The Effect of Peppermint on Memory Performance

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Key Points

- Alzheimer's Disease, a neurodegenerative disease impairing memory, thinking, and behavior, affects one in eight adults in the United States and is projected to cost the country $200 billion in 2012
- Recent research suggests peppermint essential oils improve memory and retrieval in cognitive tasks requiring sustained focus
- Although memory enhancement via an olfactory mechanism is well-supported, relatively little research investigates a similar outcome when peppermint is ingested prior to a memory task
- In this study, we analyze the effects of ingested peppermint via consumption of peppermint tea on cognitive performance when compared to a baseline tap water control, with hypothesized increases in EEG activity and visual working memory
- Analysis of heart rate, blood pressure, EEG activity, and performance on a memory task revealed no significant difference under experimental conditions, suggesting that consumption of peppermint does not mediate memory enhancement

Word count: 143

Abstract

Recent research suggests the potential for natural compounds to serve a protective function in the preservation of memory and cognition. Olfactory mechanisms have been examined in detail, but little research has examined the possible mechanisms by which ingestion may enhance cognitive performance. Here, we investigate the influence of peppermint intake, in the form of decaffeinated tea, on performance in a memory task and physiological measures relative to a tap water control. A result of peppermint's calming effects, heart rate and blood pressure were hypothesized to decrease, while increases in EEG activity were expected to correspond to increased memory performance. Data analysis showed no significant trends in physiological variables or memory performance, suggesting consumption of peppermint does not mediate alertness or enhanced cognitive performance. This study's limited EEG analysis is inconclusive, but a correlation between tea consumption and potential beta waves suggests peppermint-mediated improvements in concentration. Further research investigating compound metabolism is required to optimize quantification of memory performance following peppermint ingestion.

Introduction

Alzheimer's Disease, a form of dementia affecting memory, thinking, and behavior, currently affects one in eight adults and is the sixth leading cause of death in the United States. According to *Alzheimer's Disease Facts and Figures*, the disease is projected to cost the United States $200 billion this year, increasing rapidly as the Baby Boom generation reaches late-adulthood (Williams, 2012). Neurodegenerative disorders appear to be mediated by apoptosis of central nervous system astroglia and the resulting dysregulation of transmitter release, myelination, and long-term potentiation (Koo *et al*, 2000). No cure or treatment is known, rendering prevention and symptom management strong motivators of research on the potential to prolong cognitive function. Recent studies suggest the possibility of combating Alzheimer's disease through diet, supplements, and "brain-training" designed to challenge cognitive function. The possible protective effects of vitamin and herb supplements have drawn substantial attention and created a market for products such as "Memory Gum" and peppermint essential oils. A study at the University of Cincinnati claimed experimental subjects who were exposed to the scent of peppermint showed increased performance on tasks requiring sustained focus (Brand & Ydstie, 2007). Whether or not this is "hard science," however, remains open to debate. Skeptics argue that peppermint is nothing more than aromatherapy, and favors social facilitation, the tendency for an audience to enhance performance in common tasks, as a more likely explanation.

Existing literature suggests that consumption of natural compounds can improve memory. Fish oils, extra virgin olive oil, and antioxidant-rich foods such as spinach and berries have been shown to improve working memory and reduce loss of established memory (Bickford *et al.*, 2000; Hashimoto *et al.*, 2011; Farr *et al.*, 2012). More recently, studies examining the effect of aroma on memory and alertness suggest that aroma of peppermint may increase cognitive function. Further, animal studies have shown the ability of volatile organic compounds

to directly affect physiology and behavior. Compounds emitted from a deciduous oak attenuate stress in a rate model, indicated by a return from hyperthermia to the homeostatic range (Akutsu *et al*,. 2002).

A study of peppermint's modulation of long-term potentiation showed a direct correlation between peppermint oils and enhanced memory (Moss *et al.*, 2008). When compared against exposure to other ambient odors, peppermint produced a marked increase in word recall accuracy (Herz, 1997). In recall tests of extended memory, improved cognitive function arose in response to exposure to peppermint aroma during both the learning and memory retrieval tasks (Herz, 1997). *In vivo* exposure of glial cells to peppermint oil has been shown to inhibit heat-shock-induced apoptosis of astrocytes in rat and human cell models, suggesting peppermint's preservation of central nervous system microglia as a mediator of improved cognitive function (Koo *et al.*, 2000).

In a battery of questions assessing cognitive performance, aroma of peppermint increased alertness and performance on tasks requiring sustained visual attention. Exposure to the aroma also reliably produced EEG fluctuations during REM sleep, ruling out subject expectancy as a confounding variable. ANOVAs of task accuracy in peppermint versus control groups revealed increases in the quality of working memory without sacrificing speed. The aroma did not influence subjective mood but produced a significant increase in alertness and thus demonstrated peppermint's ability to modulate cognitive performance independent of effects on motivation (Moss *et al.*, 2008).

Despite numerous studies on the correlation between olfaction and cognition, there is little known about whether a similar correlation exists when peppermint is tasted during a learning and recall task. This mechanism would require pharmacological action, including compound absorption and subsequent neuronal action. In this experiment, we hypothesize that ingestion of caffeine-free peppermint tea will improve performance on a test of visual working memory over a baseline tap water control. We expect to observe increases in EEG quantification of brain activity and decreases in both heart rate and blood pressure, a result of peppermint's calming effects. Self-report data will be collected to account for confounding variables such as inter-individual variation in alertness, gender, and caffeine consumption.

Materials and Methods

All experimental data were recorded under test subject numbers in a document separate from subject names in order to maintain confidentiality. These measurements served as a basis of comparison to determine whether beverage consumption alone was enough to change this data. Baseline blood pressure and heart rate were collected from all subjects at the start of the experiment, before consumption of the assigned water or tea. All blood pressure measurements were taken on the upper left arm using an a standard blood pressure cuff. The subject remained in a seated position with arm resting at heart level. Heart rate was taken using an oximeter attached to the left index finger, and the oximeter reading was positioned out of sight from the subject to avoid subject anxiety from watching their heart rate fluctuate.

Once initial measurements were taken, eight ounces of the assigned beverage (room temperature tap water or room temperature Stash brand Peppermint Caffeine Free Herbal Tea, was consumed over a period of two minutes. Tea was prepared according to package directions and cooled to room temperature to limit olfaction as a confounding variable. An equivalent number of test subjects were randomly assigned to consume either water or tea in the first test, to control for performance discrepancies attributed to the novelty of the memory test during the first trial. All test subjects completed a second test under the alternate condition in a later week. This experimental design of repeated test subjects allowed direct comparison of individual memory performance under both the tea and water conditions. This led to the possibility of more complex data analysis versus simple comparison of performance averages which cannot simultaneously account for physiological changes. Direct comparison of a single subject's variations in performance is most indicative of peppermint's influence on memory.

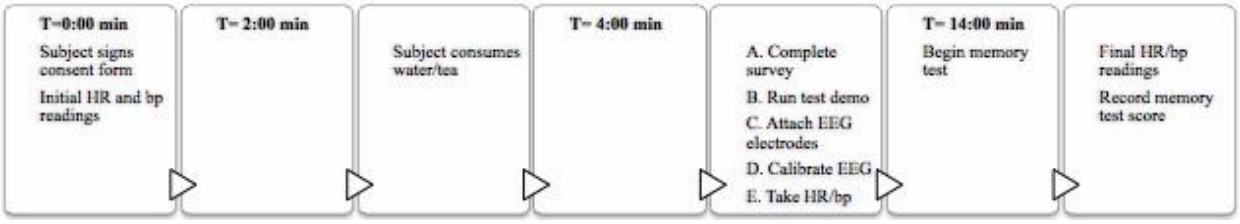

Figure 1

Following beverage consumption over a two minute period, ten minutes were allotted for the subject to complete pre-experiment survey questions (Appendix I). EEG electrodes were placed and pre-test heart rate and blood pressure were taken (Figure 1). Survey questions documented both a subjective self-report of alertness and the number of hours the subject slept the night prior to data collection. Subjects also indicated their caffeine consumption prior to the test to be below, equal to, or greater than normal levels Finally, this time served as a window during which the compounds consumed in the tea could be metabolized and take effect. Baseline EEG data was recorded for a period of twenty to thirty seconds while the test subject sat relaxed and with eyes open. In an effort to condense total test duration, we opted not to perform a full pre-consumption EEG and instead compared only the water and tea post-consumption data.

An introduction to the memory activity instructed subjects to concentrate on the association between colors and shapes presented in a series under a certain time interval. Before performing the task themselves, participants viewed a demonstration of the "colors" version of the online AARP Brain Health Shapes and Colors game (*Brain Health*, 2012). Once it was clear that participants understood the task, the experimenter selected consistent settings for the game: difficulty level seven, "colors task", "four seconds", "eight figures". The experimenter indicated the beginning of the task on the EEG program. Participants then performed the task, seeing eight consecutive figures, each a different shape and a particular color, for a period of four seconds each. After viewing all eight figures, participants were again presented with the shapes. This time presented in four different colors, the test subject was asked to select the shape in the color that matched one of the eight initial figures. The experimenter indicated task completion on the EEG data. Percentage of correct responses and average response time, as calculated by the AARP Brain Health website, were documented. Finally, the participant's post-experiment heart rate and a blood pressure were recorded.

Independent t-tests and analyses of variance (ANOVAs) were performed in Microsoft Excel to determine whether there was a significant difference between participants' memory scores, response time, initial and final systolic and diastolic blood pressure, and initial and final heart rate under the tea condition as compared to the tap water control. An alpha value was set to be significant at 0.05, and a p value of less than 0.05 suggested significance.

Results

Decaffeinated tea was strategically chosen to control for caffeine as a confounding variable. Stash Tea, unlike many other mint teas, consists of 100% pure peppermint leaves, thus allowing experimental trends to be attributed directly to the effects of peppermint.

Despite the purity of the tea, no significant physiological trends emerged following consumption of peppermint. An Analysis of Variance (ANOVA) test showed the difference between the baseline heart rate of the participants before drinking tea and before drinking water was not statistically significant ($p=0.64$). Therefore, the heart rate baseline data for each condition serves as a reference point to determine change in heart rate. *Figure 2* compares initial heart rate with changes observed at ten and fifteen minutes post-consumption. There were no significant differences between the basal heart rate and heart rates 10 minutes (pre-test) or 15 minutes (post-test) after the consumption of water ($p=0.44$ and $p=0.51$, respectively). Similarly, *Figure 3* further shows no significant difference in heart rate 10 minutes or 15 minutes following tea consumption ($p=0.37$ and $p=0.79$, respectively). There were no significant differences across tea and water conditions 10 or 15 minutes after consumption ($p=0.70$ and $p=0.66$, respectively).

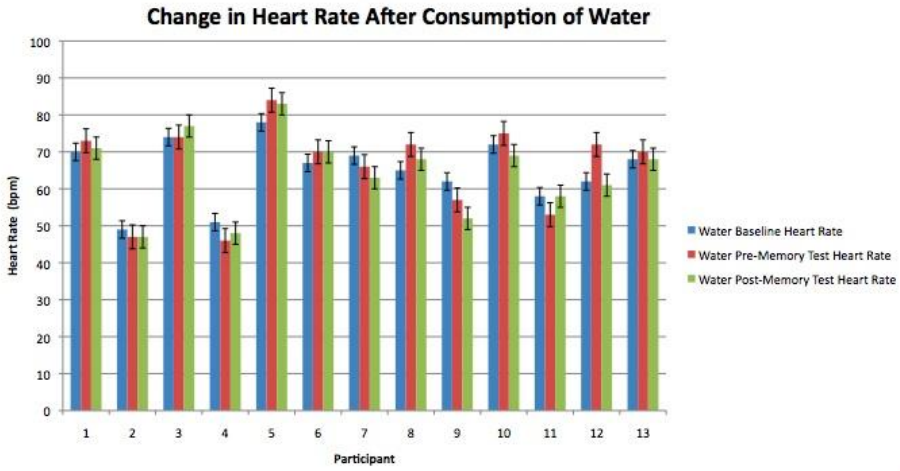

Figure 2

ANOVA tests were used to compare baseline, pre-, and post-test systolic blood pressure in both the water and tea conditions. *Figure 4* shows that neither water nor tea led to significant differences in systolic blood

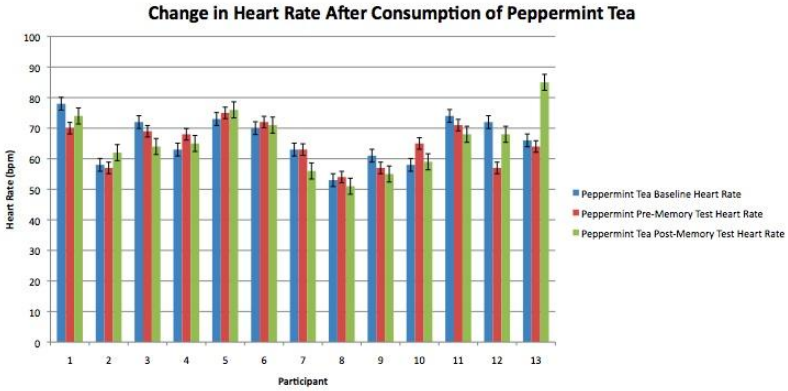

Figure 3

pressure throughout the experiment (p=0.81 and p=0.95, respectively). Mean systolic blood pressure measurements of water and tea at each time point were compared using paired t-tests, shown in *Figure 5*. As expected, baseline blood pressure measurements showed no significant differences between water and tea consumption (p=0.80). Pre- and post-test comparisons of water versus tea did not show any significant differences either (p=0.98 and p=0.81, respectively).

Analysis of diastolic blood pressure showed no significant differences. ANOVAs comparing all timepoints for water and all timepoints for tea showed no differences for baseline, pre-test, and post-test results (p=0.746 and p=0.968). Comparing conditions at baseline, pre-test, and post-test did not reveal significant results either (p=0.462, p=0.692, and p=0.741, respectively).

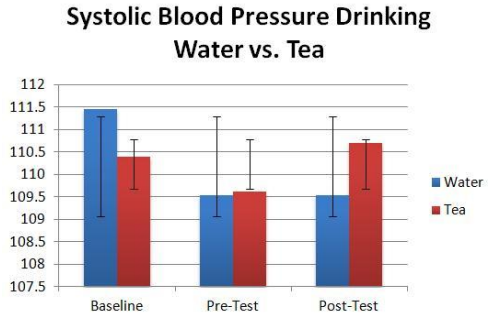

Figure 4

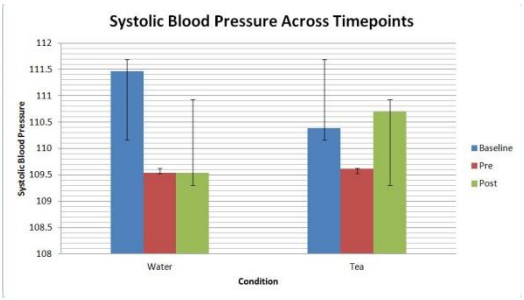

Figure 5

The only EEG data available for analysis was the composite wave as opposed to specific alpha, beta, delta, and theta waves due to a misunderstanding of Biopac Student Lab procedure. Experimenters compared the amplitude of the composite wave over approximately twenty seconds during the baseline and the time of the task for both the tea and water conditions. Water consumption did not lead to a significant change in wave amplitude between the baseline reading and the task (p=0.081), nor was there a difference in amplitude when comparing the baseline during the water and tea conditions (p=0.124). The difference in wave amplitude for the tea and water conditions during the memory test was not significant (p=0.058). Wave amplitude at baseline and mid-task, in contrast, did differ significantly under the tea trial (p=0.012), with the amplitude of the baseline waves being significantly higher (*Figure 6)*.

Figure 7 shows the effect of peppermint on memory performance to be statistically insignificant (p=0.900). The average percent correct for both water and tea test were 77 and 78, respectively. Five participants showed significant differences between the two tests; three showed significantly better performance upon drinking tea, and two showed significantly better performance upon drinking water. These individual differences were not substantial enough to significantly influence the results in either direction.

Discussion

Analyses of physiological and memory performance data suggest there is no correlation between the consumption of peppermint and cognitive function. Comparison of baseline, pre-test, and post-test systolic and diastolic blood pressure data failed to show a statistically significant difference in either the tea or water trials. Similarly, analyses of heart rate for both tea and water across timepoints and between conditions suggest peppermint has no significant physiological impact. Increasing peppermint dosage and experiment duration have potential to reveal statistically significant physiological change and should be considered for future experiments.

Our ability to analyze EEG data was severely limited by our failure to save readouts in the wave-separated form. Subject data was saved in a single wave-consolidated image so that isolation of beta and theta waves would not be an option upon return to the saved data. ***Future experimenters must note this***

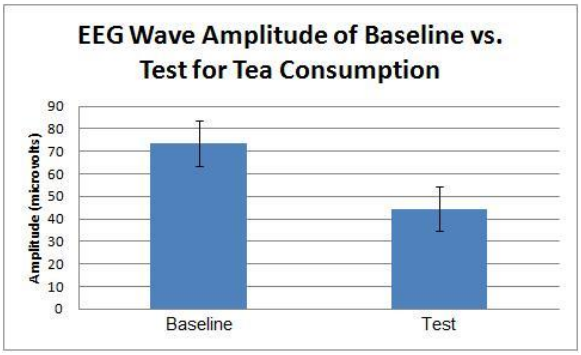

Figure 6

limitation and extrapolate data waves prior to saving and closing the subject's original EEG trial. The accessible EEG data, i.e., overall wave amplitude, provides limited information about subjects' brain activity throughout the experiment. The comparison of the amplitude of waves during baseline readings and during the memory test after tea consumption was the only significant difference that emerged; baseline amplitude was significantly higher than task amplitude. This amplitude difference may suggest a transition toward low-amplitude waves like beta waves, which are associated with concentration and problem solving (Mureriwa, 2001). If this is the case, peppermint tea would appear to facilitate increased problem-solving behavior during a task.

The average difference in percent correct between water and tea conditions during the memory test was insignificant. Five of the subjects, however, did demonstrate differences between conditions. Three subjects (8, 12, and 13) performed significantly better during the tea condition, and the other two subjects (6 and 11) performed significantly worse during the tea condition. A further look into survey data shows possible correlations to the results observed. Subject 6, who had better memory recall when drinking water, had consumed less caffeine, gotten less sleep, but only reported being slightly less alert under the water condition. Subject 13, who had better memory recall after drinking tea, had no difference in caffeine intake or sleep but did report feeling more alert the day of the tea consumption. Increased overall alertness may have led to an increase in performance. Subject 8, who performed memory recall better after drinking tea, had gotten less sleep that day but had consumed more caffeine. The increase of caffeine could have led to an increase in overall performance. Five outliers in a pool of thirteen participants is too large of a group to trust the overall results of the data. To support the null data that was found, it is important in future experiments

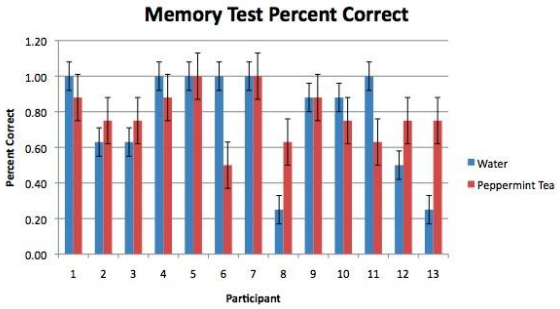

Figure 7

to increase the participant pool. In addition, it is important to analyze participants with similar caffeine consumption and alertness in an attempt to standardize conditions.

Despite this experiment's lack of evidence, the success of previous studies performed with peppermint oil on memory is promising. In this study, the dose of peppermint used was determined in a very qualitative way. Future studies should include a precise measurement of peppermint in each serving prior to consumption, whether it be via pH or metabolite analysis. In addition, the dose that was distributed was chosen arbitrarily. Further studies should be done to determine the amount of time it takes the body to metabolize peppermint, and experimenters should base physiological and memory tests on those findings.

Initially, one peppermint tea bag infused was chosen as the dosage because it was an easily accessible and administrable quantity. Upon further review, one tea bag does not necessarily control the precise quantity of peppermint oil either packaged in the tea-bag or infused into water. A direct way to resolve this problem is to use peppermint oil directly, a substance that can be precisely measured. A meta-analysis performed by HG Grigoleit determined the amount of peppermint oil effective in aiding gastro-intestinal issues to be 0.1-0.24 mL of peppermint oil per subject when administered orally (Grigoleit, 2005). According to the same study, the onset of effects of the oil range from 2 minutes to 3 hours depending on formulation of the oil administered. When peppermint oil was administered orally, in enteric coated capsules, results were observed 2-3 hours later on average. In future experiments, it may be beneficial to administer peppermint and allow 2 hours to metabolize the compound before the experiment begins. Further studies would hopefully provide insight to alternative therapy for Alzheimer's disease and other causes of memory loss.

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Appendix I

Survey

Date: _____

Age: _____

Gender: Male Female

Have you consumed caffeine in the last five hours?

Yes No

How does this compare to your usual caffeine intake? Less Average More

How much did you sleep last night?

0-2 hours 3-4 hours 5-6 hours 7-8 hours 9+ hours

On a scale of 1 to 7, how alert do you feel right now?

1 2 3 4 5 6 7