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The Acute Effects of caffeine and L-theanine on Cognition in Older Adults

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Abstract

Introduction: Cognitive decline is an impairment that affects many adults and has the potential to be decelerated. Previous studies show that caffeine and L-theanine positively affect cognition in a young population. L-theanine is an amino acid found in tea that produces a relaxation affect. Therefore, the purpose of this study is to determine the acute effects of caffeine and L-theanine on cognition in older adults. **Methodology**: Fifty-three older adults ages 55 and older participated in this study. Each adult completed the Mini Mental State Exam and participated in a health questionnaire. Both Trails Making Tests (Trails A and Trails B) and the Stroop Color-Word test were administered to measure cognition. Only the trails B and the last portion of the Stroop Color-Word test will be analyzed because they proposed the greatest challenge to the individual. This double-blind controlled trial randomly assigned the participants 100 mg caffeine, 200 mg of L-theanine, or a placebo (microcrystalline cellulose). After a 60-minute wait period, all tests were repeated and compared to baseline measurements. **Results:** There was no statistically significant group by time interaction for the Trails B test ($p = 0.389$). However, there was a time effect interaction between pre-and post-measurements ($p = 0.000$) showing that time to complete the test decreased. The Stroop Color Word test also had no statistically significant group by time interaction ($p = 0.632$), but the time effect showed a significant difference ($p = 0.001$). Each group improved their testing time, but not one specific supplement statistically influenced that improvement. **Discussion:** Although not statistically significant, Trails B and the Stroop Color Word test showed a decrease in time to complete each test, suggesting that caffeine and L-theanine could affect cognition. The rate of absorbance decreases with age, therefore the wait period

could have been longer than the studies where the age range was lower. For some studies that did obtain the results we expected, their dosage was higher and we chose a safe dosage previously administered on a younger population.

Introduction

Cognition is the ability to formulate thoughts and actions, and direct those actions to obtain goals (Miller & Wallis, 2009). In older adults, cognition plays a major role in their daily living and activities. Cognitive decline begins early in a person's life, their 20s-30s, and gradually declines into older adulthood (Salthouse, 2009). This decline in cognition leads to serious conditions, such as a greater risk of potential injuries and diseases, which propose threats to older adults as they continuously age (Ball et al., 2002; Bishop, Lu, & Yankner, 2010). Previous studies examined ways to lesson the decline and keep adults' minds healthy longer. Every 20 years, experts from all over the world have predicted that the amount of people with dementia will double (Ferri et al., 2005).

Out of individuals 65 years of age and older 7% are affected by cognitive impairment. That percentage increases to 30% when the population involves individuals who are 80 years of age and older (O'Brien et al., 2003) Since cognitive decline affects so many individuals, this research will study the cognitive effects of Caffeine and L-Theanine on older adults.

Caffeine

Caffeine is used by 80% of the world making it the most widely used psychoactive drug (Ogawa & Ueki, 2007). In the brain, specifically the hippocampus and

cortex, caffeine functions as an adenosine receptor antagonist. This receptor typically slows metabolic activity, but with caffeine, this function is opposed. Due to this physiological effect, caffeine is used to treat memory problems and disorders leading to positive results such as improved alertness, short-term attention, and psychomotor abilities (Arab, Biggs, O'meara, Fitzpatrick, & Longstreth 2011).

L-theanine

L-theanine provides a relaxation effect when taken and has been used since ancient times (Juneja et al., 1999). Pharmacological effects of L-Theanine include increases in concentration, memory, and learning (Henriquez-Aedo, 2013). L-theanine has been supplemented in several different substances such as beverages, candies, and other food products for its effects on relaxation (Juneja, 1999). Like caffeine, L-Theanine demonstrates similar effects on the health of the brain and contributes to reversing cognitive decline with potential uses in the older adult population (Foxe et al., 2012; Camfield, Stough, Farrimond, & Scholey, 2014).

Previous studies observed the effects of caffeine and L-Theanine consumption in younger adults but have yet to look at older adults specifically. Therefore, the purpose of this study is to determine acute effects of caffeine and L-Theanine on cognition in older adults.

Literature Review

Many studies have looked at the effects of caffeine and L-theanine on cognition, but they have focused primarily on a younger population. In several different studies

comparing L-theanine with a placebo, it was shown that alpha activity level increased in the occipital area within the brain with the ingestion of L-theanine, hence contributing to cognition. The amount of L-theanine for these studies varied from 50mg to 200mg. The participants in all three of these studied were all classified as young adults (Song, Xu, Liu, & Feng, 2003; Owen, Parnell, Bruin, & Rycroft, 2006; Kelly, Gomez-Ramirez, Montesi, & Foxe, 2008). There is a correlation between ingesting L-theanine and the release or reduction of dopamine and serotonin. Dopamine and serotonin are linked to memory and the ability to learn (Juneja, Chu, Okubo, Nagato, & Yokogoshi, 1999). In a study conducted using rats, operant conditioning was used to determine what effect L-theanine had on these two neurotransmitters. Operant conditioning has been defined as "the further performance of an action depends on the consequences experienced upon its completion". The amount of dopamine released and traced in the rats was significantly higher following L-theanine injection. However, the serotonin component was decreased. In a review summarizing the research performed on the effects of caffeine and L-theanine, many points were made clear. They were all consistent with the suggestion that caffeine improves cognition. However, there were some discrepancies whether L-theanine improved cognition or did not contribute to an effect (Touretzky & Saksida, 1997; Bryan, 2008). A five-way crossover study was conducted with 19 young individuals (mean age of 29.2) in 1998. The findings further validate the hypothesis that caffeine and L-theanine consumption alter cognitive functioning in a positive manner. Even though there was a difference, caffeine and L-theanine affect cognition on different levels. In this study, caffeine improved critical flicker fusion (CFF) performance greater than L-theanine did. This finding is important because previous studies had questioned

the abilities of L-theanine, but this one showed a contribution from L-theanine even though is was less than caffeine's effect (Hindmarch, Quinlan, Moore, Parkin, 1998). In a study conducted with 24 young adults (18-35 y), similar results were obtained. The Stroop Color Word test was administered at each of the four visits and the visits were held at least 48 hours apart. Compared to a placebo, the number of correct responses by an individual who consumed caffeine improved significantly. Also, the test was performed much faster following caffeine consumption. The participants treated with L-theanine performed with fewer errors than someone who was given the placebo ($p<0.005$) (Dodd, Kennedy, Riby, & Haskell-Ramsay, 2015). A study conducted in 2008 dissolved 100 mg of L-theanine and 50 mg of caffeine in water. Plain water acted as the placebo. This was possible due to L-theanine and caffeine being flavorless in this study. They also tested a younger population age 21 to 40 y. They found that their low dosing did not replicate the results they saw in previous studies. They used 100mg of L-theanine where the study they were replicating had used 200mg of L-theanine. This was significant because it suggests there is a potential threshold on the amount of caffeine and L-theanine ingested to see a noticeable cognitive change within the human mind (Kelly, Gomez-Ramirez, Montesi, & Foxe, 2008). A study that reaches our age group better was performed on Chinese adults 55 years of age and older. The Chinese version of the MMSE was used to measure cognitive functioning. The individuals were divided up by the amount of tea they consumed (low, medium, and high). Tea is important because it contains both caffeine and L-theanine. Associations were made about the relationship of consumption level and cognitive impairment. As the consumption levels increased, the risk of cognitive impairment decreased linearly (Feng, Ng, Niti, Kua, & Yap, 2008). In

Japan, another study was conducted involving individuals 70 years of age and older. They used a Japanese language adapted version of the MMSE to test cognitive function. This study touched on another important aspect, location in the world. Their study showed that the consumption of green tea led to a decrease in cognitive decline in their population. They further explained that in comparison to other regions of the world such as North America and Europe, dementia was less prevalent in Japan where green tea was greater consumed. This strengthened the argument that dementia is less prevalent among those who consume more caffeine and L-theanine (Kuriyama et. al., 2006).

Due to the previous conclusions, this study will look at the effects of caffeine and L-theanine as it relates to cognition in older adults. This study includes only older adults due to the minimal research conducted on this population. 200 mg of caffeine and 200 mg of L-theanine will be used because it is known that there is an amount that shows a difference in cognition (Kelly et. al, 2008). As many researchers have studied younger populations, it is important to know how these substances affect older adults. This research can lead to more answers about the cognitive decline many older adults face (O'Brien et al., 2003).

Methodology

Participants

Participants included 53 older adults from the Northwest Arkansas region. These subjects were 55 years of age or older and scored a 24 or higher on the Mini Mental State Exam in order to be participate in this study (Molloy, Efrem, & Alemayehu, 1991). We studied 23 male subjects and 31 female subjects.

Assessments

The subjects were informed of the study in its entirety and asked to sign an informed consent prior to starting. Basic information including height, weight, age, sex, and physical activity were obtained. Each subject completed a health history questionnaire regarding his or her current heath and previous health history. This information will help to get baseline measurements to determine the effectiveness of the additional caffeine or L-theanine that potentially could be added. Individuals who are pregnant, did not score a 24 or higher on the MMSE, undergoing chemotherapy, or taking diabetic medication will be excluded from this study (Molloy et al., 1991).

Measures

In this randomized, double-blind controlled trial, a fraction of the individuals were given 100 mg of caffeine, another fraction were given 200 mg of L-theanine, and the last fraction were given a placebo. This study required one visit lasting approximately two hours. At the beginning of the study the participants completed quality of life surveys, caffeine questionnaires, and cognitive tests to get baseline measurements. The cognitive tests are both Trails Making Tests (Trails A and Trails B) and the Stroop Color-Word Test. The Stroop Color-Word test has four components increasing in difficulty as tested. The first part is simply identifying colors, the second is reading the names of colors, the third challenges the participant to say the color of the ink the word is written in and not reading the word (example: red being spelled yet colored green). The final component is a combination of saying the right color and reading the correct word. After completion, the subjects were given one of three pills: 200 mg of L-theanine, 100 mg of

caffeine, or a placebo containing microcrystalline cellulose. At this point the subjects entered a 60-minute wait period to assess the acute effect on cognition. After the wait period, the Stroop Color-Word test and both Trails Making Tests (Trails A and Trails B) were performed again. These results were compared to the baseline results to determine the acute effects on cognition.

Statistical Analysis

A repeated measures MANOVA was conducted to determine the effectiveness of the supplements (caffeine and L-Theanine) on cognition of older adults. The independent variables are supplement group assignment and time. The dependent variables include the cognitive assessments (Stroop and Trails). Significant will be set at $\alpha = .05$ and the Bonferroni correction was applied if multiple univariate analysis are performed. Post-hoc analysis were performed using Cohen's *d*. Results will be reported as means + *sd*.

Results

Trails B and the last portion of the Stroop Color Word test were evaluated due to the fact that those were the most challenging on cognition. Trails A and the first three parts of the Stroop Color Word test helped the participant get acquainted and comfortable with the testing.

Trails B

For Trails B, each supplement showed a decrease in time to complete the test. Individuals randomized to the caffeine trial decreased by 10.5 seconds, L-theanine by 17.8 seconds, and the placebo by 9.9 seconds. There is a moderate time effect for caffeine and L-theanine, but not for the placebo ($d = 0.59$, $d = 0.50$, $d = 0.19$), showing that the

supplements had an effect of the improvements over time. However, there is no statistically significant group by time interaction ($p = 0.389$). There is a significant time effect between pre-and post- measurements ($p = 0.000$) showing that the participants decreased their time to complete the test but it was not linked to any particular supplement (caffeine, L-theanine, or the placebo). There was a 17% improvement from pre to post testing.

Stroop Color Word test

The Stroop Color Word test produced similar results with a decrease in time to complete the test but it there was no statistically significant group by time interaction ($p = 0.632$). Caffeine decreased by 6.1 seconds, L-theanine by 8.5 seconds, and the placebo by 11.7 seconds. There was a moderate time effect for all three supplements, however the time effect was higher for caffeine and L-theanine than the placebo ($d = 0.48$, $d = 0.55$, $d = 0.47$), showing that the time decreased and was influenced more by caffeine and L-theanine supplementation although it was not shown statistically. There was, however, a significant time effect between pre-and post-measurements ($p = 0.001$). Resembling the trails B results, the Stroop Color Word test improved by decreasing the time of completion when repeated for the second time by 20%.

The results from this study were not statistically supportive of the hypothesis that there would be a change in cognitive function depending on the supplement they were randomly assigned. The second time the participants completed the tests, they decreased their time, showing that they improved. However, these results do not statistically support that the improvements came from the randomized supplementation.

Discussion

There are a few potential reasons our hypothesis was not statistically supported by our results. In previous studies, the use of caffeine and L-theanine studied a younger population. With older adults, the rate of metabolism and absorbance of particular substance decreases. It could have worked better with a longer wait period than just 60 minutes (O'Malley, Crooks, Duke, & Stevenson, 1971).

In our study, we chose to supplement either 100 mg of caffeine or 200 mg of L-theanine to ensure a safe dosage for the older adults based off of previous studies and the fact that we did not want to increase their intake of caffeine and L-theanine drastically (Song, Xu, Liu, & Feng, 2003; Owen, Parnell, Bruin, & Rycroft, 2006; Kelly, Gomez-Ramirez, Montesi, & Foxe, 2008). However, in a study where they found significant results, they found that more cognitive advancements came from the combination of the caffeine and L-theanine where we just tested them apart from each other. This studied differed from ours due to the fact that they used attention task as their indicator for cognitive improvement and supplemented 97 mg of L-theanine in addition to 40 mg of caffeine (Einother, Martens, Rycroft, & Bruin, 2010).

In other studies where they used similar doses, they were testing a younger population who might have less exposure to these substances therefore more sensitive to their beneficial effects. The older an individual is, it is likely they have had more exposure to these substances compared to a young child or even adult. The younger population showed more alterations in cognition from supplementation potentially due to the fact that they have not had this type of supplementation before and their metabolisms are not used to it. Caffeine and L-theanine were more foreign to the bodies of the younger population compared to the older population. Its foreign nature could have a greater

effect on a first time user than an older adult who has consumed large amounts of caffeine and L-theanine over the course of their life (Foxe, Morie, Laud, Rowson, Bruin, & Kelly, 2012).

Even though the results were not statistically significant, there was a decrease in time to complete these tests after supplementation. The supplement with the largest decrease in time was L-theanine followed by caffeine for both Trails B and the last portion of the Stroop Color Word test. Although it was not significant, a decrease shows that there is potential for future studies to continue to study the effects caffeine and L-theanine have on cognition with a couple of alterations. These alterations include increasing the wait period or choosing to supplement caffeine and L-theanine simultaneously.

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