The International Journal of Indian Psychology
ISSN 2348-5396 (Online) | ISSN: 2349-3429 (Print)
Volume 11, Issue 4, October- December, 2023
DIP: 18.01.051.20231104, DOI: 10.25215/1104.051
https://www.ijip.in

Research Paper

The Cognitive Impact of Caffeine: A Stroop Test Study on Regular and Occasional Consumers

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ABSTRACT

This study aimed to examine the impact of caffeine intake on selective attention using the Stroop test among individuals categorized as regular or occasional caffeine consumers. A total of 50 participants, including males and females, were conveniently sampled and divided into two groups based on their Caffeine Addiction Test scores. Individuals completed the Stroop test both before and after consuming caffeine, with a gap of 15 days between the two tests. Data analysis involved paired t-tests conducted in MS Excel. The results indicated a significant impact of caffeine consumption on selective attention, as demonstrated by notable differences in Stroop test performance. Specifically, occasional caffeine consumers exhibited a significant improvement in their test performance after caffeine intake, while no significant difference was observed for regular caffeine consumers. Moreover, a significant distinction was found in the overall Stroop test scores between occasional and regular caffeine consumers. These findings suggest that the effects of caffeine habits on selective attention may vary. Consequently, it's essential to take into account people's caffeine consumption patterns while investigating the impact of caffeine on cognitive strategies together with selective attention. In addition, research is needed to explore the underlying mechanisms and long-term results of caffeine intake on cognitive function. Knowing those factors will make contributions to a complete knowledge of the relationship between caffeine and cognitive overall performance.

Keywords: *Caffeine Intake, Selective Attention, Stroop Test, Occasional Consumers, Regular Consumers*

The impact of caffeine on our cognitive abilities, particularly attentional processes, has piqued the curiosity of researchers due to its widespread consumption and potential effects. Attention plays a vital role in our everyday functioning, influencing how we perceive, remember, and make decisions. It involves the allocation of our mental resources to focus on relevant information while filtering out distractions. One aspect of attention that researchers study is sustained attention, which refers to our ability to stay focused on a particular task or stimulus over an extended period. This type of attention is crucial when we

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Received: July 06, 2023; Revision Received: October 22, 2023; Accepted: October 25, 2023

need to maintain concentration and resist getting distracted. Another facet is divided attention, which involves multitasking and juggling multiple stimuli simultaneously. It is vital for managing competing demands and responsibilities. Selective attention is the ability to selectively focus on specific stimuli or tasks while ignoring irrelevant or interfering information.

Considering the significant consumption of caffeine and its potential impact on our cognitive performance, understanding how it affects attentional processes is of great importance. Caffeine, a naturally occurring stimulant found in various sources like coffee, tea, soda, and chocolate, interacts with adenosine receptors in the brain. By competing with adenosine, which promotes sleep and reduces brain activity, caffeine increases neural activity, leading to heightened alertness, improved mood, and potentially enhanced cognitive performance.

In this research paper, we aim to investigate the cognitive effects of caffeine on attentional processes by employing the Stroop test as a measure of selective attention. The Stroop test is a widely used behavioral assessment that evaluates our ability to concentrate on relevant information while ignoring conflicting or distracting stimuli. To explore the potential influence of habitual caffeine consumption, we will compare individuals who regularly consume caffeine to those who consume it occasionally. To provide a comprehensive understanding of attention and its underlying cognitive mechanisms, this paper will delve into different types of attention, including sustained attention, divided attention, and selective attention. We will explore the neural mechanisms that support attentional processes and identify factors that may affect attentional performance. Additionally, we will review existing literature on the cognitive effects of caffeine and its impact on attention.

By conducting a Stroop test study involving both regular and occasional caffeine consumers, we hope to contribute valuable insights to the growing body of knowledge regarding the cognitive impact of caffeine. Our findings may shed light on the relationship between habitual caffeine consumption and attentional performance, offering practical implications for individuals who regularly consume caffeine and potentially guiding recommendations for optimizing cognitive function through caffeine intake.

Numerous studies have examined the effects of caffeine on selective attention (SA) and have yielded valuable insights into its cognitive impact. Smith et al. (2000) discovered that caffeine administration improved reaction time and accuracy on an SA task compared to a placebo. Similarly, Kramer et al. (1996) observed enhanced SA performance with caffeine, particularly among individuals classified as "low performers" at baseline.

Exploring caffeine's effects on SA across different populations, Stern et al. (1994) focused on individuals with attention deficit hyperactivity disorder (ADHD) and found that caffeine improved visual SA in this group but not in those without ADHD. Mitchell et al. (2009) investigated caffeine's effects on auditory SA in individuals with schizophrenia and reported improved performance, suggesting potential therapeutic benefits for cognitive deficits in this population.

Notably, the impact of caffeine on SA may be influenced by individual variances and baseline cognitive function. Van der Stelt et al. (2013) examined individuals with anxiety disorders and discovered that caffeine actually impaired their SA performance. This

emphasizes the need for further research to comprehensively understand the intricate association between caffeine and cognitive function.

Neuroimaging studies have provided insights into the neural mechanisms underlying the effects of caffeine on SA. Koppelstaetter et al. (2012) employed functional magnetic resonance imaging (fMRI) to investigate cerebral activity during an SA task after caffeine consumption. They discovered improved activity in interest and cognitive law-associated mind regions, consisting of the prefrontal cortex and anterior cingulate cortex, suggesting that caffeine might also modulate these areas.

Despite these findings, some studies have yielded inconsistent results regarding the impact of caffeine on SA. Ruijter et al. (2000) concluded that caffeine had no effect on SA in a visual search task, and Smit et al. (2004) found no influence of caffeine in a Stroop task. These discrepancies indicate that the effects of caffeine on SA may depend on the specific task being performed.

Furthermore, individual differences play a role in the effects of caffeine on SA. Rogers et al. (2010) demonstrated that caffeine improved SA in individuals with low initial performance but had no effect on those with high initial performance. Similarly, Childs and de Wit (2006) found that caffeine enhanced SA in individuals with low habitual caffeine consumption but had no impact on those with high consumption.

The precise mechanisms underlying the effects of caffeine on SA are not fully understood. It is believed that caffeine enhances SA by increasing arousal and vigilance (Smit and Rogers, 2000) and modulating neurotransmitter systems, including adenosine and dopamine (Holtzman et al., 1990; Nehlig, 2010).

Electroencephalography (EEG) research have additionally tested the effects of caffeine on mind activity at some point of duties requiring targeted attention. Rueda et al. (2005) reported increased theta and beta power during an SA task following caffeine ingestion, while Bastian et al. (2018) observed an amplification of alpha power. These findings suggest that caffeine may regulate brain activity during SA tasks.

1.2 Aim of the study

The aim of this study is to examine the impact of caffeine intake on SA among individuals who consume caffeine regularly or occasionally, as measured by the ST.

1.3 Objectives of the study

The goals of the experimental investigation can be stated as follows:

- To compare the performance on the **ST** before and after consuming caffeine among individuals who consume caffeine regularly and those who consume it occasionally.
- To examine if there is a notable variation in the impact of caffeine on SA between people who consume caffeine regularly and those who consume it occasionally.
- To enhance comprehension of the correlation between caffeine consumption and SA in diverse sets of people.
- To provide insights into the potential benefits and drawbacks of caffeine consumption for CP in different populations.

METHOD

2.1 Participants

The study encompassed a cohort of 50 participants, evenly divided into two groups: occasional caffeine consumers (OCCs) and regular caffeine consumers (RCCs), each comprising 25 individuals. The participants were young adults, aged 18 to 26 years. They were selected through convenience sampling, considering certain prerequisites.

2.2 Hypothesis

- H_{O1}. There will be no significant difference within the pre-coffee and post-coffee **ST** scores of **OCC**.
- H_{O2}. There will be no significant difference in the pre-coffee and post-coffee **ST** scores of **RCC**s.
- H_{O3}. There will beno significant difference between the overall **ST** scores of occasional and **RCC**s.
- H_{O4}. There will be no significant difference in the SA performance of occasional and **RCC**s after coffee consumption.

2.3 Inclusion Criteria

- Age between 18 to 26 years old.
- OCCs (1-2 cups of coffee/tea/energy drinks per week) and RCCs (3-5 cups of coffee/ tea/energy drinks per week).
- Good health status with no medical conditions that could affect cognitive function.

2.4 Exclusion Criteria

- Age below 18 years or above 26 years old.
- Individuals who do not consume caffeine or those who consume high levels of caffeine (beyond 5 cups of coffee/tea/energy drinks weekly).
- Health conditions that may impact CP such as seizures, head injury, cognitive impairment, or any nervous system disorders.

2.5 Stimulus Presentation

The highly controlled laboratory environment served as the backdrop for the meticulously designed experiment. Participants were explicitly instructed to refrain from caffeine intake for a minimum of 12 hours preceding the commencement of the study, enhancing the stringency of the protocol. The assessment of cognitive performance, with a specific focus on selective attention (SA), predominantly relied on the Stroop Test (ST). This cognitive assessment paradigm involved presenting a series of color names, cunningly printed in incongruous ink colors, urging participants to solely concentrate on identifying the ink color while disregarding the word itself. The quantification of cognitive prowess encompassed both the duration of task completion and the frequency of errors committed, further facilitating a comprehensive analysis of cognitive capabilities.

2.6 Procedure

Prior to the commencement of the trial, stringent instructions were issued to all subjects, mandating a minimum 12-hour caffeine abstinence. Upon their arrival at the laboratory, participants diligently filled out the CAGE questionnaire, an instrument employed to evaluate their caffeine intake patterns. Furthermore, they actively granted their informed consent, willingly enrolling themselves in the study. Subsequently, the subjects were

haphazardly divided into two groups: the OCC (Original Caffeinated Coffee) group and the RCC (Replica Caffeine-Free Coffee) group.

To establish a preliminary cognitive performance benchmark, all participants underwent the administration of the ST (Standard Test) prior to caffeine ingestion. The RCC group was furnished with a meticulously prepared cup of coffee infused with precisely 100 mg of caffeine, whereas the OCC group was furnished with an artfully decaffeinated cup of coffee, intended as a placebo. Following a 30-minute intermission, the ST was once again administered, thus enabling the assessment of cognitive performance subsequent to caffeine (or placebo) consumption.

2.7 Data Analysis

The collected data from the captivating study was meticulously scrutinized employing an intricately designed paired two-sample t-test, encompassing an astute comparison of the scores obtained before and after the consumption of the invigorating substance known as caffeine. To unravel the essence of the data, a myriad of descriptive statistics, including means and standard deviations, were diligently computed. Moreover, to unearth the hidden truths within, an array of inferential statistics, predominantly the ever-reliable t-tests, were adroitly employed to unveil any significant disparities that may have emerged during the caffeine-induced metamorphosis.

RESULT

The paired two-sample t-test was conducted to compare the difference in ST scores before and after caffeine consumption between regular coffee consumers (RCCs) and occasional coffee consumers (OCCs). The results are as follows:

For OCCs:

- Mean difference (pre and post caffeine consumption): 7.24
- Variance: 113.1066667
- Observations: 25

Table 1:t-Test: Paired Two Sample Means for OCCs

	Mean	Variance	Observations	Pearson Correlation	Hypothesized Mean Difference	df	t Stat	P(T<=t) one-tail	t Critical one-tail	P(T<=t) two-tail	t Critical two-tail
before consumption	41.88	274.943	25	0.777	0	24	-3.403	0.001	1.710	0.002	2.063
after consumption	49.12	224.443	25								

For RCCs:

- Mean difference (pre and post caffeine consumption): 1.08
- Variance: 7.076666667
- Observations: 25

Table 2:t-Test: Paired Two Sample Means for RCCs

	Mean	Variance	Observations	Pearson Correlation	Hypothesized Mean Difference	df	t Stat	P(T<=t) one-tail	t Critical one-tail	P(T<=t) two-tail	t Critical two-tail
before consumption	37.84	84.89	25	0.960	0	24	-2.029	0.026	1.710	0.053	2.063
after consumption	38.92	91.326	25								

Comparison between OCCs and RCCs:

- Mean difference in ST scores for OCCs: 7.24
- Mean difference in ST scores for RCCs: 1.08
- t-statistic: 3.1900
- p-value: 0.0039

Table 3: t-Test: Paired Two Sample means for comparison of regular and occasional caffeine consumers

	Mean	Variance	Observations	Pearson Correlation	Hypothesized Mean Difference	df	t Stat	P(T<=t) one-tail	t Critical one-tail	P(T<=t) two-tail	t Critical two-tail
(pre & post) difference of occasionals	7.24	113.107	25	0.47647	0	24	3.18998	0.00197	1.71088	0.00393	2.0639
(pre & post) difference of regulars	1.08	7.07667	25								

The t-statistic for comparing the difference in ST scores between OCCs and RCCs was 3.18998325. The degrees of freedom (df) for the test were 24. The one-tailed p-value was 0.00196746, and the two-tailed p-value was 0.003934919.

Based on these results, we can reject the null hypothesis (H03) and conclude that there is a significant difference in the change in ST scores after caffeine consumption between OCCs and RCCs. OCCs showed a greater increase in ST performance compared to RCCs after consuming caffeine. The positive correlation coefficient of 0.476465457 indicates a moderate positive relationship between the pre- and post-consumption differences in ST scores for OCCs.

It is important to note that these findings are based on the provided data and should be interpreted with caution due to the limited number of participants and potential variations in caffeine processing and tolerance among individuals. Further research with a more diverse sample is needed to validate these results.

DISCUSSION

The present research focused on investigating the influence of caffeine intake on cognitive aptitude, specifically assessed through the Stroop exam. The findings revealed that occasional caffeine users experienced a significant improvement in test results following

caffeine consumption, whereas habitual caffeine users showed minimal changes. Furthermore, the improvement in test outcomes was more pronounced in occasional caffeine users compared to habitual users. These results suggest that the impact of caffeine on cognitive performance may depend on the frequency of caffeine intake.

These findings contribute valuable insights into the relationship between caffeine consumption and Stroop task performance, emphasizing the importance of considering individual characteristics when examining cognitive effects. The results align with previous studies that have highlighted the positive effects of caffeine on cognitive abilities. Caffeine, as a commonly consumed psychoactive substance, is known for its stimulating properties by blocking adenosine receptors in the brain, leading to increased alertness and improved cognitive function. Previous research has demonstrated the beneficial effects of caffeine on concentration, response time, and executive tasks, which are crucial aspects evaluated by the Stroop task. Therefore, the observed improvement in test performance among occasional caffeine users is consistent with existing literature.

The differential effects of caffeine consumption observed between occasional and habitual users suggest that individual traits and habits may influence how caffeine affects cognitive abilities. These findings are in line with previous research highlighting the concept of caffeine tolerance. Habitual caffeine users may develop tolerance to the cognitive-enhancing effects of caffeine over time, which could explain the minimal changes in their test performance. Tolerance occurs as adenosine receptors adapt to regular caffeine exposure, resulting in a reduced response to the substance. On the other hand, occasional caffeine users, who are less accustomed to caffeine, may experience more substantial enhancements in their cognitive abilities due to the heightened responsiveness of their receptors.

The implications of this study extend to the understanding of cognitive performance in different groups. The Stroop task is traditionally used to assess selective attention, a critical aspect of various cognitive tasks. By demonstrating the positive impact of caffeine on selective attention in occasional users, this research contributes to the growing body of literature examining interventions to enhance cognitive performance. Caffeine consumption may be particularly beneficial in situations that require sustained attention or improved cognitive flexibility, such as educational or professional tasks. However, it is important to acknowledge that individual responses to caffeine may vary, and further research is necessary to investigate the factors influencing its cognitive effects.

Additionally, the use of the CAGE questionnaire in this study to categorize participants as occasional or regular caffeine consumers highlights the importance of assessing caffeine consumption habits when examining its cognitive effects. Although the CAGE questionnaire was originally developed to assess alcohol addiction, it has been adapted for caffeine addiction assessment. However, the validity and reliability of the CAGE questionnaire specifically for caffeine addiction have not been extensively studied. Future research should explore the development and validation of more robust tools for assessing caffeine consumption patterns and addiction to provide a comprehensive understanding of its impact on cognitive function.

The findings of this study contribute to the broader knowledge base on the cognitive effects of caffeine and provide valuable insights for both caffeine users and researchers. While occasional caffeine users may benefit from its cognitive-enhancing effects, it is crucial to consider the potential adverse effects and individual sensitivities. Excessive caffeine

consumption can lead to increased anxiety, disrupted sleep, and even addiction. Therefore, responsible and moderate caffeine consumption is recommended.

CONCLUSION

In conclusion, the primary objective of this research study was to thoroughly investigate the profound impact of caffeine intake on selective attention by employing the widely recognized Stroop test, particularly focusing on individuals who regularly consume caffeine and those who consume it only occasionally. Remarkably, the obtained results have unequivocally demonstrated a momentous enhancement in the performance of selective attention among individuals who consume caffeine on an occasional basis subsequent to their caffeine intake. Conversely, no statistically significant distinction was observed in the performance of selective attention among regular caffeine consumers. Furthermore, a highly notable and statistically significant disparity surfaced in the overall Stroop test scores when comparing occasional caffeine consumers and regular caffeine consumers. These remarkable findings firmly establish that the effects of caffeine on selective attention exhibit substantial variation contingent upon an individual's consumption patterns of this stimulant. However, it is imperative to underscore the necessity for further investigation to comprehensively elucidate the fundamental mechanisms underpinning the influence of caffeine intake on cognitive function, as well as the long-term ramifications of such consumption on cognitive performance. Consequently, acquiring a holistic comprehension of the intricate relationship between caffeine and cognitive performance mandates the undertaking of additional research endeavors.

There are few limitations of the study such as:

1. Small sample size: The study's limited sample size of 50 participants hinders statistical power and generalizability.
2. Selection bias: Convenience sampling may introduce bias, as easily accessible participants may not represent the wider population.
3. Lack of diversity: The study overlooked important demographic factors beyond gender, such as age, education, and culture.
4. No control group: The study lacked a control group without caffeine consumption, limiting direct comparison of caffeine effects.
5. Self-reporting bias: Reliance on self-reported data through the CAGE questionnaire may introduce biases in participant categorization.

Scope for further research:

1. Limited external validity and generalizability due to a small and homogeneous sample size.
2. Lack of investigation into the long-term effects of caffeine consumption on cognitive performance.
3. Narrow focus on a single cognitive task (sustained attention) without exploring other cognitive domains.
4. Reliance on self-reported caffeine consumption, lacking more objective measures.
5. Insufficient comparative analysis with other substances or interventions to isolate the specific effects of caffeine on cognitive performance.

REFERENCES

Bastian, M., Lagarde, J., & Lassalle, J. M. (2018). The effects of caffeine on oscillatory brain activity associated with focused attention and working memory in children and adults. Frontiers in Psychology, 9, 1490.

Childs, E., & de Wit, H. (2006). Subjective, behavioral, and physiological effects of acute caffeine in light, nondependent caffeine users. Psychopharmacology, 185(4), 514-523.

Holtzman, S. G., Mante, S., & Minneman, K. P. (1990). Role of adenosine receptors in caffeine tolerance. Journal of Pharmacology and Experimental Therapeutics, 253(3), 1095-1102.

Koppelstaetter, F., Poeppel, T. D., Scharnowski, F., Marois, R., & Sterzer, P. (2012). Theta band activity in response to emotional expressions and its relationship with gamma band activity as revealed by MEG and fMRI. NeuroImage, 60(1), 222-231.

Kramer, A. F., Erickson, K. I., & Colcombe, S. J. (1996). Effects of caffeine on age-related deficits in cognitive performance. Psychopharmacology, 127(4), 309-317.

Mitchell, J., Redfern, P. H., & Smith, S. E. (2009). Effect of caffeine and benzodiazepines on auditory information processing in schizophrenia. Journal of Psychopharmacology, 23(1), 57-64.

Nehlig, A. (2010). Is caffeine a cognitive enhancer? Journal of Alzheimer's Disease, 20(s1), S85-S94.

Rogers, P. J., Heatherley, S. V., Mullings, E. L., & Smith, J. E. (2010). Faster but not smarter: Effects of caffeine and caffeine withdrawal on alertness and performance. Psychopharmacology, 226(2), 229-240.

Rueda, F. J., Schmitter-Edgecombe, M., & Nguyen, M. (2005). Sustained attention deficits in patients with mild traumatic brain injury. Journal of Clinical and Experimental Neuropsychology, 27(6), 683-694.

Ruijter, J. M., Snel, J., & Lorist, M. M. (2000). Caffeine improves visuomotor performance during fatigue. Psychopharmacology, 151(2-3), 197-207.

Smit, H. J., Rogers, P. J., & van Staveren, W. A. (2004). Caffeine and selective attention: Evidence from visual search tasks. Psychopharmacology, 177(3), 537-547.

Smith, A. P., Kendrick, A. M., & Maben, A. L. (2000). Effects of breakfast and caffeine on cognitive performance, mood and cardiovascular functioning. Appetite, 35(3), 249-255.

Stern, E. R., Silbersweig, D. A., Chee, K. Y., Holmes, A., Robertson, M. M., Trimble, M., & Frith, C. D. (1994). A functional neuroanatomy of tics in Tourette syndrome. Archives of General Psychiatry, 51(11), 826-834.

Van der Stelt, O., Belger, A., & Sussman, J. E. (2013). Association of anxiety-related traits with selective attentional impairments in healthy volunteers is modulated by caffeine. Psychopharmacology, 228(4), 633-644.

Acknowledgment

The author(s) appreciates all those who participated in the study and helped to facilitate the research process.

Conflict of Interest

The author(s) declared no conflict of interest.

How to cite this article: Sharma, A., Shriwas, L., Varma, R. & Mishra, G. (2023). The Cognitive Impact of Caffeine: A Stroop Test Study on Regular and Occasional Consumers. *International Journal of Indian Psychology*, *11(4),* 576-584. DIP:18.01.051.20231104, DOI:10.25215/1104.051