The Impact of Chocolate and Pet Interactions on Cognitive Function

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Contents

1 Abstract

Everyone experiences stress in their daily lives, potentially impacting their cognitive abilities along with myriad other factors. This study focuses on the usage of chocolate and pet interactions to improve cognitive abilities. The aim was to determine whether consumption of chocolate and interaction with pet animals has an acute effect on cognitive abilities as tested by performance on an examination consisting of mental arithmetic problems. The study utilizes a Two-Way Randomized Block Design to examine the impacts of the percentage cocoa in the chocolate and the type of pet, blocked by gender, on cognitive function as measured by change in score on a mental arithmetic test. Results indicate no significant impact due to percent chocolate, type of pet, their interaction, or gender on change in test score.

2 Introduction

Individuals experience numerous stressors in everyday life, ranging from environmental factors such as temperature to unexpected events like a traffic jam. This stress impacts human cognition in a variety of ways depending on both the level of stress and the type of task at hand. When faced with an easy task, a higher level of stress has proven to be beneficial, while for more difficult tasks a lower level of stress results in improved performance. (Sandi) We seek to investigate factors which may mitigate stress to enhance cognition when seeking to succeed at a mentally stimulating, difficult task.

Past research has shown that pet interactions lead to a significant reduction in stress and increase in positive mood for both pet owners and non-owners. Furthermore, there is no significant difference in the impact on stress for cats and dogs. (Khalid) Research has indicated that direct interaction with dogs through touch results in a reduction in stress. (Binfet) These findings are validated in further studies, indicating a clear association between interactions with animals and a reduction in stress. (Machová) Therefore, we seek to investigate the impact that direct contact with a pet for a period of ten minutes has on cognitive function. Based on the lack of difference between cats and

dogs in terms of impact on stress, we seek to expand this field of study further by the introduction of a third type of pet animal, the crocodile. Despite the clear link between animal interactions and stress and stress and cognition, there has yet to be a clear relationship between animal interactions and cognition directly, indicating further research such as this study is a necessity. (Thayer) A connection between animal interactions and nature exposure has been investigated in the past, and we seek to investigate if a potential connection exists between animal interactions and chocolate consumption.

It has been shown that consumption of chocolate results in a reduction in perceived stress for some individuals. (Al Sunni) Much as with the interactions with animals, this stress reduction may result in changes in cognitive performance. However, chocolate, or more specifically cocoa flavanols, have been proven to impact the brain and improve cognition. It has been shown that cocoa flavanols have neuroprotective and neuromodulatory properties as a result of long-term consumption. (Sokolov) Consumption of dark chocolate bars results in an increase in brain activity, which may be tied to cognitive functioning, although the exact effects are not well known. (Berk) Chocolate consumption has been shown to result in an acute improvement in cognitive performance within two hours. (Scholey) There have been multiple studies into the usage of cocoa flavonoids to enhance cognitive abilities, which have indicated fast effects after the consumption of chocolate on cognition. (Socci) Therefore, our study seeks to verify these results through further experimentation into the impacts of chocolate consumption on mental abilities, in conjunction with potential cognitive improvements as a result of pet interactions reducing stress.

3 Methods

3.1 Participants

The participants for this study are islanders from the island of Providence. Participants are restricted to the island of Providence to control for potential differences

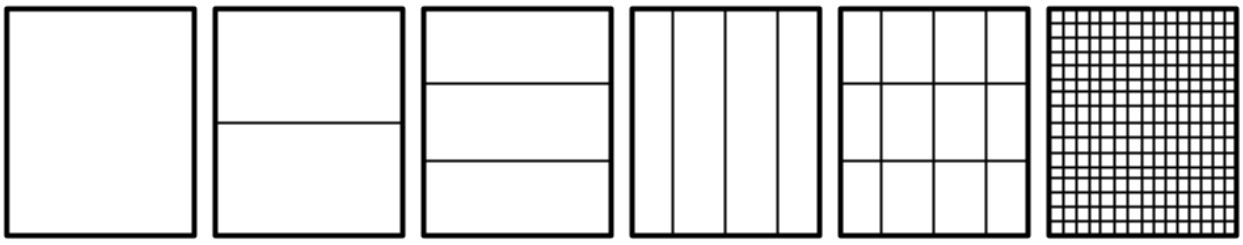
across the three islands. As adult-level processing speed, response inhibition, and working memory are achieved by age 19 (Luna), we restrict participants to individuals aged 19 and older. A list of all households in the island of Providence was obtained. From this, random households were selected using R; if multiple eligible individuals are present in a household, one is selected at random. Both male and female subjects were selected with this process.

3.2 Design

The study is set up as a Two-Way Randomized Block Design, with the following parameters:

Response Variable	Change in "Mental Arithmetic Difficult" Test Score			
Treatment 1: % Chocolate	40%	70%	85%	99%
Treatment 2: Pet	Dog	Cat	Crocodile	
Blocking: Gender	Male	Female		

The factor diagram is detailed below:



We focused on chocolate and pet interactions due to their known impacts on stress, cognition, and the impact of stress on cognition. Finally, we will block with gender to account for possible differences in reaction across genders.

3.3 Instruments

To conduct our study, we used virtual tasks and people on the island. Chocolate is consumed orally in the form of dark chocolate bars. Pet interactions are applied as the subject sits with the assigned pet for a period of time. Mental ability is measured via the application of a test of difficult mental arithmetic problems, for four minutes before and after treatment.

3.4 Procedure

1. Obtain consent from subjects throughout the island of Providence. An equal number of male and female subjects must be obtained.
2. Randomly assign these subjects (already divided by block) into treatment groups for study. These groups are the combinations of the two treatments, for a total of 12 treatment groups per block.
3. For each subject, measure their baseline mental ability through the mental arithmetic difficult task.
4. For each subject, apply the first treatment (chocolate) by having them eat a chocolate bar of the assigned cocoa percentage. Then, have the subject wait for two hours to ensure the chocolate has had time to take effect. (Socci) Then, apply the second treatment by having the subject sit for ten minutes with their assigned pet. Ten minutes is sufficient for pet interaction to impact stress levels. (Khalid)
5. For each subject, measure mental ability again through the mental arithmetic difficult task.
6. For each subject, compute the difference in score in the mental arithmetic difficult task before and after treatment. This is our response variable.

4 Data Analysis

4.1 Type of Statistical Analysis

We will conduct an ANOVA on the data collected. We will perform an analysis of variance breakdown for the model testing change in scores against Chocolate Percentage, Pet Type, and their interaction, blocked by gender, utilizing the R software. The analysis will use F-tests within groups and blocks to determine if there is a significant difference in the change in test scores between the groups. This will test if either of the treatments, or their interaction, have a significant impact on the change in test scores on the mental arithmetic difficult task.

4.2 Sample Size Determination

We aim to have a minimum power of 0.80 in our study, which means a probability of at least 0.80 that we will correctly reject the null hypothesis if it is false. We used a significance level of $\alpha = 0.05$, which is the probability of falsely rejecting the null hypothesis. We will be using a two-way complete block design, which means the largest degree of freedom required for any of our F-tests is 6, for the interaction between Chocolate Percentage and Pet Type. Utilizing a medium effect size of 0.25, G*Power reveals that the minimum sample size required for a power of 0.80 is 225. However, to have a balanced design, we will have a sample size of 240, so that each group will have 10 subjects. This gives us a true power of 0.83.

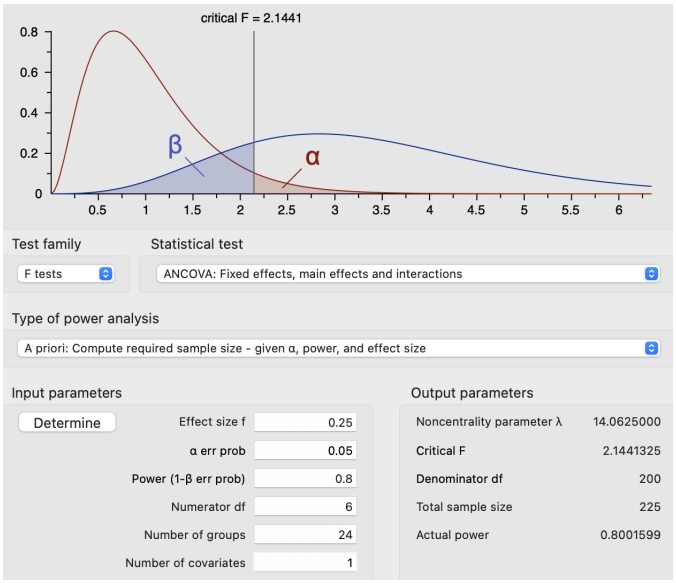


Figure 1: Sample Size Determination

5 Results

5.1 Data Visualization

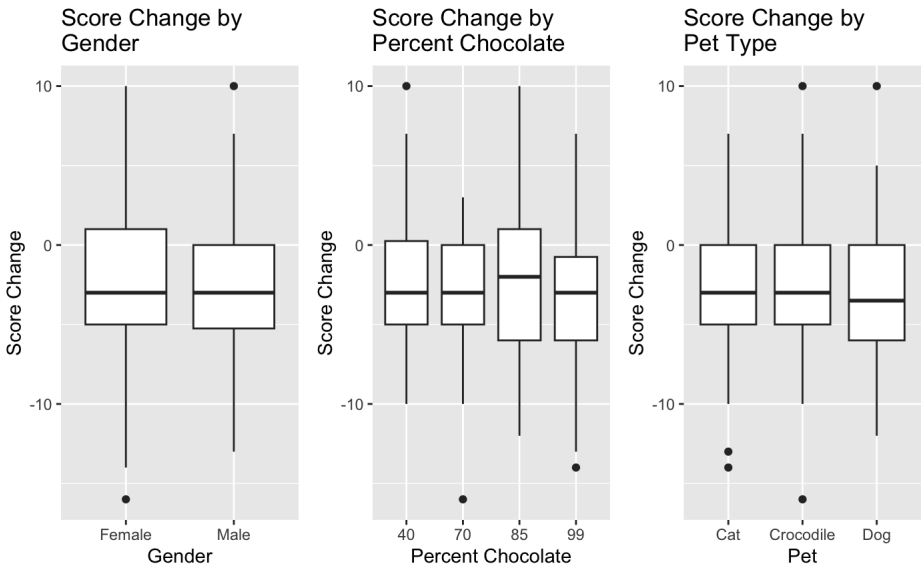


Figure 2: Box Plots Comparing Change in Test Score by Factor

Based on the similarity between each set of side-by-side boxplots, it appears unlikely that there are significant effects due to any factor.

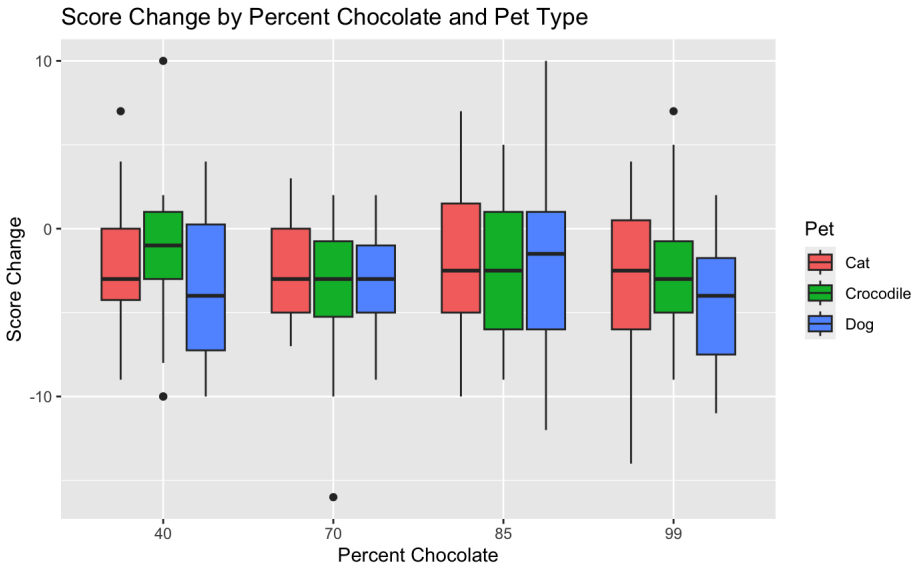


Figure 2: Side-by-Side Box Plots with Interaction

This set of box plots once again shows few differences, indicating the results are likely not significant. However, there is slightly more differentiation for the Dog pet type at 40% Percentage Chocolate.

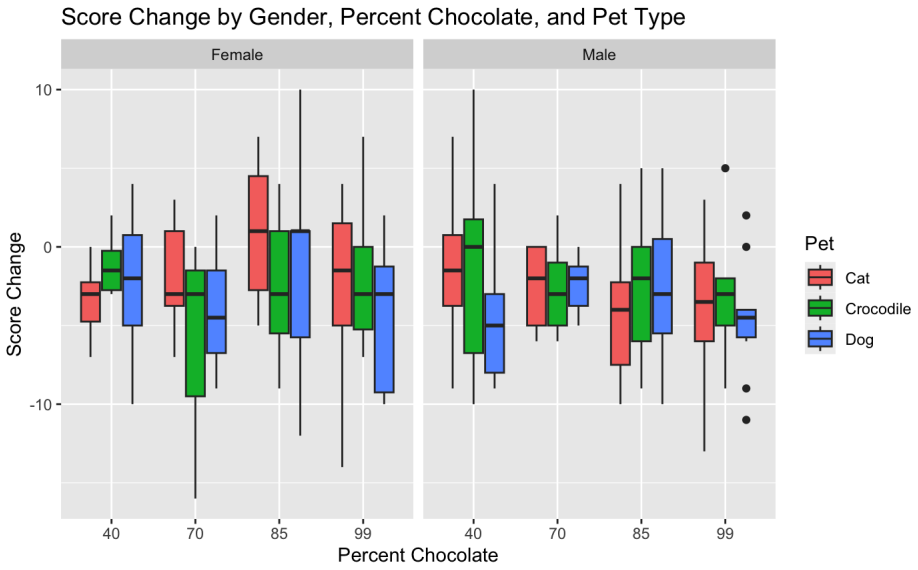


Figure 3: Side-by-Side Box Plots Including Blocking

Once results are blocked by gender, more differences make themselves clear in the box plots. This indicates that, with blocking, results may be significant. However, the box plots are still largely similar to each other, despite these greater deviations.

5.2 Interaction Plot

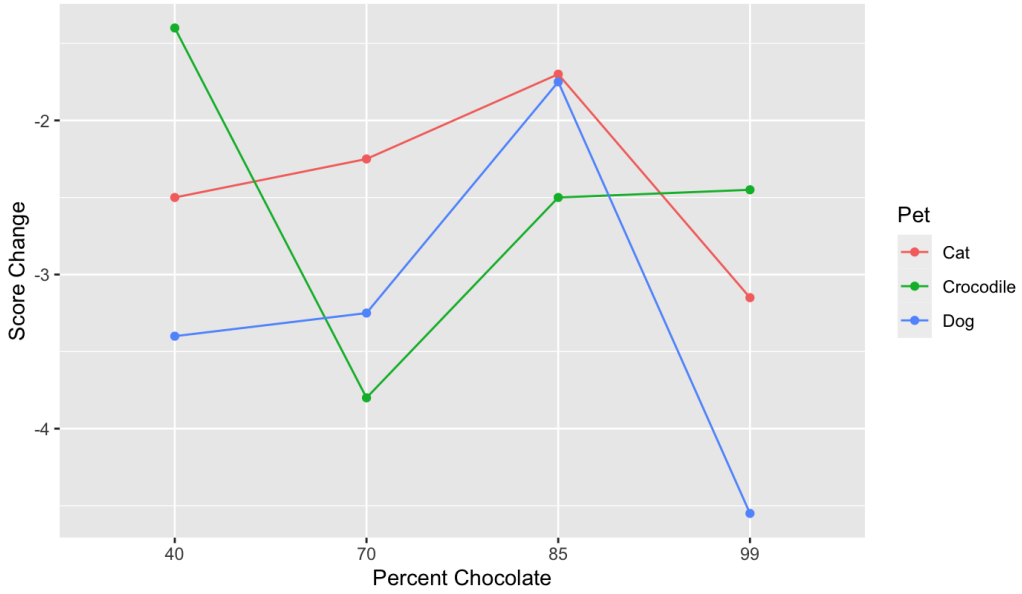


Figure 4: Interaction Plot of Percent Chocolate and Pet Type with Score Change as Response

The plot suggests that the interactions must be considered due to both the extremely different behavior with regard to the pet type of Crocodile and the difference in slope for pet types Cat and Dog between Percent Chocolate 70%, 85%, and 99%.

5.3 Model Diagnostics

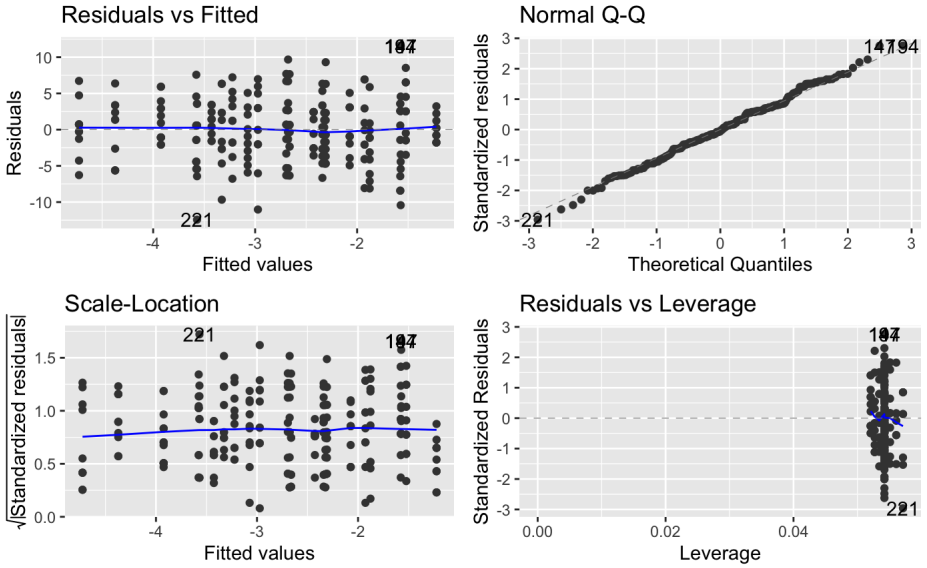


Figure 5: Diagnostic Plots for Analysis of Variance Model

The Residuals vs. Fitted and Scale-Location plots both indicate that the constant variance assumption is satisfied. The Normal Q-Q plot shows the residuals follow the line very closely. Lastly, the Residuals vs. Leverage plot indicates the presence of a few high leverage points, but nothing to be concerned about. As the plots indicate all assumptions will hold, the model is valid.

5.4 ANOVA Analysis

Factor	DF	Sum Square	Mean Square	F Value	P Value
% Chocolate	3	72.6	24.183	1.2949	0.2769
Pet	2	32.3	16.137	0.8641	0.4228
Gender	1	10.0	10.002	0.5356	0.4650
% Chocolate:Pet	6	83.8	13.960	0.7475	0.6120
Residuals	227	4239.3	18.675		

All of the p-values are greater than 0.05. This indicates that neither the design factors nor the interaction have a significant effect on the change in test scores.

6 Discussion

The aim of our study was to determine the impact of chocolate consumption and pet interactions on cognitive function as measured by change in performance on the mental arithmetic difficult test. The sample size of 240 was sufficient to obtain a power of 0.80. It is important to note that subjects were not selected via simple random sampling, so the results are not fully generalizable; random assignment to treatments does however mean we can establish a causal relationship if our results are significant.

Before testing our model, we visualized the data using a series of side by side boxplots. These boxplots helped to reveal information about the impact of each of the factors, independently and when considering interactions. From the boxplots, we found that each factor was unlikely to have a significant impact on the change in test score. They also suggested that interactions should be considered, as the boxplots became more spread out and dissimilar as we considered the interactions between the factors. This was, in fact, supported by our interaction plot, so the interaction between percent chocolate and pet type was included in our final analysis of variances.

Our ANOVA analysis revealed that none of the factors were significant. The p-values of 0.2769, 0.4228, 0.4650, and 0.6120 are all greater than 0.05, indicating that there are no significant differences as a result of any of the factors or interactions. This is an unexpected result, especially the lack of significance for the chocolate concentration percentage. Past research has revealed that chocolate consumption results in an improvement in cognitive abilities (Socci), so the lack of significance is unexpected. The lack of significance with regards to pet interactions, however, is not too surprising. Although animal interactions have long been conclusively tied to stress reduction, studies have not yet managed to show an improvement in cognitive abilities related to such interactions, which was a motivating factor for this study. (Thayer)

Future research into this field of study is necessary to investigate possible relationships. As the p-value obtained for percent chocolate was lower than that for the other factors, although still quite large, it is possible that a much larger sample size, and thus higher power, would have yielded significant results. Additionally, as cognitive ability is impacted differently by stress depending on the assigned task (Sandi), further studies should be carried out with different measures of cognitive ability, as these may yield different results. We utilized mental arithmetic difficult as it was similar to the Serial Threes and Serial Sevens subtraction test which revealed an improvement in cognitive performance (Scholey), but different measures may be useful to investigate. We also must acknowledge the lack of detail provided by the instruments at hand on the island. It is unclear how exactly the subjects interacted with the pets, for example, which may have impacted the study—after all, it has been shown that physically interacting with a pet has a much greater impact than other forms of interaction. There are numerous ways in which this study may be expanded upon further in the future to delve deeper into the potential relationship, despite the lack of evidence found in this study.

7 Conclusion

We did not find any significant effect on cognition as a result of either chocolate percentage or pet type. These findings do not match the literature in terms of the effect of cocoa flavanols, which indicate that consumption of chocolate results in an improvement in cognitive function. (Scholey) This study failed to find a conclusive link between pet interactions and cognitive function, matching the outcome of past studies. (Thayer) Further study is necessary to investigate these factors, potentially utilizing different measures of cognitive function to account for the varying impact of stress depending on the task at hand.

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