



The Effects of Caffeine on Cognitive Function Across Developmental and Adult Populations: A Systematic Review

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Manuscript details:

Received: 23.05.2026
Accepted: 25.06.2026
Published: 30.07.2026

Cite this article as:

Yunghsin Chao (2026) The Effects of Caffeine on Cognitive Function Across Developmental and Adult Populations: A Systematic Review, *Int. J. of Life Sciences*, 14 (2): 91-99.

Available online on <http://www.ijlsci.in>
ISSN: 2320-964X (Online)
ISSN: 2320-7817 (Print)



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ABSTRACT

Caffeine is one of the most commonly consumed psychoactive substances in society, with about 69% of the U.S. population consuming at least one caffeinated beverage per day. While caffeine's effect in adults is well researched, its impact on the developing brain remains poorly understood. Because the adolescent brain is still undergoing neurodevelopment, such as synaptic pruning, myelination, and maturation of the prefrontal cortex and hippocampus, caffeine may affect cognitive processes differently in adolescents compared to mature brains. Additionally, the effect of caffeine on the brain may be altered by age-related differences in caffeine metabolism and the regulation of sleep. This systematic review synthesizes evidence examining the relationship between caffeine intake and cognitive functioning across developmental and adult populations. A structured literature search was conducted using PubMed to identify papers and studies assessing caffeine exposure and cognitive outcomes using behavioral tasks, standardized cognitive batteries, questionnaires, and neuroimaging methods. The paper contains various study designs and outcome measures; therefore, a qualitative synthesis was performed to better draw conclusions from them. Overall, my findings indicate that caffeine is more consistently associated with acute cognitive benefits in adults, especially in attention, reaction time, and executive function. Though in the elder adult population (+65 years old or older), caffeine intake was not associated with a lower risk of cognitive decline. In contrast, studies in developmental populations (under 18 years old) report neutral or negative effects of caffeine intake on cognitive and behavioral outcomes. These findings highlight the importance of considering the individual's age when evaluating caffeine's cognitive effects. Ultimately, this research paper argues that more cautious approaches and usage of caffeine during periods of neurodevelopment are needed.

Keywords: Caffeine, Cognition, Developmental Stage, Neurological Effect

INTRODUCTION

Caffeine is one of the most widely consumed psychoactive substances in the world, present in products such as coffee, tea, energy drinks, soft drinks, chocolate, and even certain medications. As such, it is no surprise that a 2022 survey by the International Food Information Council (IFIC) suggests that 93% of American adults consume caffeine,

with 75% reporting daily usage and 25% reporting consuming a caffeinated product three or more times a day (International Food Information Council, 2022).

Caffeine is an adenosine receptor antagonist, which means it blocks the effect of adenosine, resulting in higher alertness and decreased physical fatigue. The mechanism of how caffeine increases attention is well studied. Without caffeine, adenosine accumulates over time and promotes sleepiness by decreasing neural activity and reducing arousal (Huang *et al.* 2011). While caffeine's mechanism has been well characterized in the adult population, it has not yet been as thoroughly studied during developmental stages, where the ongoing brain maturation may affect how these neural signaling pathways respond to caffeine exposure.

Across different stages of life, the body's physiological and biological systems change, which can alter how it responds to different substances. For instance, liver's, which is the primary organ for caffeine clearance, metabolism differs substantially between the youth population and adult population, with the half-life of caffeine over 80 hours, whereas in adults, it's roughly 3–7 hours (Kaplan *et al.* 1997). This unstable pattern of metabolic rate among younger people suggests that caffeine may lead to more significant sleep disruption than in adults with stable metabolic rates, indicating that the effects of caffeine on cognition may differ across age groups. Additionally, varying metabolic rates can help explain why studies assessing developmental and adult populations often report different results regarding caffeine's impact on cognitive function (Vanboxtel, 2003).

Caffeine use during adolescence may have unique cognitive effects compared with those observed in mature brains. Research papers focusing on caffeine and cognition use a wide range of methodologies, including behavioral measures, self-report measures, standardized cognitive tasks, and neuroimaging methods. While caffeine is often associated with enhanced alertness and attention in adults, its cognitive effects during development are unclear and may be harmful. These developmental differences highlight the importance of understanding the differences between developing and mature brains when evaluating caffeine's cognitive effects. As such, this systematic review paper will review current literature on the effects of caffeine consumption across different stages

of human development, including childhood, adolescence, adulthood, and elder adulthood.

MATERIALS AND METHODS

A systematic search was conducted on PubMed for qualitative studies on caffeine and its effects. Searches were performed using a combination of keywords such as chronic caffeine, memory, cognitive function, long-term effect, learning, or neuroplasticity, resulting in the search terms (Table 1). Initial screenings were performed by author AC based on titles and abstracts, followed by full-text reviews and quality appraisal. Studies that include investigations of the relationship between caffeine consumption and its effect on cognition, such as memory, attention, or learning in human participants, are included; articles were excluded if they focused on other unrelated substances, did not assess cognitive outcomes, did not focus on human participants, or lacked a clear methodology.

Table 1 The search terms used in the systematic review

Search Terms
chronic caffeine and memory performance NOT review
caffeine long-term effects, neuroplasticity NOT review
caffeine and cognitive impairment NOT review
caffeine learning and memory NOT review
caffeine hippocampus NOT review
caffeine and working memory NOT review
chronic caffeine neuroplasticity NOT review
chronic caffeine neuropsychological NOT review

Table 2 Reasons for article exclusion during study screening

Screening stage	Reason of exclusion
Title/Abstract Screening	Not related to caffeine exposure, did not measure cognitive outcome, Non-human studies, Confounded with other psychoactive substance
Full-text Review	Insufficient methodological detail, Not primary sources (Review articles or meta-analyses), Duplicate articles, Full text unavailable

The final selected papers were categorized based on whether caffeine demonstrated beneficial, neutral, or harmful effects on cognition. Papers that meet *all* criteria are included in this study and categorized based on whether caffeine showed beneficial, neutral, or harmful effects on cognition.

Among the results on PubMed, papers deemed irrelevant or duplicates were removed, and the remaining papers were accessed through full text, and those that failed to meet the criteria were excluded. The remaining papers were included for full-text in-depth review, and either were removed or used for the final paper. If papers are excluded, reasons are shown in table 2.

RESULT

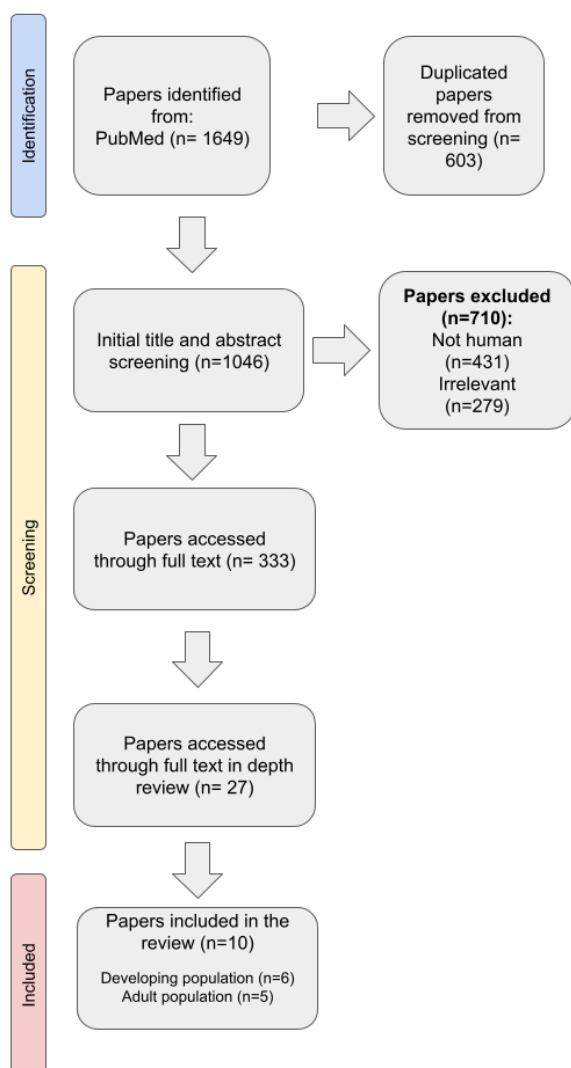


Figure 1: Flow diagram of screened publications

The search criteria and paper selection process are summarized in Figure 1. The blue box represents initial identification via PubMed; the yellow box represents the screening process, as mentioned later; and the red box represents the final inclusion of the paper. The combined search resulted in 1649 papers before duplicates were removed. The remaining 1046 papers underwent title and abstract screening. During title and abstract screening, 710 studies were excluded, including non-human studies ($n = 431$) and non-relevant studies unrelated to the topic. Papers excluded included those that did not discuss chronic caffeine exposure, effects of caffeine on cognitive outcomes, or contained confounding variables such as cognitive diseases ($n = 279$). A total of 333 papers were accessed in full text, and 306 were excluded for failing to meet the criteria, leaving 27 papers included for in-depth review. A paper meets the criteria if it has met *all* of the following: population must involve healthy human subjects within either the "developing" (children/adolescents) or "adult" population; and the paper must provide measurable data on cognitive domains (e.g., executive function, memory, or attention). Finally, 15 papers were removed due to insufficient details and lack of relevance, leaving 10 papers included in this systematic review, with 5 focusing on the developing population and 5 on the adult population. The study designs vary widely, including different age groups, habitual caffeine intake versus acute dosage, and different cognitive domains' assessment. Five of the total studies focused on the adult population, while the remaining 5 assessed the developing population.

Chronic caffeine usage in adults:

Multiple studies have examined the association between caffeine consumption and cognitive outcomes in adult populations (Vanboxtel *et al.* 2003), Krieger *et al.* (2025), Paz-Graniel *et al.* 2021), Gardener *et al.* 2021), Tieges *et al.* 2004). Studies of the adult population have associated caffeine use with either a beneficial or neutral outcome. This unbiased literature review revealed that the outcomes were explicitly focused on either the young or elder adult population. Therefore, noting that both cognitive function and neurobiological processes undergo changes throughout adulthood, the adult population was further divided into two subsections: young adults (20 to 35 years old) and elder adults (65 years or older) (Park *et al.* 2025). This distinction within the adult population allows for a more interpretable

interpretation of results, as younger adults typically exhibit stable cognitive performance and fully developed neurological systems, whereas older adults may experience age-related cognitive decline. Separating these populations helps clarify whether caffeine's effects vary with baseline cognitive status and age-related psychological and physiological changes.

The difference in caffeine's effect on young adults and elder adult

The effects of caffeine on cognition in young adults:

Experiments among young adults, who, for this review, are defined as those aged 20 to 35, reported improvements in reaction time, sustained attention, vigilance, working memory, and executive function (Borota, *et al.* 2014). For instance, caffeine may enhance certain aspects of cognitive performance, such that reaction time is faster after caffeine consumption. This is demonstrated by preserving the acute thermogenic response, measured with the DynavisionTM D2 Visuomotor device to record reaction time (Krieger *et al.* 2025). However, among young adults, who are defined as younger than 35 years old, caffeine's effect is also proven to be limited, as results show amplitudes were not affected by caffeine in error-related negativity (ERN) measurement, which is a sharp, negative-going event-related potential (ERP) component in EEG, with amplitude measuring the magnitude of the brain's internal response to an error (Tieges *et al.* (2004). Overall, studies suggest that caffeine can temporarily enhance cognitive performance, particularly reaction time, vigilance, and sustained attention, among young adults in short-term contexts. Taken together, positive and neutral outcomes suggest that among young adults, caffeine can enhance immediate cognitive performance; however, it does not substantially alter underlying cognitive control.

The effects of caffeine on cognition in elder adults:

While the studies with young adults focused on cognitive improvements, papers on elder populations, which are adults aged 65 years and older in this review, discussed the effect of chronic caffeine usage on cognitive decline. Among the papers that focused on the elderly, one suggests that there are no significant effects of caffeine on long-term cognitive decline based on no difference in performance, such as the results of cognitive performance in participants in

Maastricht Aging Study (MAAS), which is a longitudinal, population-based cohort study based in the Netherlands that focuses on understanding normal and harmful. Baseline caffeine intake did not affect the results of either simple or complex tasks; all the changes were less than 1% (Vanboxtel *et al.* 2003). However, the other two studies indicate a negative correlation between caffeine consumption and cognitive decline. This was noted in the study by Gardener, 2021), as results showed that habitual coffee intake was positively associated with the cognitive domain of executive function (Gardener *et al.* 2021). Additionally, Paz-Graniel, 2020)'s study found that higher caffeine consumption is associated with a reduced risk of poor cognitive functioning, as measured by the Clock Drawing Test and Trail Making Test B, which are brief, pen-and-paper neuropsychological assessments used to screen for cognitive impairment and executive function Paz-Graniel *et al.* 2021). Together, these results show that some studies concluded caffeine's ability to slow down cognitive decline and induce better cognitive performance, while others reported that there is no significant association with caffeine consumption and improved cognitive functions among elderly adults. These distinct results demonstrate the relationship between caffeine consumption and cognitive aging, and performance remains diverse and may depend on factors such as study design, population characteristics, and methods used to assess cognitive outcomes.

Developing Population

When evaluating caffeine's effect on the maturing population there are many important differences from the adult brain due to the rapid neurodevelopment and physiological maturation occurring. While caffeine has been widely recognized as cognitive enhancement in the adult population, especially with acute use, findings and results in developmental populations results are more mixed and the effect of caffeine tends to be negative (Borota *et al.* 2014). Among the papers that focused on developmental stage participants, two researchers marked caffeine as beneficial as it improves cognitive assessment. For example, as resulted from the Continuous Performance Task (IP-CPT), which are computer-based and neuropsychological assessment that assessed individual's cognitive domain such as sustained attention, impulsivity, and vigilance, performed in Cooper (2024)'s study, caffeine enhances sustained attention in participants ranging

from 12 to 17 years old (Copper *et al.*, 2021). Additionally, McLeod (2024)'s study using Bayley and CAT/CLAMS assessments, which are standardized tests that evaluate the mental and motor development of infants and toddlers, indicates caffeine is beneficial in part of attenuation of inflammation (McLeod *et al.*, 2024). However, other studies suggest caffeine has neutral or harmful effects on developing human beings. For instance, in (Van Batenburg-Eddes, 2014)'s study, the measurements from Behavior Regulation Index (BRI) and Metacognition Index (MI) (formed by combining scales) suggest a possible negative effect of energy drink use on behavior regulation and metacognitive skills (Van Batenburg-Eddes *et al.*, 2014). Similarly, Zhang (2021)'s study indicates that caffeine intake is negatively correlated with all the seven cognitive measures as shown in the results of cognitive measures of vocabulary comprehension, reading decoding, inhibitory control, working memory, cognitive flexibility, processing speed, and episodic memory (using NIH cognition battery and NIH Scoring and Interpretation guide for scoring) (Zhang *et al.* 2020). For papers arguing caffeine has no significant beneficial effects, they highlight how caffeine does not sustainably improve developmental stages human's cognitive assessment. For example, Ware (2025) states that the observation from resting-state fMRI to investigate default mode network (DMN) and dorsal attention networks (DAN) in participants (mean age 9.9 years old) did not find caffeine to impact the default mode network (anticorrelation between attention) (Ware *et al.* 2025). Overall, findings focused on developing populations address mixed and inconsistent relationships and associations between caffeine consumption and cognitive outcomes. While some studies pointed out the acute improvement in specific cognitive domains, such as sustained attention, the majority of the studies indicate neutral or negative outcomes when taken in consideration of behavioral regulation and multiple cognitive functions. As a result, caffeine's cognitive effects in developing populations are indicated as inconsistently beneficial or harmful and, most importantly, vary depending on the specific cognitive fields being measured.

DISCUSSIONS

This systematic review investigated the association between caffeine consumption and cognitive outcomes across life stages, finding a clear difference between adult and developmental populations. Overall, most

papers suggest a beneficial or neutral effect of caffeine consumption on cognitive function in adults. This contrasts with the results from papers focusing on developmental populations, which show that outcomes are mixed and more frequently neutral or harmful.

Young Adult population:

In the adult population, caffeine intake is positively associated with improvements in cognitive functions such as attention, reaction speed, and working memory. This increases cortical arousal and alertness in the mature brain due to caffeine's status as an adenosine receptor antagonist, which aligns well with current understanding (Ribeiro and Sebastião, 2010). Studies with young adults as participants focused mainly on acute cognitive performance due to their traits of being at peak cognitive performance and efficiency, making them most suitable for models observing cognitive-enhancing effects of substances (Kremen *et al.* 2019). Specifically, among the young adult population, caffeine has been shown to enhance acute cognitive performance on task-specific measures, as it modulates neuronal activity, as evidenced by fMRI showing signal changes in a network of brain areas associated with executive and attentional functions during working memory processes (Koppelstaetter *et al.* 2008).

Together, these studies suggest that caffeine's effect is stage dependent, not just the extent to which the effects are beneficial or harmful, but also the purpose among them. This indicates a necessity to consider age as a confounding factor in future studies. Though this age-dependent difference has not been directly shown in the literature, there is much evidence that the mechanisms by which caffeine acts change during brain maturation, such as the pruning of adenosine receptors, the maturation of the prefrontal cortex, and the stabilization of the blood-brain barrier. The distinction across populations suggests a shift in caffeine's role over the lifespan. Therefore, when evaluating caffeine's impact, it is essential to take in account age since the stimulant may carry out different functional results depending on baseline neurobiological status.

However, it is important to note that several limitations hindered investigation on how long-term caffeine exposure may influence cognitive development across the lifespan. While some studies

assessed long-term caffeine consumption, the data were not collected in a controlled experimental environment. The lack of a controlled experimental environment in the used paper results in the risk of confounding variables that affect the result. Moreover, many studies focused on short-term exposure and measured immediate cognitive performance following an acute dose or brief exposure period. Taken together, these studies do not provide an insightful view into caffeine's long-term effects on cognition. True chronic caffeine exposure, defined as regular, long-term exposure under controlled conditions in this paper, is absent from the papers accessed, making it difficult to determine whether habitual caffeine consumption leads to lasting cognitive effects beyond short-term exposure.

Elder Adult Population:

As noted by the World Health Organization, a key focus of studies on elders is identifying strategies to prevent severe cognitive decline among people over 65 years old. This goal remains essential as it improves the overall health and lifestyle of elderly citizens. Therefore, habitual caffeine intake may be more relevant to general cognitive preservation, particularly in relation to cognitive decline and executive functioning. Previous studies indicate a negative correlation between caffeine consumption and the rate of mild cognitive impairment (MCI) in a population ranging from 65–84 years old.

Across the 3 evaluating older adults, defined as participants 65 years old or older, results suggest a difference in whether caffeine plays a role in preventing cognitive decline. The distinct conclusions mainly result from differences in study populations, design, and cognitive measures. The Maastricht Aging Study followed a broad, healthy adult population over six years and found only a small effect on motor speed. This is likely because most participants were low-risk for cognitive impairment, and the study did not specifically track Alzheimer's-related changes (Vanboxtel, 2003). On the other hand, though sick elders are not included in the study, the AIBL study focused on both cognitive performance and biomarkers like A β -amyloid accumulation, revealing an aspect that was not covered by the Maastricht Aging Study due to experimental measurement designs (Gardener *et al.* 2021). Additionally, the PREDIMED-Plus study focused specifically on elderly participants who are obese or overweight with

metabolic syndrome (MetS), making them a population that is already at higher risk of cognitive decline-related disease (Whitmer *et al.*, 2005). As a result, this higher baseline risk may make caffeine's potential effects more detectable and more optimistic. Looking at the results altogether, the relationship between caffeine consumption and its effect on reducing cognitive decline in the elderly may depend strongly on experimental subjects' characteristics and study design. Studies that include healthy elders suggest caffeine has a neutral effect on long-term cognitive outcome; whereas studies that focus on populations with higher baseline risk for cognitive decline diseases suggest caffeine may potentially have beneficial and positive effects regarding long term cognition in the elderly population. These patterns suggest caffeine's possible role in improving cognition among populations already at risk of cognitive decline. As a result, standardized, longitudinal research can be conducted to measure caffeine intake and cognitive outcomes, which remain essential for clarifying whether habitual caffeine consumption contributes significantly to cognitive preservation in aging populations.

Developmental population:

Results from developmental populations were significantly more diverse and less consistently positive. While some papers suggest that caffeine can enhance acute, immediate cognitive function, most studies show neutral or negative associations between caffeine intake and cognitive or behavioral outcomes. These results indicate concern surrounding caffeine usage in children and adolescents, including sleep disruption, risk for nonoptimal cognitive development, and even increased risk of habitual caffeine consumption later in life. Overall, within the developmental population, the effects of caffeine are suggested to vary by age, the measured cognitive domain, and the measurement method. Adolescents, who are defined as being between 12 to 17 years old, show some short-term improvements in attention, which is likely due to caffeine's antagonism of adenosine A1 and A2A receptors that reduces inhibitory signaling and increases dopaminergic and noradrenergic activity in the prefrontal cortex. On the other hand, younger children or studies using broader neuroimaging or behavioral measures suggest neutral or negative outcomes, highlighting that caffeine's impact may depend on both the stage of brain development and the type of cognitive assessment

employed (Ferré, 2016). Additionally, caffeine's ability to suppress adenosine receptors reduces sleep pressure and desire, which can lead to a decrease in slow-wave activity (SWA), an indicator of the need for sleep. As noted, how slow waves during deep sleep are the specific mechanism that restores neurocapacity, developing populations would be harmed by a disrupted sleep schedule (Fattinger *et al.* 2017). These effects can be amplified by adolescents whose biologically circadian timing are delayed along with early school start schedules, increasing vulnerability to chronic sleep restriction and daytime cognitive variability and worsening cognitive performance throughout the day.

The differences in results (neutral v. harmful) most likely reflect variation in exposure pattern and developmental context rather than a chronic contradiction. For instance, in Cooper RK (2020)'s study, the experimental design focuses on acute caffeine exposure over three visits, administering a moderate dose of 3mg/kg of body weight caffeine and assessing short-term cognitive performance (Cooper *et al.*, 2021). Under laboratory conditions, confounding lifestyle variables such as sleep disruption are minimized, making the conclusion that caffeine improves sustained acute attention reasonable and aligns with the current understanding as those similar to in the adult population (Ferré S (2016). In contrast, studies that conclude caffeine's negative effect use self-report data to investigate the correlation between caffeine consumption and different cognitive domains, capturing habitual and real-world caffeine consumption over time. In scenarios where caffeine are taken persistently, repeated intake disrupts slow-wave sleep, a process critical for memory consolidation and synaptic pruning during adolescence (Fattinger *et al.* 2017). Chronic sleep disturbance may therefore reveal longer-term negative associations of caffeine's intake and effects that are otherwise not detectable in short-term experimental designs.

Overall, the results of the studies suggest that caffeine's effect on the developing population remains more complex. While an appropriate dosage may temporarily improve cognition, similar to mechanisms observed in the adult population, habitual caffeine consumption may have negative impacts, as it influences sleep patterns and neurodevelopmental processes, both of which are critical during

developmental periods (Ferré, 2016). Consequently, the short-term cognitive improvement may not be worth nor necessarily when considering long term effects on both cognition and physiological system among the developing population. Future research can focus on standardized longitudinal approaches that more precisely measure chronic, long term caffeine exposure and its relationship with sleep patterns, neurodevelopmental alteration, and environmental factors such as daily life schedules. With established standardized dosage along with measured neurobiological markers, research can clarify how caffeine intake influences cognitive development across developmental periods in human lives.

Differences Between Developing and Adult Population:

The differences observed between the developing population and the adult population suggests that caffeine's effect on cognition may be attributed to differences in neurobiological maturity and development. In adults, results are largely either beneficial or neutral, with improvements specifically in domains such as reaction time, vigilance, executive function, and sustained attention. These outcomes mainly result from caffeine's ability to inhibit adenosine receptors, which is significantly important in its effects on behavior and cognitive function (National Academies Press (2001). The blockade of adenosine receptors increases the release of neurotransmitters such as dopamine, gamma-aminobutyric acid (GABA), norepinephrine, glutamate, acetylcholine, and serotonin. This releasement leads to a change in mood, memory, alertness, and most importantly, cognitive function (National Academies Press (2001). However, caffeine's effect was shown to be mainly harmful or neutral in the developing population due to the plasticity in brain matureness. The developing brain undergoes massive reorganization, including synaptic pruning and myelination (Olini *et al.* 2013). But caffeine reduces the number of microglia, which are resident cells of the brain that regulate brain development, maintenance of neuronal networks, and injury repair and is important for synaptic pruning. This suggests how due to the instability of brains in developing populations such as children and adolescents, caffeine serves more as a harmful substance for development rather than acute cognitive performance enhancer. In conclusion, these findings suggest that while caffeine intake allows short term and acute cognitive enhancement in the adult

population, whose brains have been matured and well-developed, caffeine's effect on the developing population remains less predictable and even potentially harmful due to the immature physiological system. As a result, age and development stages are two important factors to take in consideration when evaluating the cognitive impacts of caffeine consumption across the lifespan.

Limitation:

A few limitations should be considered in this systematic review. First, across the 12 studies, experimental designs differ from one another. Such that the age group, age range, sample sizes, caffeine dosage, caffeine administration, and exposure time remain diverse across different studies. Second, 3 out of the 12 papers rely on self-reported data from participants, leading to arbitrary results that might include bias and misunderstandings. Lastly, the results across different papers might be influenced by confounding variables such as participants' sleep quality, body condition, stress level, and socioeconomic status. More forward, current study fields lack the establishment of consistent methodology and dosage of caffeine in the experiment, making it more challenging to determine the relationships between caffeine consumption and long-term cognitive outcomes.

CONCLUSION

In conclusion, current evidence as extracted from the articles suggest that caffeine's effects on cognition vary across different stages of life and different contexts of consumption among experimental groups. While moderate caffeine intake was linked to acute enhancement of cognitive function, its long-term cognitive effects remain inconsistent across studies. Additionally, differences in experimental designs, such as populations and patterns of caffeine exposure, also contributed to the distinct results. Future research can benefit from having an established standardized experimental design that focuses on longitudinal approaches and the elimination of confounding variables. By doing so, researchers may gain meaningful insight on caffeine's long-term impact on cognitive health across the lifespan.

Conflict of interest:

Regarding the publication of this research effort document, the author has no conflicts of interest.

Ethical/Compliance Statement

This study did not involve human or animal subjects; therefore, no ethics approval was required.

Data Availability Statement: Not applicable.

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REFERENCES

- Borota D, *et al* (2014) Post-study caffeine administration enhances memory consolidation in humans. *Nat Neurosci* 17(2): 201–203. doi:10.1038/nn.3623.
- Cooper RK, Lawson SC, Tonkin SS, Ziegler AM, Temple JL, Hawk LW (2021) Caffeine enhances sustained attention among adolescents. *Exp Clin Psychopharmacol* 29(1): 82–89. doi:10.1037/pha0000364.
- Fattinger S, *et al* (2017) Deep sleep maintains learning efficiency of the human brain. *Nat Commun* 8(1): 15405. doi:10.1038/ncomms15405.
- Ferré S (2016) Mechanisms of the psychostimulant effects of caffeine: implications for substance use disorders. *Psychopharmacology (Berl)* 233(10): 1963–1979. doi:10.1007/s00213-016-4212-2.
- Gardener SL, *et al* (2021) Higher Coffee Consumption Is Associated With Slower Cognitive Decline and Less Cerebral Aβ-Amyloid Accumulation Over 126 Months: Data From the Australian Imaging, Biomarkers, and Lifestyle Study. *Front Aging Neurosci* 13: 744872. doi:10.3389/fnagi.2021.744872.
- Huang ZL, Urade Y, Hayaishi O (2011) The Role of Adenosine in the Regulation of Sleep. *Curr Top Med Chem* 11(8): 1047–1057. doi:10.2174/156802611795347654.
- International Food Information Council (2022) Caffeine: Consumer Consumption Habits and Safety Perceptions.
- Kaplan GB, *et al* (1997) Dose-Dependent Pharmacokinetics and Psychomotor Effects of Caffeine in Humans. *J Clin Pharmacol* 37(8): 693–703. doi:10.1002/j.1552-4604.1997.tb04356.x.
- Koppelstaetter F, *et al* (2008) Does caffeine modulate verbal working memory processes? An fMRI study. *NeuroImage* 39(1): 492–499. doi:10.1016/j.neuroimage.2007.08.037.
- Kremen WS, *et al* (2019) Influence of young adult cognitive ability and additional education on later-life cognition. *Proc Natl Acad Sci* 116(6): 2021–2026. doi:10.1073/pnas.1811537116.
- Krieger J, *et al* (2025) A Randomized Study to Examine the Ability of a Caffeine-Based Energy Drink to Impact Energy Expenditure, Fat Oxidation, and Cognitive

Performance. Nutrients 17(23): 3793. doi:10.3390/nu17233793.

237(10): 3109–3116. doi:10.1007/s00213-020-05596-8.

McLeod RM, Rosenkrantz TS, Fitch RH (2024) Protective Effects of Early Neonatal Methylxanthine Treatment on Cognitive and Language Outcomes in Premature Infants with and without High-Risk Perinatal Factors. *Dev Neurosci* 47(3): 172–182. doi:10.1159/000540540.

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Mitchell DC (2025) An update on beverage consumption patterns and caffeine intakes in a representative sample of the US population. *Food Chem Toxicol* 196: 115237. doi:10.1016/j.fct.2025.115237.

National Academies Press (2001) Caffeine for the Sustainment of Mental Task Performance: Formulations for Military Operations. Washington, D.C. doi:10.17226/10219.

National Institute of Mental Health (2023) The Teen Brain: 7 Things to Know (23-MH-8078). Available at: <https://www.nimh.nih.gov/health/publications/the-teen-brain-7-things-to-know>.

Olini N, Kurth S, Huber R (2013) The Effects of Caffeine on Sleep and Maturational Markers in the Rat. *PLoS ONE* 8(9): e72539. doi:10.1371/journal.pone.0072539

Park DC, *et al* (2025) The Dallas Lifespan Brain Study: A Comprehensive Adult Lifespan Data Set of Brain and Cognitive Aging. *Sci Data* 12(1): 846. doi:10.1038/s41597-025-04847-7.

Paz-Graniel I, *et al* (2021) Association between coffee consumption and total dietary caffeine intake with cognitive functioning: cross-sectional assessment in an elderly Mediterranean population. *Eur J Nutr* 60(5): 2381–2396. doi:10.1007/s00394-020-02415-w.

Ribeiro JA, Sebastião AM (2010) Caffeine and Adenosine. *J Alzheimers Dis* 20(s1): S3–S15. doi:10.3233/JAD-2010-1379.

Tieges Z, Richard Ridderinkhof K, Snel J, Kok A (2004) Caffeine strengthens action monitoring: evidence from the error-related negativity. *Cogn Brain Res* 21(1): 87–93. doi:10.1016/j.cogbrainres.2004.06.001.

Van Batenburg-Eddes T, Lee NC, Weeda WD, Krabbendam L, Huizinga M (2014) The potential adverse effect of energy drinks on executive functions in early adolescence. *Front Psychol* 5: 457. doi:10.3389/fpsyg.2014.00457.

Vanboxtel M, Schmitt J, Bosma H, Jolles J (2003) The effects of habitual caffeine use on cognitive change: a longitudinal perspective. *Pharmacol Biochem Behav* 75(4): 921–927. doi:10.1016/S0091-3057(03)00171-0

Ware OD, *et al* (2025) Examining recent effects of caffeine on default mode network and dorsal attention network anticorrelation in youth. *PLOS One* 20(7): e0327385. doi:10.1371/journal.pone.0327385.

Whitmer RA, Gunderson EP, Barrett-Connor E, Quesenberry CP, Yaffe K (2005) Obesity in middle age and future risk of dementia: a 27 year longitudinal population based study. *BMJ* 330(7504): 1360. doi:10.1136/bmj.38446.466238.E0.

Zhang H, Lee ZX, Qiu A (2020) Caffeine intake and cognitive functions in children. *Psychopharmacology (Berl)*

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