The Effects of Coffee and Music on the Islanders' Memory

The Taco Belles

Haley Rao, Kai Chen Tan, Yuqing Yang, Daniel Zander

June 16, 2019

Abstract

As coffee and music has become increasingly common in the workplace, it is important to see how they might affect employees' work performance and productivity. Many studies have shown the beneficial effects of caffeine on cognitive function and memory. Studies have also suggested that music can enhance the attention and memory centers of the brain. Thus, our study aims to determine if coffee intake and music consumption have an effect on cognitive performance in working adults, specifically memory. The experimental design we chose was a Two-Way Randomized Block Design. We sampled 198 participants who are in their 30s, and blocked them by gender. Each block received all levels from the two factors, which are coffee intake and music consumption. After conducting the experiment, we performed graphical analysis and ANOVA to determine if coffee intake and music consumption have significant effects on cognitive performance in memory. Based on the results, we conclude that music appears to have an effect on memory performance, while we do not have evidence to suggest that coffee affects memory or that there is interaction between music genre and coffee dose.

1. Introduction

One of employers' top concerns in today's workplace is to maintain their employees' productivity. Employees are also concerned of their own energy levels at work because their performance determines the prospect of keeping their jobs or even earning promotions. Coffee is a staple in the modern workplace widely believed to improve alertness and boost energy for a full day at work. In fact, Americans consume up to 400 million cups of coffee a day, making coffee one of the most widely consumed caffeinated beverages in the United States. Recently, people have also been adding music to their daily work routine as music becomes easily accessible, and products such as smartphones and wireless earphones make listening to music more convenient. As drinking coffee and listening to music become common practices in the American workplace, we are interested in examining how these specific behaviors can influence work performance. In this study, we will be examining a specific aspect of work performance, which is the ability to absorb and retain information effectively.

Many studies have analyzed caffeine's effect on cognitive function and specifically memory recall. In one such experiment, participants were given a list of words to memorize and after both a short and long time delay, they were asked to recall the words that they remembered. Before being given the list, some participants were given caffeinated coffee to drink and some were given decaffeinated coffee. Participants who ingested caffeinated coffee were found to be able to recall more items on the list than those who did not. Other studies more broadly analyze the effect that coffee has on cognitive function in general. Both habitual coffee drinkers and nondrinkers were given various exams and tests to assess their memory and cognitive function and each participant received a composite score. Overall, the study found that there were no long term adverse effects on memory for those who regularly drink coffee. This finding disputes some other studies which claim that coffee can inhibit cognitive function. The researchers also concluded that it is safe to consume coffee with respect to preserving memory function. As coffee and caffeine have been shown in numerous studies to have an effect on memory and cognitive function, employers should be intrigued if the beverage can affect their employees' daily work performances.

Music has also been discovered to affect the brain's activity. A Stanford University research team showed that music engages areas of the brain associated with paying attention and updating memory. Certain genres like classical music were even found to help the brain sort events and incoming information. The continual flow of information into the brain is known as segmentation and this study noticed that transitions between musical movements can help the brain understand incoming information during this process. Another study at MIT examined how music affects certain sets of complex neural processing systems. These systems are associated with motor processing, cognition, and memory. The study found that while listening to classical music, brains exhibit a higher degree of connectivity patterns and thus are more active. Since music helps to stimulate the brain, employers may be interested to see how music can enhance the productivity and attentiveness of employees.

With prior literature stating that coffee and music affect brain activity, our study aims to examine whether coffee intake and music consumption have an effect on cognitive performance in working adults, specifically memory. Coffee and music are both design factors of interest.

Besides that, gender is identified as another factor that may have an effect on memory, but is not a factor of interest in this study. According to an experiment done by psychologists Agneta Herlitz and Jenny Rehnman in Stockholm, Sweden, women are found to perform better than men in memory tasks that involve remembering words, objects and pictures. This shows that there exists gender differences when it comes to memory and it should be taken into consideration in an experimental study. We have decided to block our participants by gender to reduce variation from this nuisance variable.

2. Methods and Procedures

2.1 Participants

The virtual participants of our study are sampled from an online website called The Island. We will be blocking our participants by gender since existing literature suggests that there are gender differences in memory. We chose to make age a held-constant factor as our objective is to figure out the effect of combining coffee and music on working adults. We will select participants who are in their 30s because they are very likely to have a steady job. For this study, the participants are all from the Island which is somewhere in the Pacific ocean, close to Australia.

2.2 Design

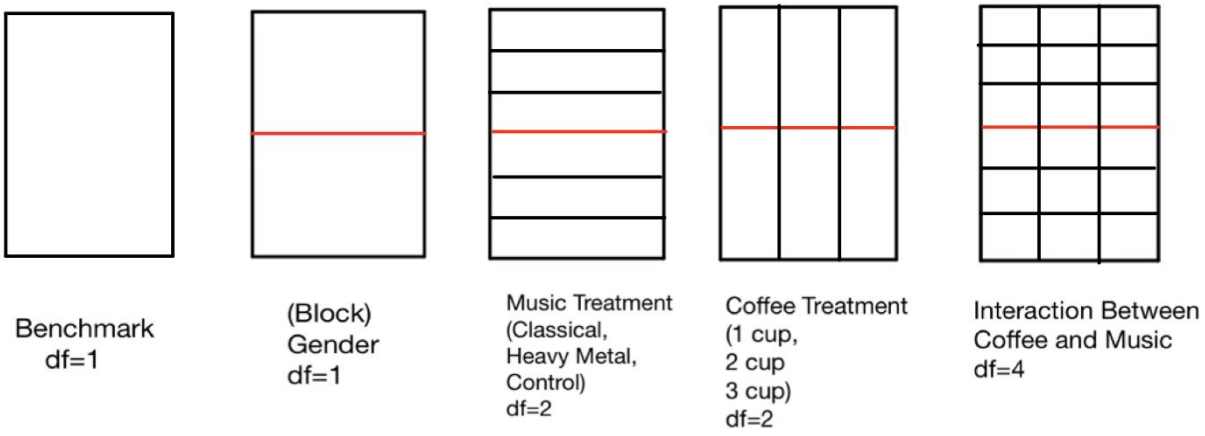
Our experiment follows a Two-Way Randomized Block Design. By using G*Power, we set the effect size be 0.25, the power to be 0.8, and the numerator degrees of freedom to be 4, and find that the required sample size will be 198. There will be 18 groups of 11 subjects. Once we obtain consent from 198 subjects, 99 females and 99 males in their 30s, we randomly assign the subjects into one of 11 groups and and then randomly assign a set of treatments to each group.

There is one nuisance and two treatment factors involved in this design. The nuisance factor is gender. The treatment factors are coffee intake and music consumption. The coffee intake factor has three levels, which are one, two or three cups of coffee. The music factor has three levels as well, which are classical, heavy metal and no music as a control. Uncontrollable

factors in this experiment include the subjects' past coffee drinking habits, overall health, and music preference. Age was held constant as all subjects are in their 30s.

In this experiment, we will measure the participants' cognitive performance by assigning them a memory game before and after their respective treatments. Participants are instructed to play a pairs memory game with 30 cards as quickly as they can, and the time taken to complete the game is recorded. The difference between the time taken before and after the treatments is calculated, and used as the response variable of this experiment.

The decomposition plot of the design is detailed below:



2.3 Instruments

The time that participants take to complete the memory game will be measured by a stopwatch. This instrument can be easily obtained.

2.4 Procedure

Step 1: Holding age range constant at 30-39, obtain consent from islanders to take part in the experiment. While not perfectly random, we will use the sample function in R to determine locations to search for participants.

Step 2: Once we have a large enough sample, use the sample function again to assign every participant into a group. Every participant, already blocked by gender, will be randomly assigned

one music treatment (Classical, heavy metal, or control) and assigned one coffee treatment (1 cup 250ml, 2 cups 500ml, 3 cups 750ml).

Step 3: Have each subject perform the memory test and record results.

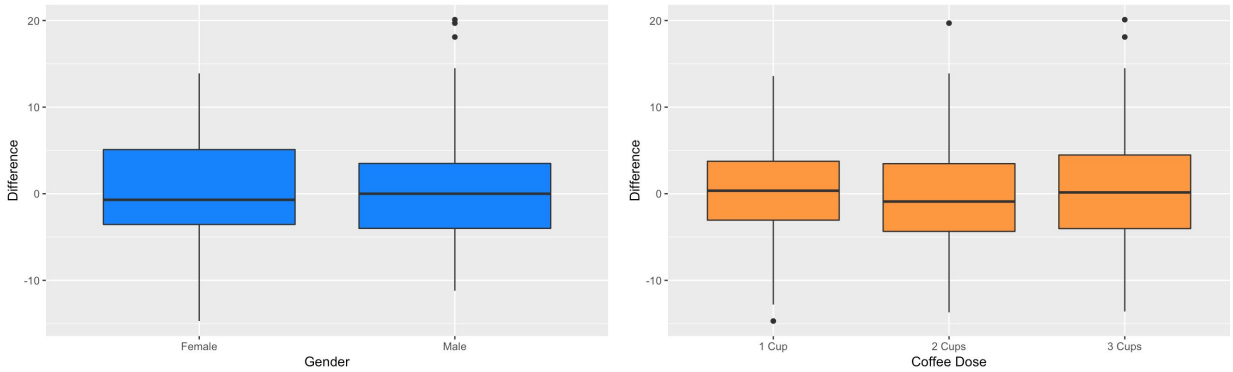
Step 4: Have everyone complete their respective treatment. They will drink the assigned coffee dosage and listen to the assigned music for 10 minutes. The 10 minutes of listening to music will also give time for the caffeine to take effect.

Step 5: Have the participants perform the memory test again another 10 minutes after finish listening to the music and record results. These results will be the response variable. (Studies have shown that levels of caffeine peak within 15 minutes of consumption, so 20 minutes allow ample time for subjects to feel the effect of coffee.)

2.5 Data Analysis

As this is a quantitative study, we will carry out a statistical analysis. The statistical analysis we will be using is an ANOVA analysis using R. We will measure the significance of the F-values outputted by the ANOVA table to determine if there is significance in the treatments, block, and interaction. We will reject the null hypothesis that what is being measured has no effect on memory performance if the ANOVA F test produces a p-value less than .05, and fail to reject the null otherwise.

3. Results



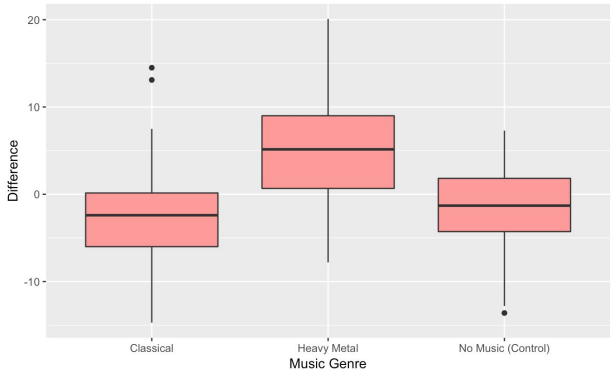


Figure 1: Boxplots comparing Difference in Time Taken to Complete Memory Game and Gender, Coffee Dose and Music Genre. A positive response variable means that subjects took a longer time to complete the second memory game. A negative response variable means that subjects perform better at the second memory game after receiving the treatments.

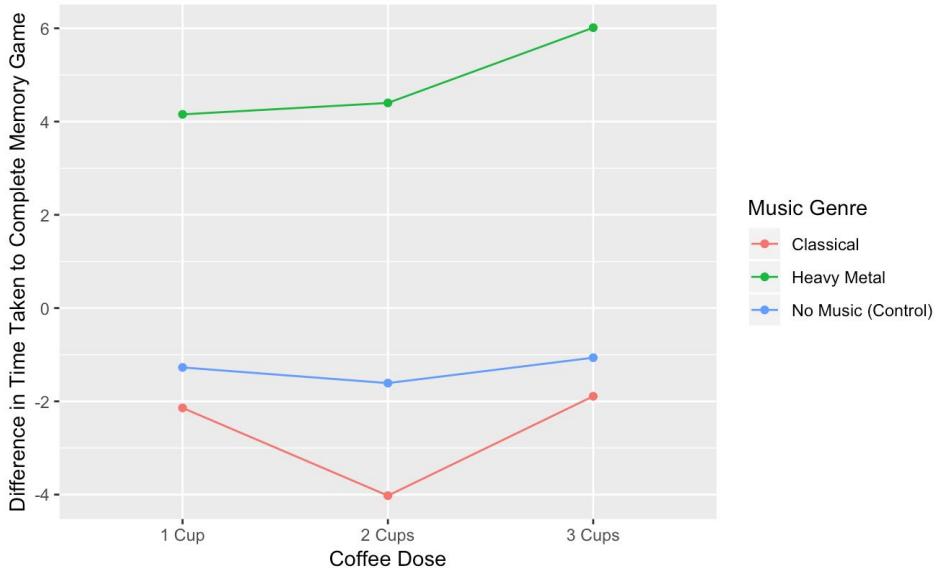


Figure 2: Interaction Plot of Coffee Dose and Music Genre with Difference in Time Taken to Complete Memory Game. There does not appear to be interaction between coffee does and music genre.

	df	Sum Sq	Mean Sq	F value	Pr(>F)
Coffee Dose	2	68	33.8	1.034	0.58358
Music Genre	2	2130	1065.1	32.560	**7.21e-13**
Gender	1	17	16.6	0.507	0.4770.477
Coffee Dose: Music Genre	4	40	10.1	0.308	0.8720.872
Residuals	188	6150	32.7		

Table 1: Two way ANOVA with interaction and blocking.

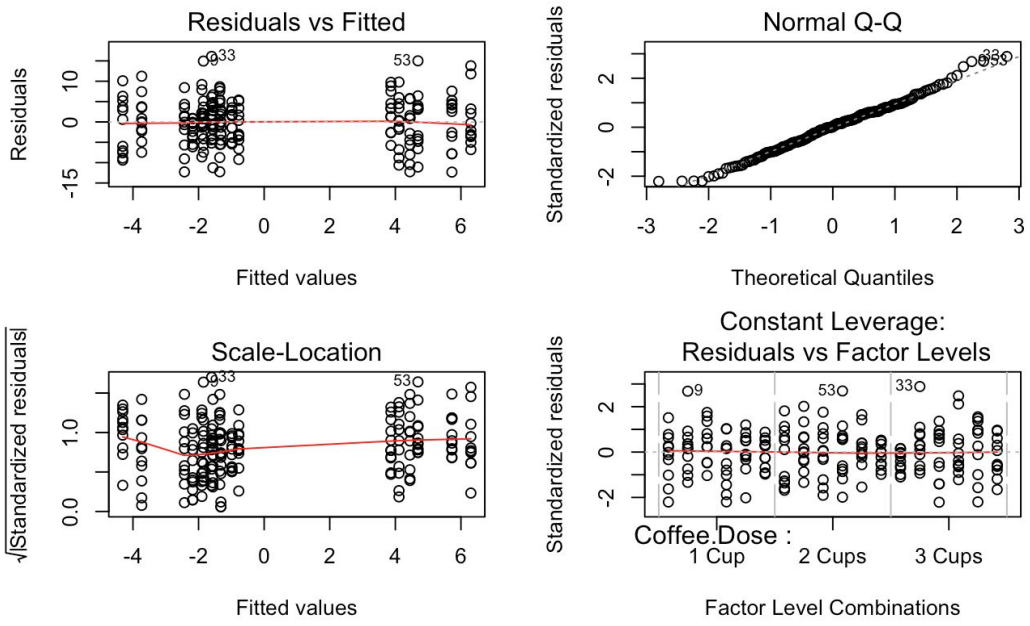


Figure 3: Residual Diagnostic Plots for ANOVA. The diagnostic plots show the residuals are independent, normal and have constant variance.

4. Discussion

It is helpful to first investigate the data we collected with graphical illustrations before performing an Analysis of Variance (ANOVA). First of all, we created boxplots to see if groups receiving different treatments had significantly different results. Our first box plot shows that there seems to be no significant difference in effect from gender, which was used as the blocking factor in this experiment due to existing research showing that gender affects memory capabilities. Next, it is clear that the number of cups of coffee consumed by subjects does not significantly affect their performance in memory games, since the boxplots cover the same range of data, with minimal differences that do not appear to be large enough to be significant. Only the boxplot with different treatments of music genre produced an output that could suggest a significant difference. Those who were given heavy metal music appeared to have positive difference in time taken to complete memory tests, whereas those who were given classical or no music have negative difference. This suggests that subjects who listened to heavy metal music performed significantly worse on the second memory test in comparison to the first. Subjects who listened to classical music performed similarly to the control group who listened to no music. Finally, the interaction plot shows that there is no significant interaction between coffee dose and music genre. Regardless of number of cups of coffee consumed, memory of participants improved after listening to classical music, and worsened after listening to heavy metal. We did not check for gender interaction because this was used as a blocking factor rather than a treatment factor.

After our observations, we turned to ANOVA in R and found that our initial conclusions were largely confirmed. With a p-value of 0.477, the gender blocking factor was statistically insignificant, which shows that gender was not an effective blocking factor in this experiment. Next, the coffee dosage factor was insignificant with a p-value of 0.358, and the interaction between coffee dosage and music genre was also insignificant with a p-value of 0.872. Lastly, the music genre factor is shown to be statistically significant with a p-value of 7.21e-13. This result does not allow us to conclude the direction of the effect of each treatment, but we confirmed that heavy metal music negatively affects memory performance by looking at the graphical analysis.

Finally, by running diagnostic plots for our model, we checked to see if our model is valid, and thus, has no major errors that would make our results unreliable. From the plots, we could see that the residuals from our model satisfy the normality and constant variance assumptions. Since the diagnostic plots do not show anything to suggest model invalidity, we can accept our conclusions from the model as satisfactory.

5. Conclusion

We chose this study to pinpoint what could be effective in improving work performance at today's workplace. One way to get an idea for work performance is by measuring memory speed, since a high-functioning memory is very useful to achieve maximum productivity when performing many difficult and often tedious tasks that are commonly found in today's high-stress work environments. Coffee was chosen as a factor since it is becoming ever present for people to pour themselves multiple cups of coffee throughout the day as a method of staying more productive and to activate brain performance, and these benefits could be measured through memory test performance. Music was selected as a factor since it has a ubiquitous presence amongst people working and studying, with users insisting that they are only able to focus when listening to music. This is put to the test by using music as a factor for the memory test, as higher focus should lead to improved results. If these treatments were to significantly improve memory, then there would be evidence that our subjects could perform better when at work by listening to music.

When it comes to drinking coffee, our results do not provide evidence that would lead us to recommend our subjects to rely on coffee to improve their memory skills. On the other hand, we have evidence to suggest that music does affect memory performance. By looking at the graphics and ANOVA table, results actually reveal that different music genre will affect performance for our subjects differently. While classical music showed no significant difference from a control group that didn't listen to any music, heavy metal music showed a weakening performance, so we would not recommend using loud music such as heavy metal to improve memory ability in the office.

While our experiment produced useful and reliable results, there were some limitations. First, our experiment was limited because while it was designed to suggest habits for people in busy offices where retention of information is crucial, that is rarely the only important skill required for working adults who turn to music and coffee to aid their performance. For example, coffee serves multiple functions for people, but only one of which may be to improve cognitive performance. Next, we recognized that coffee is often used by people who are tired or exhausted to keep themselves awake. Since we could not sample people who are low on sleep or exhausted, our experiment is limited because we cannot study the possibility that coffee helps performance in a special case like this one.

Our experiment could be improved by increasing the sample size and the corresponding power. While our power of 0.8 is a good standard to clear, going beyond it would greatly improve the experiment. Our experiment could have also been improved by increasing the range of coffee dosage. Instead of serving 1, 2, and 3 cups of coffee, we could serve 0, 2, and 4 cups. This would create a coffee control group in addition to a music control group, and the different amounts of caffeine could potentially create a significant difference.

Lastly, to further our study, a future research question would look to expand the range of music categories investigated. While we were limited to heavy metal and classical music in our experiment, we would want to look into the effects of other music genres such as hard rock, smooth jazz and country. As we expand the study to include more categories, it could be possible to determine trends about what we would expect to have an effect on memory and what we would expect to not have an effect.

References

Association for Psychological Science. (2008, February 21). Sex Differences In Memory: Women Better Than Men At Remembering Everyday Events. ScienceDaily. Retrieved from www.sciencedaily.com/releases/2008/02/080220104244.htm

Johnson, Jon. (2018, May 13). How long does a cup of coffee keep you awake? Retrieved from https://www.medicalnewstoday.com/articles/321784.php

Korczynski, M. (2003). Music at Work: Towards a Historical Overview. *Folk Music Journal, 8*(3), 314-334. Retrieved from http://www.jstor.org/stable/4522689

Ryan, L., Hatfield, C., & Hofstetter, M. (2002). Caffeine Reduces Time-of-Day Effects on Memory Performance in Older Adults. Psychological Science, 13(1), 68-71. Retrieved from http://www.jstor.org/stable/40063698

Smith, S. (1985). Background Music and Context-Dependent Memory. *The American Journal of Psychology, 98*(4), 591-603. doi:10.2307/1422512

Stanford Medicine. (2007, August 1). Music moves brain to pay attention, Stanford study finds. Retrieved from https://med.stanford.edu/news/all-news/2007/07/music-moves-brain-to-pay-attention-stanford-study-finds.html.

Wilkins, R., Hodges, D., Laurienti, P., Steen, M., & Burdette, J. (2012). Network Science: A New Method for Investigating the Complexity of Musical Experiences in The Brain. Leonardo, 45(3), 282-283. Retrieved from http://www.jstor.org/stable/41550649