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The Short-Term Effect of Caffeine Consumption on Reading Performance

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Abstract:

Objective: Caffeine, a widely consumed psychoactive substance, is recognized for its cognitive-enhancing effects, notably enhancing performance on tasks requiring narrative comprehension, where it has been shown to boost both acuity and speed. This study investigates the impact of caffeine intake on reading acuity and evaluates changes in reading speed post-caffeine consumption.

Material and Methods: Employing a cross-sectional design, nineteen participants with distance best-corrected vision of 6/6 or better (equivalent to logMAR 0.00 or better) (mean age=22.5±1.00 years old) and near vision of 0.1 logMAR (N5) were recruited. Baseline measurements of reading acuity and speed were taken using the article sourced from *Perpustakaan Tun Abdul Razak* (PTAR) and Buari-Chen Malay Reading Chart (BCMRC) before coffee consumption, respectively. Participants consumed 200 mg of Nescafe Gold (caffeine) before the subsequent assessment. The time taken to read the reading materials was recorded, alongside any errors.

Results: While reading speed significantly increased post-caffeine consumption (t=-7.536, p-value<0.001), reading acuity remained unaffected (t=-0.378, p-value=0.705). These results suggest a moderate dose of 200 mg of caffeine can enhance reading speed without compromising acuity in young adults.

Conclusion: This indicates that caffeine mainly affects the rate of reading, while it does not alter the reading acuity of individuals.

Keywords: caffeine, reading acuity, reading speed

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Introduction

Described as the world's most popular drug, caffeine is recognized for its proactive effects on the central nervous system, influencing an individual's mood[1]. According to the International Coffee Organization, forecasts indicate a steady increase in coffee consumption in Malaysia from 635,000 coffee bags in 2020 to 800,000 in 2021 and 2022[2,3]. Studies suggest that young adults, particularly university students who consume caffeine, are likely to exhibit higher levels of focus and attentiveness in class compared to non-consumers[1]. Moreover, caffeine intake has been shown to enhance memory and motor skills in individuals.

In healthy adults, caffeine has a half-life of approximately 3-6 hours, reaching its peak plasma concentration between 20 and 120 minutes after consumption[4]. Consequently, it exits the body around four hours post-ingestion. During its peak plasma concentration, caffeine enhances proficiency in sentence pattern analysis during proofreading while showing no impact on the ability to detect misspelled words[5]. This facilitates easier text comprehension and the ability to assess the accuracy of depicted images. The effect of caffeine varies depending on individual tolerance levels and consumption amounts. Some individuals may be more sensitive to its effects, while regular users may develop a tolerance, necessitating higher doses for similar outcomes[6]. An intake of 200 mg, equivalent to about two and a half cups of coffee, is adequate to promote wakefulness, enhance mood, and alleviate fatigue[5]. Research indicates that caffeine typically takes effect within five to thirty minutes and can last up to twelve hours. However, excessive consumption exceeding 300 mg or 2-3 cups may lead to adverse effects such as insomnia, reduced fine motor control, and increased anxiety[7]. Hence, consuming caffeine judiciously and being mindful of potential negative repercussions is advisable. Pregnant women and individuals with certain medical conditions should consult their healthcare provider before consuming caffeine to prevent unfavorable side effects.

The act of reading entails the interpretation of written or printed symbols, such as letters and words, to extract meaning and comprehension from the text itself. Additionally, reading is a foundational skill enabling individuals to access information, acquire knowledge, and communicate effectively. Research suggests that reading is a unique human ability utilized by millions daily, demanding diverse cognitive capabilities for mastery[8]. For the brain to process visual information received through the eyes and transform symbols into coherent words, phrases, and passages, the eyes must scan the text in a left-to-right manner during reading. This cognitive process encompasses several skills, including letter recognition and phonetics, vocabulary comprehension, grammatical understanding, and grasping the broader context and significance of the text.

One of caffeine's benefits lies in its positive effects on various cognitive tasks, including narrative comprehension tests, which have enhanced both speed and accuracy, facilitating easier interpretation of sentences and determining their accuracy[5]. Moreover, caffeine intake influences reading speed, accuracy, and visual acuity at a distance. A study observed an increase in visual acuity for approximately 30 minutes following instant coffee consumption, followed by a gradual decline over 60 to 90 minutes. This enhancement in visual acuity is attributed to a combination of caffeine and sugar, as their mixture has been shown to improve performance in executive functioning and attention tasks[9]. Furthermore, caffeine enhances the detection of morphosyntactic errors during proofreading assignments by enhancing global pattern analysis of phrases[10]. In addition, caffeine enhances sentence pattern analysis, improving the identification of errors during proofreading, while it does not affect the ability to detect misspelt words[5,11]. A single dose of 200 mg caffeine improved global processing, without

any effect on local information processing, alerting, spatial attention and executive or phonological functions. This improvement in global processing was accompanied by faster text reading speed of meaningful sentences, whereas single word/pseudoword or pseudoword text reading abilities were not affected. These effects of caffeine on reading ability were enhanced by mild sleep deprivation. These findings show that a small quantity of caffeine could improve global processing and text reading skills in adults[11]. It can be concluded that drinking a cup of coffee before studying can lead to decrease in eye movement fixation period and increase in information encoding and processing speed[12].

Drawing from existing literature, we hypothesized that caffeine, by influencing sentence pattern analysis, might also positively impact reading tasks, including reading acuity and speed. Considering reading acuity and speed, further investigation is warranted into how coffee consumption influences reading comprehension. In testing typical young adult readers, we anticipated that caffeine would affect text reading speed without altering other reading abilities or cognitive functions associated with reading. Thus, this study aimed to compare the effects before and after caffeine consumption on reading acuity and speed. A dose of 200 mg caffeine in one sitting is deemed moderate and equivalent to approximately two and a half cups of coffee, posing no harmful effects on subjects[5].

Material and Methods

Study design

This study employed a cross-sectional study design, which entailed observing each participant at a singular point in time. The research was conducted at the Faculty of Health Sciences, UiTM Puncak Alam Campus.

Participant selection

This study adhered to the tenets of the Declaration of Helsinki and obtained approval from the Research Ethics Committee of Universiti Teknologi MARA (FERC/FSK/MR/2023/00063). Data collection commenced after participants completed and signed the consent form and received an explanation regarding the study's objectives and potential side effects. Power calculations were performed using GPower analysis software version 3.1, determining a total sample size of 20 for this study. However, one participant was excluded due to their status as a non-caffeine drinker. The final total participants involved were 19. This calculation was based on a two-tailed paired analysis with an alpha (α) level of 0.05 and an effect size (f) of 0.60, resulting in a study power of 0.70[11]. Participant selection utilized a convenience sampling method, with ages ranging from 20 to 25. Subsequently, participants underwent screening assessments, including visual acuity and binocular function evaluations.

Inclusion and exclusion criteria

All participants underwent visual acuity assessments using the Bailey-Lovie distance acuity chart and the Buari-Chen Malay Reading Chart (BCMRC). Inclusion criteria encompassed corrected distant vision of 0.0 logMAR (equivalent to 6/6) or better and near vision of 0.1 logMAR (equivalent to N5) or better without binocular vision issues, systemic diseases, or ocular history problems. Exclusion criteria comprised corrected distant vision worse than 0.18 logMAR (equivalent to 6/9), near vision worse than 0.3 logMAR (equivalent to N6), binocular vision issues, or a history of ocular problems. Additionally, heavy caffeine consumers and non-drinkers were excluded to mitigate the influence of caffeine tolerance. Survey on Google form was distributed prior to the data collection to identify the potential participants. The survey was designed to categorize participants based on their caffeine intake. Heavy caffeine consumers included individuals who consumed more than 400 mg of caffeine per day, which was roughly equivalent to more than four cups of brewed coffee.

In comparison, non-drinkers included individuals who never consumed caffeine. Participants were instructed to abstain from consuming caffeinated beverages for at least 48 hours before the trial as recommended by a previous study to ensure complete caffeine washout[13].

Visual stimuli

The experiment was done in a well-controlled photometry room where the illumination was kept constant at 500 lux during all visual stimuli presentations to ensure consistent lighting conditions. An article from the online database of *Perpustakaan Tun Abdul Razak (PTAR)*, comprising 500 words, was presented in Malay with black text on a white background. Opting for black text on a white background is common for digital text due to its enhanced readability and improved participant experience. The chosen font type for the text was Times New Roman, set in 12-point size, as larger text sizes are generally considered more readable[14] (Figure 1). All participants were required to read the text aloud from a laptop, with the same device utilized by each participant. The Buari-Chen Malay Reading Chart (BCMRC) was employed for assessing reading acuity. This chart comprises high-contrast Arial font with 14 print sizes, spanning from 1.3 logMAR to 0.0 logMAR in 0.1 logMAR increments, which corresponds to the inclusion criteria of near vision of 0.1 logMAR (equivalent to N5) or better. Each print size presents six Malay words distributed across two lines. Printed on A4-sized white matte material, the chart features a double-sided layout with black text on a white background to ensure high visibility[15] (Figure 2).

Kesejahteraan Kesihatan Rakyat Melalui Filantrofi Islam

Malaysia mencatatkan peningkatan jumlah perbelanjaan kesihatan daripada RM16.3 Billion pada 2008 kepada RM26.21 Billion pada 2018 seperti yang dilaporkan di dalam Laporan Kementerian Kesihatan Malaysia (2018). Manakala dalam Belanjawan 2020 peruntukan untuk perbelanjaan penjagaan kesihatan awal adalah sebanyak RM 2.6 billion berbanding tahun sebelumnya sebanyak RM28.7 bilion (Bernama, 2019). Populasi penduduk Malaysia pada 2020 yang meningkat kepada 32.7 juta orang berbanding 32.5 juta orang pada 2019 berserta trend jangka hayat rakya Malaysia yang semakin meningkat menyumbang kepada kesukaran kerajaan dalam memastikan perkhidmatan kesihatan bersubsidi dapat diberikan kepada seluruh rakyat (Penerbitan Anggaran Penduduk Semasa Malaysia, 2020). Ini adalah kerana kerajaan menghadapi kekangan dari sudut ketidakcukupan belanjawan dalam menyediakan kemudahan kesihatan, urusan pengambilan kakitangan baru serta kekurangan kemudahan fasiliti kesihatan.

Oleh sebab itulah, dana seperti filantrofi Islam memainkan peranan penting dalam membantu mengurangkan bebanan kerajaan yang mana dicadangkan penubuhan Pusat Sehenti Rehabilitasi dan Rawatan Kesihatan (PSRR) melalui dana filantrofi Islam di seluruh negara sebagai perkhidmatan sokongan yang boleh digunakan oleh rakyat yang berpendapatan rendah dalam membantu usaha kerajaan untuk meningkatkan kesejahteraan kesihatan rakyat. Majlis Agama Islam Negeri serta Institusi Zakat dan Wakaf dapat membantu membangunkan perkhidmatan kesihatan berupa pemeriksaan kesihatan, pusat dialisis, perkhidmatan fisioterapi dengan kos yang rendah kepada masyarakat.

Kertas kerja ini bertujuan untuk membincangkan kepentingan perkhidmatan kesihatan atau pusat sehenti yang dibangunkan menggunakan model Filantrofi Islam sebagai instrumen kewangan baru untuk membantu rakyat yang berpendapatan rendah khususnya golongan B40 dan asnaf dalam meningkatkan kesejahteraan kesihatan. Kertas kerja ini turut membincangkan tentang keperluan mewujudkan pusat rehabilitasi atau pusat sehenti bagi kesihatan untuk kemudahan masyarakat awam dan golongan asnaf yang meliputi kemudahan kesihatan seperti rawatan hemodialisis, rawatan fisiologi dan pemeriksaan kesihatan percuma. Model ini dirangka bertujuan untuk membantu pentadbir dana filantrofi Islam melaksanakan tanggungjawab dan amanah dengan lebih cekap serta sebagai model kesejahteraan untuk masyarakat khususnya golongan yang memerlukan seperti golongan berpendapatan rendah dan miskin yang perlu diberikan keutamaan dalam mengecapi kesejahteraan dalam semua aspek kehidupan. Ini boleh direalisasikan melalui usaha menyeluruh semua pihak termasuk kerajaan dan agensi Islam seperti pusat zakat dan wakaf.

Kos perbelanjaan kesihatan kerajaan di Malaysia yang semakin meningkat menyebabkan kerajaan menanggung beban dalam memberikan rawatan bersubsidi kepada rakyat yang memerlukan. Hospital kerajaan yang sesak dengan pesakit serta ketidakupayaan kakitangan dan ketidakcukupan peralatan menambahkan lagi masalah untuk memberikan perkhidmatan yang cekap kepada pesakit. Menurut Abdul Rahman Ramdzan & Ihsanudin Abas (2019), jumlah katil yang tidak seimbang antara sektor awam (70%) dan swasta (30%), meningkatkan beban kewangan yang mana perbelanjaan tahunan kesihatan Malaysia adalah 4.7% daripada Keluaran Dalam Negara Kasar (KDNK) yang mana nisbah kerajaan kepada swasta adalah 50-50 peratus. Populasi Malaysia yang meningkat, kadar jangka hayat penduduk Malaysia serta kadar penyakit yang meningkat juga antara faktor yang akan meningkatkan permintaan terhadap perkhidmatan kesihatan ini (Laporan Kementerian Kesihatan Malaysia, 2018).

Hasil kajian ini turut membantu meyakinkan rakyat untuk menyumbang harta mereka sejajar dengan filantrofi Islam. Ini sekaligus meningkatkan ekonomi negara, membantu mengurangkan beban kewangan kerajaan, membantu rakyat yang memerlukan selaras dengan aspirasi kerajaan dalam Sustainable Development Goals (SDG) yang merangkumi kesejahteraan yang baik, mengurangkan ketidaksamarataan, perkongsian untuk mencapai matlamat kemampanan ekonomi.

Figure 1 Reading text used in the experiment

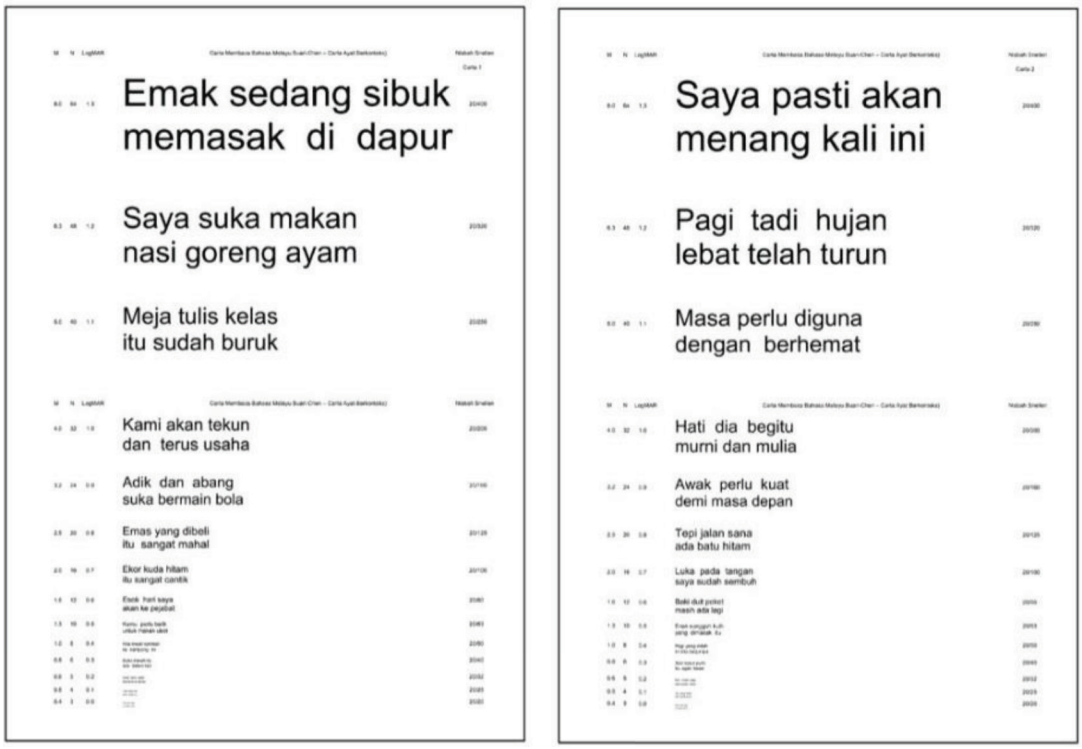

Figure 2 Buari-Chen Malay Reading Chart (BCMRC)

Experimental procedure

The participants in this study were recruited from UiTM Puncak Alam and ranged in age from 20 to 25 years old. Information regarding the subjects' caffeine consumption status was collected through a Google Form. Baseline reading acuity and reading speed measurements were obtained before the participants consumed coffee. Both readings were measured binocularly for all participants. They were instructed to ingest 200 mg of Nescafe Gold (caffeine) which corresponds to approximately 60 mg per 2 g serving, based on manufacturer information before the post-assessment began. Nescafe Gold was selected for its moderate caffeine content[16]. The coffee was measured using a digital scale. Following 30 minutes of coffee consumption, participants were instructed to read the smallest and clearest print size from the reading acuity chart, utilizing the BCMRC. For the reading speed assessment, participants were asked to read an article of 500 words with black text on a white background to maximize contrast and reduce eye strain. Voice recordings were utilized throughout the assessment to identify any reading mistakes and calculate each participant's average reading speed. Reading speed was determined for each sentence by dividing the number of correct words in the sentence to the time taken (in a minute) to read the sentence[17]. Both task 1 and task 2 were randomized for post-caffeine consumption using a computer-generated random sequence to ensure unbiased task order. All readings were scored by the same observer to eliminate inter-observer variability. This consistency helps ensure the reliability of the measurements.

Results

Demographic characteristics

The study sample comprised 19 participants, predominantly female (73%) and aged mostly 22–23 (85%). None of the participants were smokers. Caffeine consumption was varied, with 32% drinking both coffee and tea, 26% preferring only coffee, and smaller percentages consuming combinations of soft drinks, coffee, and tea. The frequency of caffeine intake was primarily occasional (55%), and daily consumption was mostly below 200 mg (79%). Caffeine intake timing varied, with 37% consuming it at night and 37% at multiple times of the day. Awareness of caffeine's psychological effects was low, with only 11% aware, and similarly, 16% were aware of its effects on vision (Table 1).

Table 1 Demographic characteristics

Parameters	Frequency (n=19)	Percentage (%)
Gender		
Male	5	27
Female	14	73
Age (years)		
20	1	5
21	1	5
22	6	32
23	10	53
24	1	5
Smoking status		
Yes	0	0
No	19	100
Type of caffeine		
Soft drink	1	5
Coffee	5	26
Tea	3	16
Coffee and tea	6	32
Soft drink and tea	2	10.5
Soft drink, coffee and tea	2	10.5
Frequency of caffeine consumed in a week		
Sometimes	4	20
Occasionally	11	55
Often	4	20
Amount of caffeine consumed daily (mg)		
0–100	9	47
100–200	6	32
200–300	4	21
>300	0	0
Time of caffeine intake		
Morning	4	21
Afternoon	1	5
Night	7	37
All of the following	7	37
Awareness of caffeine effect on psychological effects		
Yes	2	11
No	16	84
Maybe	1	5
Awareness of caffeine's effect on vision		
Yes	3	16
No	13	68
Maybe	3	16

Reading acuity

Paired-t test was performed to compare the average of two dependent variables, pre- and post-reading acuity. The test revealed an insignificant difference between pre- and post-reading acuity (t (18)=-0.378, p-value=0.705). The results of the paired test are presented in Table 2.

Table 2 Comparison of reading acuity before and after caffeine intake

Variable	Pre-reading acuity Mean±S.D.	Post-reading acuity Mean±S.D.	t-statistic	p-value
Reading acuity (logMAR)	0.20±0.11	0.20±0.15	-0.378	0.705

S.D.=standard deviation

Reading speed

A paired t-test assessed the difference between pre- and post-reading speed means. The analysis revealed a statistically significant mean difference between pre- and post-reading speed (t (18)=-7.536, p-value<0.001). Post-reading speed (M=129.31, S.D.=10.42) was significantly higher than pre-reading speed (M=115.36, S.D.=11.11). Details of the paired t-test results are presented in Table 3.

Table 3 Comparison of reading speed before and after caffeine intake

Variable	Pre-reading speed Mean±S.D.	Post-reading speed Mean±S.D.	t-statistic	p-value
Reading speed (wpm)	115.36±11.11	129.31±10.42	-7.536	<0.001

S.D.=standard deviation

Discussion

The study examined the impact of caffeine on reading performance in young adults. Findings revealed that a moderate dose of 200mg of caffeine significantly increased reading speed (t=-7.536, p-value<0.001) without affecting reading acuity (t=-0.378, p-value=0.705). These results indicate that caffeine can enhance reading speed without compromising visual clarity.

Reading acuity

The impact of caffeine on reading acuity has been a subject of interest in scientific research, with studies investigating its potential to enhance or impede reading performance. While some research suggests positive effects, others indicate potential drawbacks or no significant influence. A study highlighted an inverted U-shaped relationship between caffeine dosage and cognitive performance, suggesting that there may be an optimal range of caffeine intake for maximizing reading acuity[18]. Consuming too little caffeine could diminish its positive effects on reading performance. On the contrary, previous studies reported negative correlations between caffeine intake and reading improvement. The study suggests that caffeine intake might not always improve reading acuity[19,20]. Our finding aligns with these findings, where there is an insignificant reading acuity as a function of caffeine consumption. Despite the existing research, some limitations warrant consideration. Small sample sizes could limit the generalizability of findings. While our sample size of 19 was determined through power analysis, it is relatively small compared to other studies[19]. This limitation may affect the generalizability of our findings, and future studies with larger sample sizes are needed to confirm our results.

Reading speed

Reading speed denotes how individuals can process and comprehend written content, typically quantified in words per minute (wpm)[18]. This speed can vary greatly among individuals and is subject to factors such as reading proficiency, comprehension aptitude, familiarity with the subject matter, and text complexity. Our findings revealed a significant disparity between pre- and post-reading speeds following thirty minutes of caffeine consumption. This aligns with a recent study, which demonstrated that ingesting a single 200 mg dose of caffeine notably increased reading speed compared to a placebo condition without significantly impacting error rates[11,21]. This indicates that caffeine intake facilitates quicker word recognition, enhancing reading speed. Such effects contribute to improved visual performance during reading tasks.

Additionally, research suggests caffeine consumption can enhance memory performance, possibly through

increased norepinephrine[22]. Therefore, the enhanced reading speed post-caffeine consumption may be attributed to improved memory, enabling subjects to read text accurately and swiftly compared to pre-caffeine intake. While caffeine predominantly influences reading speed, it is essential to note that other factors, such as font typeface, can also impact reading. The current study utilized the Times New Roman font typeface due to its widespread use in reading materials.

The consumption of caffeine has been shown to enhance cognitive and psychomotor performance. For instance, research investigating the immediate impact of caffeine on reaction time (RT) indicates that caffeine intake enhances both the accuracy and speed of responses in reaction time tasks[23]. Similarly, our observations revealed an increase in reading speed with caffeine consumption. The heightened reading speed experienced under the influence of caffeine could be attributed to its positive effects on stimulus processing and decision-making abilities[24]. It is recognized that individual variations in baseline reading speed might affect how participants respond to the intervention[25]. Faster or slower readers might experience the effects of caffeine differently, influencing their performance on reading tasks. However, there was an oversight in adhering strictly to the sentence selection method described in the current study. This may have contributed to the observed lower reading speeds. Future studies could stratify participants based on their baseline reading speeds to explore if and how the intervention's effectiveness varies across different reading abilities. This could provide more nuanced insights into the relationship between baseline performance and intervention outcomes.

Limitation

One of the key considerations in our study is the potential for a learning effect due to the repetitive reading tasks undertaken by the subjects. A learning effect, or practice effect, refers to the improvement in performance resulting from repeated exposure to the same or similar tasks[26]. In our context, this could mean that participants may have shown improved reading speed and possibly even reading acuity simply because they became more familiar with the text through repetition; rather than due to the effects of caffeine alone. While our study did not explicitly control for learning effects, the potential influence of repeated reading tasks should be acknowledged. In future studies, incorporating the longer interval between tasks and the use of different texts that is unfamiliar will be crucial for more accurately assessing the effects of caffeine on reading performance[27].

It is acknowledged that cognitive function is important factor that could potentially impact reading performance[28,29]. While our study focused primarily on the direct effects of caffeine on reading speed and acuity, we recognize the importance of these additional variables. Cognitive function was not directly measured in this study. We assumed that all participants, being young adults and university students, possessed a baseline level of cognitive function sufficient for the tasks involved. Nevertheless, future studies will benefit from including a cognitive assessment to control for individual differences in cognitive abilities. In addition, future study should incorporate a standardized caffeine tolerance assessment. Instruments such as the Caffeine Consumption Questionnaire (CCQ) or the Caffeine Use Disorder Questionnaire (CUDQ) can be considered for this purpose.

Conclusion

In conclusion, our study demonstrates that a moderate dose of 200 mg of caffeine can enhance reading rate without compromising reading acuity in young adults. These findings suggest potential benefits of caffeine

consumption for tasks requiring sustained attention and reading performance, although further research with larger sample sizes is necessary to substantiate these effects. These results underscore the complex relationship between caffeine intake and cognitive function, particularly in tasks requiring rapid processing, such as reading. While caffeine enhances reading speed, its influence on reading performance, such as comprehension and acuity, may be less pronounced. Further investigation is warranted to elucidate the mechanisms underlying the observed effects and to explore potential moderating variables that may influence the relationship between caffeine and reading abilities. Understanding these nuances can inform strategies for optimizing cognitive performance and may have implications for domains where reading proficiency is critical.

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Conflict of interest

The authors declare that they have no competing interests.

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