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Tea, coffee and green tea consumption and mental health outcomes: A systematic review and meta-analysis of observational and intervention studies on stress and related conditions

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Abstract
This review aims to examine the effects of tea, coffee, and green tea consumption on human cognitive performance and mental health. Tea, coffee, and green tea are widely consumed beverages worldwide and contain various bioactive compounds that may influence cognitive function and mental health. Research has suggested that caffeine, the primary psychoactive compound in coffee and tea, can improve cognitive function, including attention, alertness, and working memory. The effect of caffeine on cognitive performance may be moderated by individual differences in caffeine metabolism and genetic factors. Green tea contains high levels of catechins, which have been linked to improved cognitive function, such as attention and working memory, as well as reduced risk of cognitive decline and dementia. Theanine, an amino acid found in green tea, has also been associated with relaxation and reduced anxiety. In addition to cognitive performance, tea, coffee, and green tea consumption have been linked to improved mental health outcomes. Research has suggested that coffee consumption may be associated with a lower risk of depression, while green tea consumption has been linked to reduced symptoms of anxiety and stress. However, the evidence regarding the effects of tea, coffee, and green tea on cognitive function and mental health is mixed, and further research is needed to fully understand the potential benefits and risks of these beverages. Additionally, individual differences in caffeine metabolism, genetic factors, and other lifestyle factors may influence the effects of tea, coffee, and green tea on cognitive function and mental health.

Keywords: Caffeine, coffee, green tea, neurocognitive, tea

1. Introduction
Tea consumption has been associated with a range of health benefits, including improved cognitive function and reduced risk of depression and anxiety. The bioactive compounds found in tea, including caffeine, theanine, and flavonoids, are thought to contribute to these mental health benefits. Several studies have found that tea consumption is associated with improved cognitive function, including attention, memory, and processing speed. Other studies have found that tea consumption is associated with reduced risk of depression and anxiety, although the evidence is less consistent. The majority of studies on tea and mental health have been observational in nature, and there is a need for more randomized controlled trials to establish causal relationships. There is considerable variation in the types of tea consumed and the amounts consumed across different populations, which may affect the observed associations with mental health outcomes [1]. Caffeine is a widely consumed psychoactive substance that is found in coffee, tea, and some soft drinks and energy drinks. Caffeine has been shown to have both positive and negative effects on mental health outcomes, depending on the dose consumed and the individual's sensitivity to caffeine. Some studies have suggested that caffeine consumption may be associated with improved cognitive function, including attention, reaction time, and memory. Other studies have suggested that caffeine consumption may be associated with increased anxiety and decreased quality of sleep, particularly when consumed in large amounts or close to bedtime. There is limited research on the relationship between caffeine intake and quality of life, particularly among young adults. The study by Black *et al.* found that caffeine intake was associated with increased anxiety and decreased quality of life among female university students in the UK. Further research is needed to explore the potential negative effects of caffeine consumption on mental health outcomes, particularly among vulnerable populations such as young adults [2]. Caffeine is a widely consumed psychoactive substance that is found in coffee, tea, and some soft drinks and energy drinks.

Caffeine is known to have a stimulating effect on the central nervous system and has been shown to improve attention and cognitive performance in a variety of tasks. Some of the assumptions about caffeine's effects on attention and cognitive performance are based on outdated or incomplete information. For example, while it is widely believed that caffeine improves sustained attention and vigilance, some studies have found that caffeine may actually impair performance on tasks that require sustained attention. The effects of caffeine on attention and cognitive performance may vary depending on individual factors such as age, sex, and genetics. Research is needed to fully understand the effects of caffeine on attention and cognitive performance, as well as the potential risks and benefits of caffeine consumption [3]. Depression is a common mental health disorder that is associated with significant morbidity and mortality. Coffee and tea are two of the most widely consumed beverages in the world and are major sources of caffeine. Caffeine is known to have psychoactive effects and has been hypothesized to have both positive and negative effects on mental health outcomes such as depression. Coffee and tea consumption were both associated with a reduced risk of depression, and that there was a dose-response relationship between caffeine intake and reduced risk of depression. Research is needed to confirm these findings and to explore the potential mechanisms underlying the protective effects of coffee, tea, and caffeine on depression [4]. L-theanine is an amino acid found in green tea that has been shown to have psychoactive effects. Previous studies have suggested that l-theanine may improve cognitive function, including attention and reaction time response. The study conducted a randomized, double-blind, placebo-controlled study to investigate the effects of l-theanine on attention and reaction time response in healthy young adults. The study found that l-theanine supplementation improved attention performance and reaction time response in the participants compared to placebo. These findings support the potential use of l-theanine as a natural cognitive enhancer [5].

Depression is a common mental health disorder that is associated with significant morbidity and mortality. Caffeine is a widely consumed psychoactive substance that has been hypothesized to have both positive and negative effects on mental health outcomes such as depression. The study conducted a cross-sectional analysis of data from the National Health and Nutrition Examination Survey to investigate the relationship between caffeine intake and depressive symptoms in adults. The study found that lower caffeine intake was associated with greater levels of depressive symptoms among female participants, but not among male participants. These findings may have important implications for the role of caffeine in mental health and highlight the need for further research in this area [6]. Cognitive impairment is a major health concern among elderly populations, and tea consumption has been hypothesized to have potential cognitive benefits. The research conducted a cross-sectional study among Chinese elderly individuals to investigate the relationship between tea consumption and cognitive impairment. The study found that tea consumption was associated with lower prevalence of cognitive impairment, with the strongest association observed among individuals who consumed green tea. The study suggest that the cognitive benefits of tea consumption may be attributed to the presence of catechins and other bioactive compounds with neuroprotective properties. These findings highlight the potential value of tea consumption as a simple and accessible strategy for promoting cognitive health in elderly populations [7]. Green tea has been suggested to have potential cognitive and mood-enhancing effects, but the evidence is mixed and often contradictory. To investigate the effects of green tea on cognition, mood, and brain function in humans. The review found that green tea consumption was associated with modest improvements in cognitive performance, particularly in attention and memory tasks. Green tea consumption was also found to have beneficial effects on mood, with reductions in anxiety and improvements in subjective well-being reported in some studies. The cognitive and mood-enhancing effects of green tea may be attributed to the presence of L-theanine, an amino acid that has been shown to promote relaxation and improve attention. These findings suggest that green tea consumption may have potential value as a natural and safe strategy for enhancing cognitive performance and promoting emotional well-being [8]. Tea consumption has been suggested to have potential protective effects against cognitive impairment and dementia, but the evidence is mixed and often contradictory. Meta-analysis of the literature to investigate the effects of tea consumption on cognitive function and the risk of developing cognitive impairment or dementia. The review found that regular tea consumption was associated with a reduced risk of cognitive impairment and dementia, particularly among individuals aged 55 years or older. Tea consumption was also found to have modest beneficial effects on cognitive function, particularly in the domains of attention, processing speed, and executive function. The cognitive and neuroprotective effects of tea may be attributed to the presence of bioactive compounds such as flavonoids and caffeine, which have been shown to improve cerebral blood flow, enhance synaptic plasticity, and reduce oxidative stress and inflammation. These findings suggest that regular tea consumption may have potential value as a dietary strategy for preventing or delaying cognitive decline and maintaining cognitive health in later life [9]. The study conducted by Mitchell *et al.* (2014) aimed to determine the caffeine intake from beverages among the US population. The study used data from the National Health and Nutrition Examination Survey (NHANES) and found that coffee and tea were the main sources of caffeine intake, with coffee accounting for 71% of caffeine intake in the US population. The study also found that caffeine intake from energy drinks has increased significantly in recent years [10]. The potential cognitive benefits of cocoa flavanols have gained interest in recent years, with several studies suggesting that regular consumption of cocoa flavanols could improve cognitive performance and provide neuroprotective effects. Cocoa flavanols have been shown to increase cerebral blood flow and oxygenation in the brain, which could enhance cognitive function by supporting brain metabolism and reducing oxidative stress. In addition to improving cognitive function, cocoa flavanols may also have beneficial effects on mood and mental health, as they can enhance the synthesis and release of certain neurotransmitters such as dopamine and serotonin. This review by Nehlig summarizes the current evidence on the neuroprotective effects of cocoa flavanols and their influence on cognitive performance, providing insights into the potential mechanisms underlying these effects and highlighting the need for further research in this area [11].

The study investigated the relationship between tea consumption and cognitive impairment and decline in older Chinese adults. Tea, particularly green tea, is a rich source of bioactive compounds such as catechins and theanine, which have been shown to have neuroprotective effects. Age-related

cognitive decline is a major public health concern, and identifying modifiable risk factors such as tea consumption may help prevent or delay cognitive impairment in older adults. The study used data from the Singapore Longitudinal Aging Studies, which included over 1,000 Chinese adults aged 55 years and older who were free of dementia at baseline. Cognitive function was assessed using standardized tests at baseline and at follow-up visits over a 6-year period. Results showed that regular tea consumption was associated with a lower risk of cognitive impairment and decline in older Chinese adults. This study adds to the growing body of literature on the potential cognitive benefits of tea consumption, particularly in the elderly population [12]. The prevalence of dementia and cognitive decline is increasing globally, creating a need for effective prevention strategies. Epidemiological studies have suggested that coffee, tea, and caffeine consumption may have a protective effect against cognitive decline and dementia in late-life. However, the evidence regarding the relationship between coffee, tea, and caffeine consumption and cognitive decline and dementia is inconsistent, with some studies reporting positive effects and others showing no effect or even negative effects. A systematic review can help to provide a comprehensive summary of the available evidence and assess the quality of the studies included. Aimed to examine the relationship between coffee, tea, and caffeine consumption and the prevention of late-life cognitive decline and dementia. Overview of the methods used to identify and select the studies included in the review, as well as the quality assessment of the studies. The results of the review suggest that moderate coffee and tea consumption may have a protective effect against cognitive decline and dementia, but the evidence for caffeine consumption is inconclusive. The need for further research to clarify the relationship between coffee, tea, and caffeine consumption and cognitive decline and dementia, as well as to investigate the potential underlying mechanisms of any protective effects observed [13]. Cognitive impairment is a common health issue among older adults. Green tea and L-theanine have been suggested to improve cognitive function and reduce the risk of cognitive impairment. Previous studies have shown that green tea and L-theanine may have potential neuroprotective effects. The present study aimed to investigate the effects of a combination of green tea extract and L-theanine on cognitive function in subjects with mild cognitive impairment. The study used a double-blind, placebo-controlled design to ensure the validity of the results. The study found that the combination of green tea extract and L-theanine significantly improved memory and attention in subjects with mild cognitive impairment, suggesting the potential use of this combination as a natural intervention for cognitive impairment [14]. The study investigated the effects of a proprietary blend of Magnolia officinalis and Phellodendron amurense bark extracts on stress levels and liver function in healthy adults. Stress is a common condition that affects many individuals and has been associated with various negative health outcomes, including impaired liver function. The proprietary blend of Magnolia and Phellodendron extracts has been traditionally used in Chinese medicine for reducing stress and anxiety. However, there is a lack of scientific evidence supporting its efficacy in reducing stress levels and improving liver function. Therefore, this randomized, placebo-controlled, double-blind clinical trial aimed to determine the effects of this proprietary blend on stress levels and liver function in healthy adults. The findings of this study can provide important insights into the potential benefits of this natural supplement for stress management and liver health [15]. Type 2 diabetes is a major public health concern globally. Cinnamon, a commonly used spice, has been suggested to have potential benefits for people with type 2 diabetes. A systematic review and meta-analysis was conducted to evaluate the efficacy of cinnamon interventions on glycemic control, lipid profiles, and other related outcomes in people with type 2 diabetes. The study aimed to provide evidence-based recommendations for the use of cinnamon as an adjunct therapy for type 2 diabetes [16]. Tea consumption has been associated with various health benefits including reducing the risk of cognitive decline and dementia. Age-related cognitive decline and dementia are major public health concerns, and preventive strategies such as dietary interventions have gained attention. Several studies have investigated the potential beneficial effects of tea consumption on cognitive function, with mixed results. The current study aims to investigate the association between tea consumption and cognitive impairment in Chinese elderly individuals. The study will add to the growing body of evidence on the role of tea consumption in cognitive function and may have implications for developing dietary recommendations for cognitive health in aging populations [17]. The study evaluated the effect of flavanol-rich cocoa on cerebral blood flow (CBF) and cognitive performance in healthy elderly individuals. The study included 24 healthy elderly individuals (63-76 years old) who were randomized to consume either a high-flavanol cocoa drink or a low-flavanol cocoa drink for three days. The participants underwent transcranial Doppler ultrasound to assess CBF and cognitive testing before and after the three-day intervention. The study found that the high-flavanol cocoa drink was associated with improved CBF and cognitive performance compared to the low-flavanol cocoa drink. The consumption of flavanol-rich cocoa may have a positive impact on cerebral vasculature and cognitive function in healthy elderly individuals [18]. Dementia and Alzheimer's disease (AD) are a major public health concern and a growing burden worldwide. Coffee is one of the most widely consumed beverages in the world and has been suggested to have potential neuroprotective effects due to its bioactive components, including caffeine and antioxidants. Several observational studies have investigated the association between coffee consumption and the risk of dementia and AD, but the results have been inconsistent. A systematic review and meta-analysis can help to provide a comprehensive and quantitative summary of the available evidence on the topic. The aim of this study was to systematically review and meta-analyze the existing observational studies on coffee consumption and the risk of dementia and AD [19]. The current evidence for the use of acetyl-l-carnitine (ALC) in the treatment of depression. ALC is an endogenous compound that plays a role in energy metabolism and may affect neuronal function. Several studies have investigated the use of ALC as a treatment for depression, with mixed results. The potential benefits of ALC, including its ability to improve cognitive function and reduce fatigue. ALC may be a useful adjunct to traditional antidepressant therapy, although further research is needed to fully understand its effects [20].

2. Tea

Higher green tea consumption was significantly associated with better cognitive function in various tests, including the Mini-Mental State Examination (MMSE), the Trail Making

Test (TMT), and the Word Fluency Test (WFT). Green tea consumption may be beneficial for cognitive function in the elderly [21]. Cognitive impairment is a common health issue among older adults, and it is important to identify potential risk factors for prevention and treatment. Tea consumption is a popular habit in China, and it has been suggested to have various health benefits, including cognitive function improvement. Cross-sectional design to examine the association between tea consumption and cognitive function, as well as the potential moderating effect of demographic and lifestyle factors [22]. Tea consumption was associated with a reduced risk of Alzheimer's disease. Regular tea consumption might be a protective factor against Alzheimer's disease [23]. Several observational studies have found a potential link between tea consumption and cognitive function. Tea contains various bioactive components such as polyphenols, caffeine, L-theanine, and theaflavins, which may have neuroprotective effects. Potential mechanisms by which caffeine and other bioactive components in tea and coffee could affect cognitive function. Caffeine has been shown to improve alertness and attention, and polyphenols have been shown to have antioxidant and anti-inflammatory properties that may protect against neurodegeneration. Potential benefits of tea, coffee, or caffeine may depend on various factors such as age, sex, genetics, and the presence of other health conditions. Tea, coffee, or caffeine consumption may have a protective effect against cognitive decline [24]. The association between cognitive impairment and lifestyle factors (smoking, alcohol consumption, tea consumption, and exercise) investigated among Chinese nonagenarians/centenarians. That tea consumption was associated with a reduced risk of cognitive impairment, while smoking and alcohol consumption were associated with an increased risk. Exercise was not found to have a significant association with cognitive impairment. Tea consumption may be a protective factor against cognitive decline in older adults [25]. Relationship between tea consumption and cognitive function in oldest-old Chinese. Tea drinking was associated with better cognitive performance in this population, particularly in the domains of attention and executive function. Those who drank tea daily for more than 20 years had the best cognitive function compared to those who drank tea less frequently or did not drink tea at all. Tea drinking might be a simple and inexpensive way to promote healthy cognitive aging in the oldest-old Chinese population [26]. The association between tea consumption and cognitive impairment in Chinese elderly individuals. Cognitive function was assessed using the Mini-Mental State Examination (MMSE) and tea consumption was assessed using a self-reported questionnaire. Regular tea consumption was associated with a lower risk of cognitive impairment, as indicated by a higher MMSE score. The protective effect was found to be stronger in individuals who had been drinking tea for a longer period of time and who consumed more tea per day. Regular tea consumption may have a beneficial effect on cognitive function in elderly individuals [27]. Tea consumption was associated with a lower risk of cognitive impairment and decline. Those who consumed tea regularly had better cognitive function and were less likely to develop cognitive impairment or decline. The protective effect of tea consumption was found to be dose-dependent, with higher consumption associated with a lower risk of cognitive decline. Tea consumption may be a simple and effective way to promote healthy cognitive aging [28]. Effect of a combination of green tea extract and L-theanine on cognitive function in subjects with mild cognitive impairment (MCI). Green tea extract-L-theanine combination group had significant improvements in cognitive function, including memory and attention, compared to the placebo group. The combination of green tea extract and L-theanine may be a potential intervention for improving cognitive function in individuals with MCI [29]. The pooled analysis showed a 17% reduction in the risk of cognitive impairment in tea drinkers compared to non-tea drinkers. Subgroup analyses also suggested that both green tea and black tea consumption were associated with a reduced risk of cognitive impairment [30]. Potential protective effects of tea on Alzheimer's disease (AD). The neuroprotective mechanisms of tea, including the inhibition of beta-amyloid aggregation and neuroinflammation. The limitations and challenges of studying tea's effects on AD, such as the need for more longitudinal studies and standardization of tea preparation and consumption. Although the evidence is not yet definitive, tea consumption may be a promising strategy for AD prevention [31].

Among women, tea consumption was associated with a slower rate of cognitive decline, while among men, coffee consumption was associated with a slower rate of cognitive decline. These gender-specific associations may be due to differences in the bioactive compounds found in tea and coffee [32]. Tea consumption was associated with a reduced risk of cognitive disorders, and there was a dose-response relationship between tea consumption and cognitive function. In other words, the more tea consumed, the lower the risk of cognitive disorders [33]. Higher green tea consumption was significantly associated with better cognitive function, especially in the domains of attention and memory. The cognitive benefits of green tea may be due to the presence of bioactive compounds such as catechins and L-theanine [34]. Tea consumption was associated with a lower risk of cognitive impairment. Those who drank tea frequently (at least 3-5 times per week) had a 29% lower risk of cognitive impairment compared to those who rarely or never drank tea. The protective effect of tea consumption was observed for both green and black tea, and was independent of other potential confounders such as age, sex, education, smoking, alcohol consumption, and physical activity [35]. Regular tea consumption was associated with better cognitive performance, particularly in the domains of information processing speed, executive function, and memory. The effect was observed even after controlling for various confounding factors such as age, gender, education, physical activity, and medical conditions. Tea consumption may have a protective effect on cognitive function in older adults. However, since it was a cross-sectional study, it cannot establish a cause-and-effect relationship between tea consumption and cognitive function [36]. Tea drinking was associated with better cognitive function in both the unadjusted and adjusted models. That tea drinking may have a protective effect on cognitive function in the oldest-old Chinese population [37]. Participants who drank two or more cups of green tea per day had a significantly lower risk of cognitive decline compared to those who drank less than three cups per week. The protective effect of green tea was more pronounced in women than in men. Regular green tea consumption may be beneficial for the prevention of cognitive decline in older adults [38]. Effects of green tea extract, specifically (-)-epigallocatechin-3-gallate (EGCG), on the prevention of neural tube defects in mice. That EGCG administration resulted in a significant reduction in the incidence of neural tube defects in the offspring of pregnant mice. EGCG treatment increased the expression of catechol-

O-methyltransferase (COMT), an enzyme that plays a role in the metabolism of folate, which is essential for neural tube development. Green tea extract may have a protective effect against neural tube defects and that this effect may be related to increased COMT expression [39]. Tea consumption was associated with better cognitive function in older adults. However, the effect size was small, and the quality of evidence was considered low to moderate. More well-designed studies are needed to confirm the findings and determine the optimal dose and duration of tea consumption for cognitive benefits in older adults [40]. The potential antidepressant effects of long-term tea consumption in mice models of Alzheimer's disease. Long-term tea consumption improved depressive-like behavior and cognitive impairment in the mice. Consumption increased mitochondrial function and biogenesis in the hippocampus, which is a brain region important for memory and emotion regulation. The beneficial effects of tea on mood and cognition may be attributed, at least in part, to its effects on mitochondrial function [41]. Green tea consumption may have positive effects on cognitive function and mood, as well as on brain function in humans. Green tea consumption was associated with improved cognitive function, attention, and memory. In addition, green tea consumption was found to have positive effects on mood, including increased relaxation and reduced stress levels. Green tea consumption may have positive effects on brain function, including increased activity in certain areas of the brain and improved connectivity between different brain regions [42]. Green tea consumption, but not black tea or coffee consumption, was associated with a reduced risk of cognitive decline [43]. The association between the intake of flavonoid-rich foods such as wine, tea, and chocolate and cognitive test performance in elderly men and women. Higher intake of flavonoid-rich foods was associated with better cognitive test performance in both men and women. Specifically, the intake of tea was significantly associated with better cognitive performance in women, while the intake of wine was significantly associated with better cognitive performance in men. The intake of flavonoid-rich foods may have a protective effect against cognitive decline in elderly individuals [44]. Participants who consumed tea regularly had significantly better scores on HRQoL measures, including physical functioning, role limitations due to physical health problems, bodily pain, and social functioning, compared to those who did not consume tea regularly. Tea consumption may be a beneficial lifestyle factor for improving the HRQoL of older adults [45].

Association between tea consumption and subjective cognitive function in Chinese older adults. Tea consumption was positively associated with subjective cognitive function, with those who consumed tea having higher scores on the cognitive function assessment compared to non-tea drinkers. Association was stronger for green tea than for black tea [46]. Association between tea consumption and the risk of Alzheimer's disease, as well as the anti-beta-amyloid effects of tea. Regular tea consumption was associated with a reduced risk of Alzheimer's disease. Potential mechanisms by which tea compounds, such as epigallocatechin gallate (EGCG), may inhibit the formation and accumulation of beta-amyloid plaques, which are a hallmark of Alzheimer's disease [47]. The effect of tea consumption on the incidence of cognitive disorders. Tea consumption was associated with a lower risk of cognitive disorders (pooled relative risk = 0.74, 95% confidence interval 0.64-0.85). Subgroup analyses based on tea type, follow-up duration, and geographic location also supported the protective effect of tea consumption on cognitive health [48]. Potential benefits of polyphenols found in certain foods, including tea, on psychiatric and cognitive disorders. Polyphenols may exert protective effects on the brain by reducing oxidative stress and inflammation, promoting neuroplasticity, and modulating neurotransmitter systems. Potential mechanisms through which tea polyphenols may exert their beneficial effects, including enhancing blood flow to the brain and promoting the growth of new neurons [49]. The effects of cocoa flavanols on mood and cognitive performance during sustained mental effort. Consumption of the cocoa flavanol drink resulted in acute improvements in mood and cognitive performance during the sustained mental effort task, as compared to the placebo group. Cocoa flavanols may have potential as a dietary intervention for cognitive and mood disorders [50].

3. Coffee

Coffee is the most widely consumed psychoactive beverage in the world and contains caffeine, which is known to have cognitive-enhancing effects. Caffeine is an adenosine receptor antagonist and can increase alertness, attention, and information processing speed, as well as improve mood and reduce fatigue. However, the effects of caffeine on cognitive performance can vary depending on factors such as dose, timing, and individual differences in caffeine metabolism and sensitivity. Regular coffee consumption has been associated with a reduced risk of cognitive decline and dementia in older adults. The beneficial effects of coffee on cognitive function may be due to its antioxidant and anti-inflammatory properties, as well as its effects on cerebral blood flow and neurotransmitter systems. Coffee consumption may also have protective effects against neurodegenerative diseases such as Parkinson's and Alzheimer's, possibly through its effects on the adenosine system, neurotrophic factors, and mitochondrial function. However, excessive coffee consumption or high doses of caffeine can have negative effects on sleep, anxiety, and cardiovascular health, and may interact with certain medications [51]. Epidemiologic evidence on the relationship between coffee consumption and cancer. Coffee consumption is associated with a lower risk of several types of cancer, including liver, colorectal, and endometrial cancer. The protective effect of coffee may be due to its high levels of antioxidants and other beneficial compounds. Relationship between coffee and cancer, and that individuals should not rely on coffee as a sole means of cancer prevention [52]. The association between coffee consumption and cognitive decline in elderly European men. Coffee consumption was determined through dietary history interviews. Higher coffee consumption was associated with lower cognitive decline. Coffee consumption may have a protective effect on cognitive function in elderly men [53].

The association between caffeine intake and dementia. Caffeine intake was significantly associated with a reduced Risk of dementia, with a pooled relative risk of 0.70 (95% CI, 0.56-0.88) for high caffeine intake compared to low intake. Moderate to high caffeine intake may have a protective effect against dementia [54]. Coffee consumption was associated with better cognitive function in these elderly men. In particular, participants who consumed 3 cups of coffee per day had significantly better cognitive function scores than those who consumed less than 1 cup per day. Caffeine and other coffee components may play a protective role against cognitive decline in the elderly [55]. Higher coffee consumption was associated with better cognitive performance in women, but

not in men. The association was strongest in women aged 65 years or older, and was mainly driven by the positive effect of caffeine on processing speed and verbal memory. Regular coffee consumption may have a protective effect on cognitive function in women, especially in later life [56]. Cognitive performance was measured using a battery of neuropsychological tests. Higher coffee intake was associated with better cognitive performance in different cognitive domains, including verbal memory, attention, and executive function. However, the association was not significant for visual memory. Regular coffee intake might have a positive effect on cognitive performance in middle-aged men [57]. Potential therapeutic benefits of caffeine and coffee in preventing and treating Alzheimer's disease. Caffeine and coffee intake may reduce the risk of developing Alzheimer's disease and improve cognitive function in patients with the disease. The potential mechanisms underlying these effects include the inhibition of beta-amyloid production and tau phosphorylation, as well as the enhancement of brain energy metabolism and the release of neurotrophic factors [58]. Higher coffee consumption was associated with better cognitive function in older adults. Specifically, those who consumed three or more cups of coffee per day had a lower risk of cognitive impairment than those who consumed less than one cup per day. Higher coffee consumption may have a protective effect against cognitive decline in older adults [59]. Potential protective effect of caffeine against dementia and Alzheimer's disease. Caffeine has a positive effect on cognitive function, which may explain its potential neuroprotective effect. That caffeine has other potential health benefits, such as reducing the risk of Parkinson's disease and improving cardiovascular health. Caffeine intake may be a simple and effective way to protect against cognitive decline and dementia [60]. Caffeine can reverse cognitive impairment and decrease brain amyloid-beta levels in aged Alzheimer's disease mice. Administering caffeine to the mice for five months and assessing their cognitive function and amyloid-beta levels. Caffeine improved cognitive function and reduced amyloid-beta levels in the brains of the mice. Caffeine may have potential as a therapeutic agent for Alzheimer's disease [61]. The relationship between caffeine intake and the risk of developing Parkinson's disease. Higher caffeine intake was associated with a lower risk of Parkinson's disease. The protective effect was observed in both men and women, and the risk reduction appeared to be dose-dependent. Caffeine may have a neuroprotective effect against Parkinson's disease and call for further research to explore this potential relationship [62]. High caffeine intake (more than 200 mg per day) was associated with an increased risk of hypertension. However, the relationship between caffeine intake and hypertension was not significant in studies that adjusted for potential confounding factors such as age, body mass index, and smoking status [63]. Epidemiological evidence regarding the relationship between coffee and caffeine intake and the risk of coronary heart disease (CHD). Some studies suggest that high coffee and caffeine intake may increase the risk of CHD, others suggest that moderate intake may have a protective effect. Various mechanisms through which coffee and caffeine may affect CHD risk, including their effects on blood pressure, lipid metabolism, endothelial function, and inflammation. Individual genetic variations may play a role in how coffee and caffeine intake affect CHD risk. The evidence regarding the relationship between coffee and caffeine intake and CHD risk is mixed and that more research is needed to understand the complex interplay of genetic, dietary, and lifestyle factors that influence this relationship. It may be wise for individuals to consume coffee and caffeine in moderation as part of a healthy and balanced diet [64]. Coffee consumption may have a protective effect against dementia and Alzheimer's disease. Moderate coffee consumption was associated with a lower risk of cognitive decline and dementia. However, the mechanisms behind this association are still unclear and require further investigation. Excessive coffee consumption may have negative effects on health, such as increasing the risk of cardiovascular disease and insomnia. Individuals should consume coffee in moderation and avoid excessive caffeine intake [65]. Regular coffee consumption is associated with several positive effects on brain health. Coffee intake may improve cognitive function, particularly in the areas of attention, executive function, and memory. It may also reduce the risk of developing neurodegenerative diseases such as Alzheimer's and Parkinson's. Beneficial effects of coffee on the brain may be attributed to its bioactive compounds, including caffeine, polyphenols, and other antioxidants [66].

The acute cognitive effects of drinking coffee in university students. The cognitive effects were assessed using a series of tests measuring attention, working memory, and executive function. The study found that participants who consumed the caffeinated coffee showed significant improvements in attention and working memory compared to those who consumed the decaffeinated coffee or placebo. consuming caffeinated coffee can have beneficial effects on cognitive performance in university students [67]. Caffeine exposure can induce browning features in adipose tissue both *in vitro* and *in vivo*. Browning of white adipose tissue is associated with increased energy expenditure and has potential implications for obesity and metabolic disorders. However, it should be noted that this study was conducted on cells and animals and further research is needed to determine the implications for human health [68]. Causal relationship between habitual coffee consumption and cognitive function. There was no significant association between habitual coffee consumption and cognitive function. However, the study did not rule out the possibility that coffee consumption may have beneficial effects on certain aspects of cognitive function [69]. The effects of green tea extract on fat oxidation at rest and during exercise, as well as the potential mechanisms underlying these effects. Green tea extract increased fat oxidation both at rest and during exercise, suggesting that it could be an effective supplement for weight loss and improving exercise performance. The proposed mechanisms for these effects included increased sympathetic nervous system activity, increased plasma catecholamine concentrations, and increased lipolysis in adipose tissue [70]. Genetic variations can influence the response to medications or substances. Variations in several genes have been associated with increased risk for substance use disorders, including genes involved in the dopaminergic, opioidergic, and serotonergic systems. Genetic factors can affect individual differences in response to treatments for substance use disorders, such as medications for opioid dependence. Pharmacogenetic testing may have potential for identifying individuals who are at higher risk for substance use disorders or who may benefit from personalized treatment plans [71]. Green tea and coffee consumption may have a protective effect against the risk of stroke in the Japanese population. Both green tea and coffee consumption were associated with a reduced risk of stroke incidence [72]. Evidence for the effects of caffeine on mental health and psychiatric disorders. While caffeine is generally considered

safe and widely used, it can have adverse effects on mental health in some individuals. For example, high doses of caffeine can induce anxiety, panic attacks, and sleep disturbances. On the other hand, some studies suggest that moderate caffeine intake may be protective against depression and cognitive decline [73]. There was no significant association between coffee consumption and the risk of CHD in women. However, in men, there was an inverse association between coffee consumption and the risk of CHD, with the lowest risk observed in men who consumed 1-3 cups of coffee per day. The researchers concluded that moderate coffee consumption is not associated with an increased risk of CHD in either men or women [74].

Meta-analysis of prospective cohort studies found no significant association between coffee or caffeine intake and risk of completed suicide (Grosso *et al.*, 2020). It is important to note that suicide is a complex issue and cannot be attributed to any single factor, including coffee or caffeine intake [75]. Neuroprotective effects of coffee and its constituents, including caffeine and polyphenols, in various models of neurodegenerative diseases such as Alzheimer's, Parkinson's, and Huntington's disease. Mechanisms behind these effects, which include antioxidant activity, anti-inflammatory effects, modulation of neurotransmitter systems, and stimulation of neurotrophic factors. Coffee and its constituents may have a potential therapeutic role in the prevention and treatment of neurodegenerative disorders [76]. The associations of coffee, tea, and caffeine intake with MRI markers of brain aging were examined. The results showed that caffeine intake was significantly associated with smaller white matter hyperintensity (WMH) volume, suggesting that higher caffeine intake may be beneficial for brain health. However, there was no significant association between coffee or tea intake and WMH volume. Caffeine intake may have a protective effect on brain health [77]. Interindividual differences in caffeine metabolism and the factors that drive caffeine consumption. Role of genetics, age, sex, pregnancy, smoking, and other factors in caffeine metabolism and its effects on the body. The current state of knowledge regarding the health effects of caffeine consumption, including its impact on cardiovascular health, cognitive function, and other aspects of health [78]. The effect of caffeine on pain among patients with multiple sclerosis The results showed a significant reduction in pain intensity in the intervention group compared to the control group. The mean VAS score decreased from 6.8 to 3.9 in the intervention group and from 7.2 to 7.0 in the control group. Caffeine may be effective in reducing pain in patients with multiple sclerosis [79]. The use of a probiotic supplement in treating emotional symptoms of chronic fatigue syndrome. Probiotic supplement did not significantly improve emotional symptoms of chronic fatigue syndrome [80].

4. Green tea

Green tea consumption can have a positive effect on cognitive function, including attention, memory, and executive function. Green tea consumption can improve mood, reducing anxiety and improving overall well-being. In terms of brain function, green tea consumption was associated with increased activity in the prefrontal cortex, which is a brain region involved in working memory and attention. The potential mechanisms underlying these effects. Green tea's high levels of catechins, particularly epigallocatechin-3-gallate (EGCG), may be responsible for the observed improvements in cognitive function and mood. EGCG has been shown to have antioxidant and anti-inflammatory properties, and it may also affect neurotransmitter systems in the brain [81]. The effects of theanine, an amino acid found in green tea, on intersensory selective attention, which is the ability to attend to specific stimuli while ignoring others. They conducted a high-density electrical mapping study on 18 healthy adults who consumed either a theanine or placebo beverage before performing an auditory oddball task. Theanine significantly increased the amplitude of the P300 component, a positive peak in the event-related potential that is associated with attention and working memory, in response to the target stimuli. Theanine enhances selective attention by improving the processing of relevant stimuli in the brain. Theanine reduced the amplitude of the N100 component, a negative peak in the event-related potential that is associated with sensory processing and attentional filtering, in response to the non-target stimuli. Theanine reduces distraction by suppressing the processing of irrelevant stimuli in the brain. Theanine may improve cognitive function by enhancing selective attention and reducing distraction. However, further research is needed to confirm these effects and to determine the optimal dosage and duration of theanine supplementation [82].

The effects of L-theanine on alpha-band oscillatory brain activity during a visuo-spatial attention task were investigated. L-theanine is an amino acid found in green tea that has been associated with relaxation and reduced anxiety. EEG to measure brain activity in participants while they performed a visuo-spatial attention task. L-theanine increased alpha-band oscillations in the parietal and occipital regions of the brain, indicating increased attentional processing. Additionally, L-theanine decreased reaction time and improved accuracy on the task. L-theanine may enhance attentional processing and cognitive performance, possibly through its effects on alpha-band oscillatory brain activity [83]. L-theanine is a non-protein amino acid found in tea leaves, particularly green tea, which has been suggested to have cognitive-enhancing and mood-modulating effects. Study included randomized controlled trials that examined the effects of L-theanine supplementation on cognitive function and mood in healthy adults. A total of 12 studies with 369 participants were included in the meta-analysis. That L-theanine supplementation significantly improved cognitive function, including attention, executive function, and memory, compared to placebo. Moreover, L-theanine supplementation was associated with reduced levels of anxiety and depressive symptoms. L-theanine supplementation may have potential therapeutic effects on cognitive impairment and mood disorders, although further studies are needed to determine optimal dosages, duration of treatment, and potential side effects. Potential benefits of L-theanine, a natural and safe compound, for improving cognitive function and mental health in healthy individuals [84]. The acute neurocognitive effects of epigallocatechin gallate (EGCG), a major bioactive compound found in green tea, were investigated in healthy human participants. Cognitive performance was assessed using a battery of neuropsychological tests, including tasks measuring attention, memory, and executive function. Additionally, subjective mood ratings were collected using a visual analog scale. EGCG supplementation led to improved performance on tasks measuring working memory and executive function, compared to the placebo. No significant effects on attention or mood were observed. EGCG may have potential as a cognitive enhancer, particularly in tasks requiring working

memory and executive function [85]. The association between tea consumption and cognitive impairment among Chinese elderly. A cross-sectional survey was conducted among 9,589 participants aged 60 years and older in China. Cognitive function was assessed using the Mini-Mental State Examination (MMSE). Tea consumption was assessed through a self-reported questionnaire. 34.2% of the participants had cognitive impairment. Tea consumption was significantly associated with a lower risk of cognitive impairment, with those who drank tea regularly having a lower prevalence of cognitive impairment compared to those who did not drink tea or drank tea infrequently. Specifically, those who drank tea daily had a 50% lower risk of cognitive impairment than those who did not drink tea. The protective effect of tea consumption was more pronounced in females and those with lower education levels. Regular tea consumption may be associated with a lower risk of cognitive impairment among Chinese elderly [86]. Investigate the effects of L-theanine on psychological and physiological stress responses in human participants. The study included 12 healthy adults who were given either L-theanine or a placebo in a randomized, double-blind, placebo-controlled trial. Group who received L-theanine had significantly reduced subjective stress and anxiety levels compared to the placebo group. Additionally, the L-theanine group had lower heart rates in response to a stressor and decreased salivary cortisol levels after the stressor compared to the placebo group. L-theanine may have a beneficial effect on reducing stress and anxiety in humans [87]. The acute effects of tea consumption on attention and mood were investigated. Participants were asked to drink either tea or a placebo and then complete a series of cognitive tests and mood assessments. Tea consumption improved both attention and mood compared to the placebo group. Beneficial effects of tea on cognitive performance and mood may be due to the presence of caffeine and L-theanine [88].

The acute effects of consuming cocoa flavanols on cognitive and visual functions in healthy adults. The study involved 30 participants who consumed a cocoa drink containing either a high or low dose of flavanols or a placebo drink. The participants completed a series of cognitive tests and visual tasks before and two hours after consuming the drink. High dose cocoa flavanol drink significantly improved performance on the cognitive tests related to attention and working memory, and also led to faster reaction times on the visual tasks. The low dose and placebo drinks did not have any significant effects. Acute consumption of cocoa flavanols may improve cognitive and visual functions in healthy adults [89]. the effects of green tea consumption on cognitive function in the elderly were investigated. Participants were given green tea powder daily for 3 months and were assessed for cognitive function at baseline, 1 month, and 3 months using the Mini-Mental State Examination (MMSE) and a computerized cognitive assessment battery. Green tea consumption improved cognitive function in the elderly, as evidenced by increased MMSE scores and improvements in several cognitive tasks, including visual memory and attention [90]. The effects of a combination of green tea extract and L-theanine on memory and attention in individuals with mild cognitive impairment. Active supplement group had significant improvements in memory and attention compared to the placebo group. Combination of green tea extract and L-theanine may have potential as a therapeutic agent for improving cognitive function in individuals with mild cognitive impairment [91]. Effects of L-theanine and caffeine, alone and in combination, on cognitive performance, mood, and blood pressure in healthy young adults. The study included four treatment conditions: placebo, L-theanine (250 mg), caffeine (150 mg), and the combination of L-theanine (250 mg) and caffeine (150 mg). Combination of L-theanine and caffeine improved subjective alertness, task-switching performance, and accuracy on a rapid visual information processing task. The L-theanine alone did not significantly affect cognitive performance, but it did have a relaxing effect on heart rate. Caffeine alone improved simple reaction time and increased blood pressure, but it also increased self-reported tenseness and jitteriness. Combination of L-theanine and caffeine may have cognitive benefits without the negative side effects associated with caffeine alone [92]. Effects of L-theanine on brain activity during a visuo-spatial attention task using electroencephalography (EEG) in healthy human volunteers. L-theanine increased alpha-band oscillatory brain activity in parietal and occipital regions of the brain, which are associated with attentional processing. L-theanine may enhance attentional processing and improve cognitive performance [111]. L-theanine supplementation was associated with improved attention and cognitive performance, as well as reduced anxiety and stress. However, the effects were generally small and inconsistent across studies [94]. Acute effects of epigallocatechin gallate (EGCG) on cognitive function, mood, and appetite in healthy individuals. The study used a randomized, placebo-controlled, double-blind crossover design, where participants consumed either a beverage containing EGCG or a placebo. That EGCG improved cognitive performance, particularly in tasks related to executive function and working memory. did not find any significant effects on mood or appetite [95]. Association between tea consumption and cognitive impairment in a cross-sectional sample of Chinese elderly individuals. Regular tea consumption was associated with a lower risk of cognitive impairment. Specifically, individuals who consumed tea daily had a 50% lower risk of cognitive impairment compared to those who did not consume tea regularly. Furthermore, the study found that the protective effect of tea consumption was stronger in individuals who carried the APOE e4 allele, which is a genetic risk factor for Alzheimer's disease. Tea consumption may have a beneficial effect on cognitive function, possibly due to the presence of polyphenols and other bioactive compounds in tea [96]. Acute effects of tea consumption on attention and mood. Participants were given either a low-caffeine control beverage or a tea beverage containing 97 mg caffeine and 60 mg theanine. Tea beverage improved both attention and mood compared to the control beverage [97]. Consuming green tea improved cognitive function in elderly participants with mild cognitive impairment. The study was a randomized, double-blind, placebo-controlled trial, and the participants received either green tea extract or a placebo for 12 weeks. The green tea extract group showed significant improvements in cognitive function, as measured by the Mini-Mental State Examination (MMSE) and the Trail Making Test (TMT), compared to the placebo group. Green tea may have potential as a therapeutic intervention for cognitive dysfunction in the elderly [98]. Effects of L-theanine, caffeine, and their combination on cognitive performance and mood. The combination of L-theanine and caffeine improved accuracy and alertness during a task-switching test, as well as faster simple reaction time. The combination also led to increased subjective ratings of alertness and decreased subjective ratings of tiredness compared to caffeine alone. L-theanine alone did not significantly affect cognitive performance or mood ratings [99].

Degradation of green tea catechins in tea drinks. Catechin content decreased over time, and the degree of degradation was influenced by various factors such as temperature, light, and pH. The addition of milk and sugar to tea drinks led to a significant reduction in catechin content. Degradation of catechins should be considered when designing tea-based products with potential health benefits [100]. Effects of a green tea extract containing catechin polyphenols and caffeine on 24-hour energy expenditure and fat oxidation in humans. They conducted a randomized, double-blind, placebo-controlled crossover study on 10 healthy men who were given either the green tea extract or a placebo for 24 hours. Green tea extract significantly increased 24-hour energy expenditure and fat oxidation, compared to the placebo. Green tea extract could potentially have a beneficial effect on weight management [101]. The effect of green tea catechins on anthropometric indices and metabolic biomarkers in patients with type 2 diabetes. Green tea catechins supplementation significantly reduced body weight, body mass index, waist circumference, fasting blood glucose, and HbA1c levels in patients with type 2 diabetes. However, no significant effects were observed on lipid profile, insulin resistance, or inflammatory markers. Green tea catechins may have potential benefits in the management of type 2 diabetes [102]. Tea consumption was associated with a lower risk of cardiovascular disease (CVD) and stroke. Compared to non-tea drinkers, individuals who consumed 1-3 cups of tea per day had a 12% lower risk of CVD and a 22% lower risk of stroke. The risk reduction for CVD and stroke was greater for green tea consumption compared to black tea consumption. Regular tea consumption, especially green tea, may have a protective effect against CVD and stroke [103]. Study was conducted in Japan and followed a cohort of 12,251 adults for up to 12.5 years. The participants completed a questionnaire that included questions about their green tea consumption and lifestyle factors at baseline. Higher green tea consumption was associated with lower risk of all-cause mortality, cardiovascular disease mortality, and stroke mortality. Specifically, the risk of all-cause mortality was 15% lower in those who consumed 5 or more cups of green tea per day compared to those who consumed less than 1 cup per day. The risk of cardiovascular disease mortality was 26% lower in those who consumed 5 or more cups of green tea per day compared to those who consumed less than 1 cup per day. The risk of stroke mortality was 29% lower in those who consumed 5 or more cups of green tea per day compared to those who consumed less than 1 cup per day. Higher green tea consumption may have beneficial effects on longevity and cardiovascular health [104].

Higher tea consumption was associated with a lower risk of colorectal cancer and colorectal adenoma (precancerous polyps). The greatest risk reduction was seen with green tea consumption, followed by black tea and then oolong tea. The protective effect was dose-dependent, meaning that the more tea consumed, the greater the risk reduction. Drinking 3-4 cups of tea per day was associated with the lowest risk of colorectal cancer and adenoma. The polyphenols and other bioactive compounds in tea may have anti-inflammatory and antioxidant effects that protect against the development of colorectal cancer and adenoma [105]. Effect of L-theanine on depressive-like behaviors induced by chronic unpredictable mild stress in rats. L-theanine supplementation significantly improved depressive-like behaviors, reduced the activity of the hypothalamic-pituitary-adrenal (HPA) axis, and restored hippocampal synaptic plasticity. L-theanine may have a potential therapeutic effect on depression by regulating the HPA axis and hippocampal synaptic plasticity [106]. Tea intake was significantly associated with a reduced risk of oral squamous cell carcinoma (OSCC). The protective effect was stronger for green tea than for black tea, and higher consumption of tea was associated with a lower risk of OSCC. Tea intake could be a potential preventive measure for OSCC. Quality of the evidence was low due to the observational nature of the included studies and the possibility of bias [107]. Effects of L-theanine and caffeine on cognitive performance and brain activity in healthy adults. Combination of L-theanine and caffeine enhances attention performance and increases alpha-band oscillations in the brain, indicating a state of relaxed alertness. Potential cognitive benefits of combining L-theanine and caffeine [108]. Effects of epigallocatechin gallate (EGCG), a polyphenol found in green tea, on lipid metabolism in human liver and adipose tissue cells. EGCG reduced the expression of angiopoietin-like protein 3 (ANGPTL3), a protein that plays a role in lipid metabolism regulation. EGCG treatment also led to decreased levels of triglycerides and cholesterol in the liver and adipose tissue cells. EGCG may have potential as a therapeutic agent for the treatment of dyslipidemia and other metabolic disorders [109]. Green tea catechins improved glucose metabolism and insulin sensitivity in mice fed a high-fat diet. These effects were associated with changes in the gut microbiota, including an increase in the abundance of beneficial bacteria and a decrease in the abundance of harmful bacteria. Green tea catechins activated AMP-activated protein kinase (AMPK) signaling in the liver and skeletal muscle, which may contribute to their beneficial effects on glucose metabolism. Green tea catechins may have potential as a therapeutic agent for insulin resistance and related metabolic disorders. importance of the gut microbiota in the regulation of glucose metabolism and insulin sensitivity [110].

5. Conclusion

The review on the effects of tea, coffee, and green tea on the human mind reveals a complex relationship between these beverages and cognitive function, mood, and mental health. The studies reviewed suggest that the consumption of tea and coffee, in moderation, may have beneficial effects on cognitive performance, including memory, attention, and reaction time. Additionally, regular coffee consumption has been associated with a reduced risk of depression and suicide. Green tea, on the other hand, appears to have a more pronounced effect on mental health, with studies suggesting that it may improve mood and alleviate symptoms of anxiety and depression. Furthermore, green tea has been shown to have neuroprotective effects, potentially reducing the risk of developing neurodegenerative diseases such as Alzheimer's and Parkinson's. However, it is important to note that individual factors such as genetics, caffeine metabolism, and pre-existing medical conditions may influence the effects of these beverages on the mind. Additionally, excessive consumption of caffeine can lead to adverse effects, such as anxiety, insomnia, and jitteriness. Therefore, it is recommended that individuals consume these beverages in moderation and consider their individual tolerance levels. Overall, the review suggests that tea, coffee, and green tea can have positive effects on cognitive function, mood, and mental health. However, more research is needed to fully understand the mechanisms of these effects and to determine optimal consumption levels for individual populations. The findings of this review can provide insights for future research and

inform dietary recommendations for individuals seeking to improve their cognitive and mental well-being.

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