect of Caffeine on Short-Term Memory in College-Aged Adults

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Abstract

Caffeine is among the most used substances around the world in various populations, but particularly among college-aged individuals. Caffeine, when used in this population, is generally believed to improve cognitive function, which includes short-term memory and focus. **Purpose:** To observe caffeine's effect on college-aged individuals' short-term memory. It was hypothesized that excessive caffeine consumption would decrease short-term memory. **Methods:** Twenty three college-aged individuals (age = 21.74 ± 1.69 years, height = 174.470 ± 10.82cm, body mass = 81.65 ± 26.82kg) participated in the study. The study was double-blinded, with neither the researchers nor the subjects knowing each dosage; participants consumed 0, 200, or 400 mg of caffeine one hour before performing a spatial memory test (on a Senaptec Sensory Station) followed by a forward and backward digit span test. Each of the three testing sessions happened on separate days with randomized amounts of caffeine that were provided prior to the session. **Results:** No significant differences for spatial memory ($F = .357$, $p = 1.055$, $\eta_p^2 = .046$) and both forward ($F = .898$, $p = .108$, $\eta_p^2 = .005$) and backward ($F = .737$, $p = .307$, $\eta_p^2 = .014$) Digit Span testing were found based on the level of caffeine consumption. **Conclusion:** Although 92% of college-aged adults are recorded to consume caffeine habitually, the findings of this study indicate that there are no improvements in short-term memory with caffeine consumption. This suggests that students should not try to consume more caffeine for better academic results.

***Keywords**:* College-Aged, Caffeine, Short-Term Memory

Introduction

Caffeine is one of the most common and accepted substances consumed globally, with a recorded 90% of adults in the United States consuming 200 mg of caffeine a day for a variety of mental and health-related benefits (Minkove, 2020). Caffeine, which is commonly ingested in the form of coffee, is believed to have cognitive benefits, increasing alertness, memory, focus, and energy (Minkove, 2020). Low doses of caffeine have been shown to enhance and improve both prefrontal activities and cognitive function (Zhang, 2020). College-aged adults, specifically students, consume more caffeine daily due to a busy schedule and the stimulating effects that caffeine can cause, with roughly 92% of students claiming habitual caffeine use (Mahoney, 2019).

In addition to cognitive benefits, caffeine is often utilized in an exercise environment to promote muscle growth and the body's ability to contract a muscle (Rosser, 2009). Preworkout is the most common form, utilizing high amounts of caffeine to stimulate the muscles and cause a stronger contraction while keeping the mind focused. Caffeine can produce these effects by binding to receptors within the body and then blocking chemicals that would lessen the benefits and performance of physical activity (Guest, 2021).

While there are many cognitive and physical benefits, caffeine can negatively affect an individual's ability to get quality rest. Caffeine promotes alertness and energy throughout the day, but a study by Drake (2013) found that when consumed in the afternoon or evening, caffeine can cause a large increase in sleep disturbances. It has been found that caffeine can make it difficult to fall asleep and can even decrease how much deep sleep is experienced (Sleep

and Caffeine, 2018). However, it has also been found that caffeine can offset the cognitive effects of sleep deprivation (McLellan, 2016).

College-aged students, who generally experience regular sleep loss, often ingest caffeine daily to promote academic ability through higher energy and alertness (Mahoney, 2019). Caffeine indirectly affects mood, arousal, and cognition, which suggests that caffeine has cognitive-enhancing abilities (Nehlig, 2020). Low to moderate caffeine ingestion, 40 mg to 300 mg, has been shown to improve vigilance, alertness, attention, and reaction time (McLellan, 2016). However, these effects are not observed in higher-order executive function and memory (McLellan, 2016). Acute paraxanthine, which is a metabolite of caffeine, has been proven to enhance the "ability to store and retrieve random information of increasing complexity from short-term memory" (Yoo, 2021). Studies have shown that caffeine improves short-term memory (Rosser, 2009; Yoo, 2021). Short-term memory recall and storage is a necessary skill and ability to perform well in an academic setting.

The study aims to determine caffeine's effect on college-aged adults' short-term memory. Previous research has shown that the ingestion of caffeine doses ranging from 32 mg to 300 mg positively affect cognitive performance, including attention, reaction time, and vigilance (McLellan, 2016). As a result, it is hypothesized that the consumption of higher doses of caffeine will result in decreased accuracy regarding short-term memory.

Methodology

Participants

The study's population was healthy college-aged adults between 18-30 years old.

Exclusion criteria included students with increased health risks and those habitually taking larger amounts of caffeine on a daily basis (>250 mg) (Childs, 2006). Participants

were recruited from a university in the southeastern United States. This study was approved by the Institutional Review Board (IRB) prior to any participant involvement.

Procedures

All of the testing sessions for this study were conducted in the human performance laboratory on the UAH campus. Participants attended their first session in the human performance laboratory, read and signed a consent form, and then the Physical Activity Readiness Questionnaire (PAR-Q+), which included a question regarding their previous medical history, such as epilepsy, that could possibly interfere with the testing on a lit screen. After completion of paperwork, participants' height and body mass were recorded with no shoes on and empty pockets. They were then assigned random caffeine amounts (0 mg, 200 mg, 400 mg) in pill form to take one hour before the next trial, of which there were three.

The 0 mg pill was a placebo, which was designed to present baseline data. The 0 mg pills were hand-made dextrose pills, while the 200 mg was a single 200 mg pill accompanied by a placebo pill, and the 400 mg was in the form of two 200 mg pills. For reference, 200 mg of caffeine is equivalent to 2 cups of coffee, and 400 mg of caffeine is equivalent to 4 cups of coffee. This was a double-blind design study, meaning that both the researchers and participants were unaware of the caffeine amounts consumed during each session. This process was repeated to reach a total of three sessions; pills for each upcoming trial were given after finishing a trial. The participants waited a minimum of 48 hours between each trial for a washout period to ensure that there would be no effects carried over between the trials. The participants were also asked to avoid consuming any caffeine within 24 hours of each trial while maintaining their regular hydration, diet, and routine; participants who failed to uphold these criteria were rescheduled for

a later date (Guest, 2021).

After taking the randomized caffeine pill, each participant who met the guidelines performed the Digit Span Test, both forward and backward, to measure the participants' short-term memory for each of the three trials. During this test, numbers were called out by a researcher with a monotone voice, and participants were instructed to repeat the numbers back to the researcher in the same order (*Multi-Ethnic Study of Atherosclerosis*, 2009). The test was terminated when a participant failed to repeat the numbers correctly; the participants were scored on how many lines of digits they recited back successfully. The results of both the forward and backward tests were recorded at each trial.

Spatial memory is another form of short-term memory that was recorded in the study. The Senaptec Sensory Station was used for a spatial memory test to evaluate short term memory in a digital format. In this test, lights flashed across the screen for a second before disappearing; the participant would then have to recall and tap the screen to recreate the pattern they were given (*Multi-Ethnic Study of Atherosclerosis*, 2009). The Senaptec Sensory Station scored this test by recording the distance of the participant's placed point from the original point provided to them. It then provided an average distance that was recorded as the score for the test.

Statistical Analysis

Both of the short-term memory data analyses were completed using the Statistical Package for the Social Sciences (SPSS), version 28. One-way analysis of variance tests were used to determine the impact of varying levels of caffeine (0 mg, 200 mg, and 400 mg) on short-term memory (Spatial Memory, Forward Digit Span, Backward Digit Span). The alpha level was set at .05 for all tests.

Results

A total of 23 participants (18-30 years of age), completed the study. All baseline participant characteristics are provided in Table 1. Spatial memory was not significantly different with varying caffeine amounts ($F = .357$, $p = 1.055$, $\eta_p^2 = .046$). Both forward and backward Digit Span testing were also not significantly different based on caffeine consumption ($F = .898$, $p = .108$, $\eta_p^2 = .005$ and $F = .737$, $p = .307$, $\eta_p^2 = .014$, respectively). See Table 2 for performance values of short-term memory based on varying caffeine consumption amounts.

Discussion

This study aimed to determine the impact of varying amounts of caffeine consumption on short-term memory within college-aged adults. Previous literature has researched the amounts of caffeine college individuals consume on a regular basis and how doses of caffeine can affect adults, separately (Rosser, 2009; Yoo, 2021). These studies also have a broader variable range, including several cognitive functions that could be impacted (Rosser, 2009; Yoo, 2021). This study, however, looked into joining these topics and how caffeine affects a population of college aged adults. This study also focuses specifically on how it can affect short-term memory, rather than simply cognitive functions as a whole. Short-term memory is exclusively observed, including a test on spatial memory to test another aspect of short-term memory.

It was hypothesized that higher doses of caffeine consumption would decrease the accuracy of short-term memory. However, this hypothesis was rejected because there were no significant differences found between short-term memory, including spatial memory, and the level of caffeine consumption of the participants at each given trial. This could be attributed to different data collection methods or studies researching a different population of caffeine users. The results of a study by Bichler (2006), also found that there were no significant differences in

short-term memory from an increase in caffeine and taurine, which coincided with the results of this study. A difference between Bichler's study (2006) and this study is that Bichler involved taurine, which is believed to have antioxidant properties and is found in many energy drinks.

A study by Han (2007) performed a spatial memory test on laboratory rats after ingesting caffeine, and they found that the caffeine group performed worse than the control group. Although Han (2007) used lab rats, this supports the theory that caffeine also negatively affects short-term memory in humans; this is not in agreement with this study. A different study by Nehlig (2010) found that caffeine hindered performance in activities that relied heavily on working memory. This study used the Digit Span Test, which used numbers instead of words. A study by McLellan (2016) showed that low to moderate (40-300 mg) caffeine levels positively affected alertness in participants but did not find the same benefits for the short-term memory of individuals. However, the results of a study by Zhang (2020) found that caffeine does have a positive impact on short-term memory. Results of study by Yoo (2021) also found that caffeine consumption improved short-term memory, observing improvements in both memory storage and retrieval.

The results of a study by Giles (2012) indicated that when habitual caffeine users were deprived of caffeine for 24 hours and asked to perform a memory and reaction time test when reintroduced to caffeine; this study found that caffeine boosts memory, which also does not support the findings of this study (Giles, 2012). Shoulder (2016) also performed a similar study, measuring caffeine levels on cognitive function in university students; in agreement with this study, no correlation was found between caffeine consumption and cognitive performance. A study by Bartrim (2020) used adult females to determine the impact of morning caffeine on cognitive function and found no

significant difference, similar to the findings of this study. Overall, studies have found that caffeine enhances all cognitive abilities, and this study did not support those claims. This could be attributed to different data collection methods or studies researching a different population of caffeine users.

The study has a few limitations. One possible limitation of the study could be with the Digit Span Test specifically. Because the digits were read aloud by a researcher instead of a computer or machine, there could be unintentional inflections when speaking the list of numbers. This could possibly affect the participants' ability to recall and recite the numbers successfully. Lastly, a set amount of caffeine was used for all participants rather than a variable amount of caffeine based on body mass. Higher BMIs could have allowed for less of an effect from the caffeine, which could have altered the results.

Further research could be done into this area to observe the variability of participants; a similar study could be conducted with only those that rarely consume caffeine, such as less than twice a week or less than 100 mg per week, to have a larger effect and remove any caffeine tolerances. In future studies, there could be an added variable of the participants' perceived alertness before consuming the caffeine; this could be achieved with a survey completed by the participants that subjectively assess their restfulness and alertness starting point before consuming the caffeine amount given. Further research could also separate the results of males and females within this population and compare the results between them to determine if this impacts the results of caffeine consumption.

In conclusion, college-aged adults in this study had no significant performance changes when introduced to moderate (200 mg) and high (400 mg) levels of caffeine ($p > .05$). College students are believed to consume the most caffeine when compared with other populations,

aiming to improve academic metrics and cognitive function in the classroom. Previous literature has shown both sides of how caffeine can affect cognitive performance (Rosser, 2009; Yoo, 2021); for example, a study by Nehlig (2010) showed a decline in short-term memory after caffeine ingestion, while a study by Bichler (2006) found no effect on memory from caffeine. While there are studies that suggest that higher levels of caffeine can enhance short-term memory, several studies show that higher levels of caffeine have no effect or negative effects on short-term memory. This study supports the claim that when college-aged adults use caffeine as a study tool or mental performance enhancement, it does not positively or negatively impact short-term memory.

References

Childs, E., & de Wit, H. (2006). Subjective, behavioral, and physiological effects of acute caffeine in light, nondependent caffeine users. *Psychopharmacology*, *185*(4). Drake, C. Roehrs, T. Shambroom, J. Roth, T. Caffeine effects on sleep taken 0, 3, or 6 hours before going to bed. *Journal of Clinical Sleep Medicine, 9*(11).

Guest, N. S., & Nelson, M. T. (2021). International Society of Sports Nutrition position stand: Caffeine and exercise performance. *Journal of the International Society of Sports Nutrition*, *18*(1), 1-37.

Mahoney, C. R., & Giles, G. E. (2019). Intake of caffeine from all sources and reasons for use by college students. *Clinical Nutrition*, *38*(2), 668–675.

McLellan, T. M. (2016). A review of caffeine's effects on cognitive, physical and occupational performance. *Neuroscience & Biobehavioral Reviews*, *71*, 294–312.

Minkove, J. (2020). *New insight into caffeine use disorder*. New Insight into Caffeine Use Disorder.

Multi-Ethnic Study of Atherosclerosis. MESA. (2009).

Nehlig, A. (2010). Is caffeine a cognitive enhancer? *Journal of Alzheimer's Disease*, *20*(1), 85– 94.

Rosser, J. I., & Walsh, B. (2009). Effect of physiological levels of caffeine on Ca2+ handling and fatigue development in *xenopus* isolated single myofibers. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology*, *296.*

Sleep and Caffeine. *American Academy of Sleep Medicine*. (2013).

Yoo, C., & Xing, D. (2021). Acute paraxanthine ingestion improves cognition and short-term memory and helps sustain attention in a double-blind, placebo-controlled, crossover trial. *Nutrients*, *13*(11), 3980.

Zhang, B., & Liu, Y. (2020). Cognition and brain activation in response to various doses of caffeine: A near-infrared spectroscopy study. *Frontiers in Psychology*, *11*.

Table 1. Baseline Participant Characteristics (*n* = 23)

Variable	*M* ± *SD*
Mean Age (years)	21.74 ± 1.69
Height (cm)	174.47 ± 10.82
Body mass (kg)	81.65 ± 26.82
Sex (female/male)	11/12

Note. Values are mean ± standard deviation.

Table 2. Reaction time and short-term memory values based on caffeine consumption

Variable	0 mg	200 mg	400 mg
Spatial Memory	0.58 ± 0.35	0.53 ± 0.34	0.46 ± 0.21
Forward D.S.	11.52 ± 2.21	11.52 ±	

2.17 11.48 ± 2.17 Backward D.S. 7.09 ± 1.95 6.83 ± 1.89 6.78 ± 1.88 *Note*. Values are mean ± standard deviation; D.S. = Digit Span