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The Effect of a One-time Dietary Consumption of Caffeine and Decaf on Short-term Memory and Attention

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ABSTRACT

Caffeine is a known brain stimulant substance that is used for hundreds of years. Caffeine is known to increase neurological activities within the hippocampus, frontal brain lope and thalamus hence increasing an individual's short-term memory (STM) and the ability to pay attention. In this study, McPherson College students were subjected to a one time consumption of caffeine and decaf were tested for improvement in STM and ability to focus using an online memory game. The hypothesis was that individuals who consumed caffeine was likely to have a better STM score than those who consumed decaf. When we analyzed the data, we found that there was a significant increase in STM scores for the decaf group and not the caffeine group On the other hand, the post scores for the ability to pay attention were higher and significant both for the caffeine group and decaf group. The data does suggest that other factors might be much more important in the development of STM than caffeine consumption. Both caffeine and decaf might help improve ability to pay attention.

Keywords: *Caffeine, Short-term memory.*

INTRODUCTION

Caffeine is a brain stimulant substance that is included in many drinking beverages, food and medicine for variety of purposes. Caffeine was discovered by accident when a goat-herder stumbled upon a bean. When his goat consumed this bean they became hyperactive and when he tried himself he also got the same effect. Although many other countries have their own stories of how it was caffeine was discovered, this story has been told for more generations than others
(Yu L, 1995).

Caffeine has been shown to affect the brain function in different ways. Specifically, caffeine may affect short-term memory and attention (Borota D, et al, 2014).Physiologically, caffeine has been shown to have the ability to bypass the blood-brain barrier, and therefore inserting its effect directly on brain tissue within minutes of consumption (McCall AL. et at, 1982). Once within the brain tissue, caffeine mostly competes with adenosines molecules and binds to their receptor and as the result it stimulate the nervous system. In doing so, research suggest that caffeine also improve both attention and memory (Borota D, et al, 2014).

Memory is the process in which information is encoded, stored, and retrieved. Memory in the brain is stored in the hippocampus. Some cognitive scientists suggest that external and internal information are encoded to memory the way such that as library books are organized in the library (Sternberg, 1966). Encoding allows information from the external environment to be stored and retrieved from either within a short period of time i.e. short-term memory or a longer period of time i.e. long-term memory or in no relationship to time i.e. episodic memory. These memory types make up the three types of Memories. The development of short-term memory involves encoding information in such a way that neuron plasticity is not reformed. Information encoded as short-term memory will therefore be easy to retrieve. Encoding for this type of memory lasts in a matter of seconds to minutes (Sternberg, 1966). However, this is different in long-term memory. In long-term memory, neuron plasticity is involved and information seems to be stored on permanent tracks. The development of long-term memory takes place slowly and gradually over a long period of time. Memory stored as long-term can last for years (Schacter, 1996). The episodic memory is distinct from either two due to the fact that it is used to represent our memory of experiences and specific events as encoded in a sequential manner (Tulving. et al, 1973).

The process of making memory is triggered by the ability of the subject to pay attention to detail. Attention is the cognitive process of selectively concentrating on one thing while ignoring other things. Attention acts as the pathway gate to the start of withholding important information with our brain from the outside environment. Significant events cause firings of neurons and thus influencing attention, which is regulated by the brains frontal lobe and a relay center called the thalamus By acting as an antagonist to the adenosine receptors A1 and A2A, caffeine enhances acetylcholine (Ach) release in the hippocampus (Adrian, et al. 1995). In this study, the authors used a micro-dialysis technique, which allowed for continual perfusion of the brain in vivo with caffeine. They concluded that oral administration of caffeine causes dose-dependent

increases in the extracellular levels of the ACh in the hippocampus of awake freely moving rats. Increased Ach release would increase stimulation of brain activity and therefore increased attention which would lead to better memory storage.

In this experiment I tested the effect of caffeine on short term memory. The hypothesis was that a one-time consumption of caffeine will have an effect on how subjects are able to remember words in a short period of time, the objective was to understand the relationship between a one-time dietary consumption of caffeine and its ability to stimulate brain tissue, to affect attention and memory. The idea is that individuals who drank caffeine would have had a better attention and memory score after consumption of caffeine rather than individuals who drank decaffeinated coffee.

MATERIALS AND METHODS

Subject selection and Caffeine preparations:

Regular classic Folgers ground coffee and classic Folgers ground decaf was purchased at a local grocery store. McPherson College students were recruited as subjects by word of mouth. Upon recruitment, subjects were asked to sign Human Subject consent-form and screened to include only subjects that drink coffee occasionally. Twenty four hours before the test, subjects asked not to drink any caffeine containing foods to avoid any biases. All experiments were done on Saturday morning at 8:00am in McPherson College Melhorn science hall. A total of twenty subjects were recruited and divided equally between the two treatment groups. Each subject was randomly assigned to do each experiment three different times on different occasions to avoid treatment biases. Subjects were also randomly assigned numbers to avoid biases during data analysis. On the day of the test, fresh coffee was brewed using a conventional coffee maker. To brew the coffee, 75mg of caffeine or decaf was weighed out and brewed with 100 ml of water. Typically, 1000ml of total coffee was brewed and distributed in 100ml aliquots to test subjects. As the coffee was brewing, subjects were asked to take an online pre-test of their memory and attention.

Memory and Attention Test:

Subjects were instructed to log in to the following website to start the elephant memory game on the American Association of Retired Persons (aarp) website. (http://braingames1.aarp.org/elephant_memory.html). Initial demographic information is required in order for the game software to configure to the proper level of words dependent of age and education level. Subjects were asked to choose the same level of difficulty for consistency (level 1). For the memory test, subjects were required to memorize 25 words in 60 seconds. At the end of the 60 seconds, a screen would appear with instructing the subject that they would see five grids of 15 words, each grid contained five words which they had just memorized. The memory test was to remember which these five words from each grid of 15 words within a shortest possible amount of time (not more than 20 seconds). Because the game is self-paced and the subject chooses when to advance him/herself, a score time is generated. The computer then computes average time it took to memorize the words and the number of current words memorized.

For the attention test, subjects were again asked to log in to the same website as above and this time asked to do the “pay attention game. The URL is for this game is different from the URL for the memory game. (http://braingames1.aarp.org/pay_attention.html). The game focused on attention of numbers and letters. Again, initial demographic information was required to assess the right level of difficulty. To play the game, subjects also had the choice to select level of difficulty. However to keep everything consistent, the same level of difficulty was selected for all subjects. To play the game, subjects were shown a series of letter and numbers to recall in the same order. To start the game, subjects were shown a series of words or numbers and asked to type back the order of series of words or letters. The series got longer and longer as the subject continued to play. The game ended when the subject failed to correctly recall the current order of series of words or letters consecutively twice. The computer then generated a score based upon how many current series of words or letters and the time it took to get that data.

RESULTS

The obtained data from the memory test was averaged and transformed. The transformation for the memory data involved subtraction of wrong words memorized and a division by total time to generate number of words memorized correctly per second (Table 1). For the attention test, the total number of series recalled was divided by total time involved to get number of series of words or numbers recalled per second (Table 1). A paired t-test was performed and a p-value generated (Table 1).

The data shown in table 1 is the comparison all of the results obtained from the study. When the pre and post attention results were compared from the caffeine group we obtained a $P \leq 0.03$ indicating that the individuals within this group improved their scores. However, when I compared the results from the pre and post from the decaf group a $P \leq 0.027$ was obtained also indicating that these individuals also

Table 1: A sample T-test analysis of pre and post test scores of results obtained from both caffeine and decaf. The total number of subjects were 10 for each group

Treatment	Pre-test Mean ± S.D	Post-test Mean +/ S.D	P-value (α = 0.05)
Caffeine Memory	1.54±0.38	1.52±.29	0.454
Caffeine Attention	2.05±1.21	3.90±2.19	0.030
Decaf Memory	1.29±.69	1.60±.65	0.187
Decaf Attention	1.39±.65	2.67±1.52	0.027

improved their scores. This could mean that both caffeine and decaf contain enough stimulants to affect brain function. When I compared the pre and post of memory I found the less significant results (table 1) indicating that other factors could be involved in the development of short-term memory.

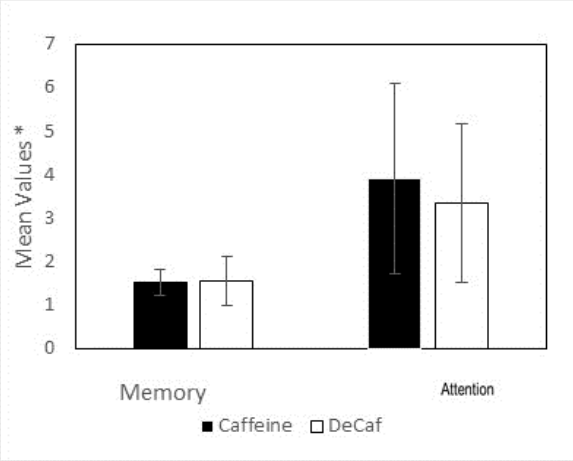

Figure 1: Comparisons of post results between caffeine and decaf of the memory and attention. There was no significant difference between the two groups perhaps due to high variability in the data set.

DISCUSSION

The results from the present study did not support the claim that one-term dietary consumption of caffeine can improve short term memory. The participants in both the caffeine group and decaf group showed a greater and significant improvement in their ability to play attention as opposed to memory words. This contradicts other previous studies. For example, Borota, et al, 2014 suggests that caffeine improves memory consolidation in humans. However, some physiologists suggest that the ability to pay attention might be the driving force in encoding information into memory (Fougnie, 2008). This study focused on undivided attention, because some studies suggest that divided attention reduce the ability to capture the information (Mulligan, 1998). With this study, all sound noise were excluded from the room, including any use of cell phones. This might explain for why we were able to see improvements in the ability to pay attention and not on memory by itself. Other studies also suggest that suggest that humans tend to use declarative memory (or short-term memory) in the morning and sematic memory (or long term memory) in the afternoons. This research study was conducted at 8:00 am and this reasoning might help to explain for why there was no difference between the caffeine and decaf group. Also, the total time for this study per participant was only 25 minutes perhaps not an adequate amount of time for a memory test.

In conclusion, because it is a human subject kind of research, it is not to control for all necessary variables that would affect the outcome of this study. Even if the participants were asked not consume any caffeine containing products at least 24hrs for the study, it is not clear whether they did or not. Prescreening before the test could have helped with this. In addition, participants demographic information such as gender, age, level of caffeine consumption and so now was not controlled for and there creating high variability within the data set. More research needs to be done in order to further understand the link between caffeine consumption, attention and memory.

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