A Study on Islanders to Determine the Effect of Methamphetamine and Dark Chocolate on Memory

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1 Abstract

Cognitive function and memory continue to be a hot topic within the world of psychological research and related media. Finding ways to alter or improve this sort of mental ability could massively benefit the general public. In an attempt to make an imperative discovery, my group aims to take two substances that have been linked to altering cognitive function and memory; dark chocolate and methamphetamine and see how taking these two substances at different levels affects the memory score of subjects. Our study involves testing male islanders who live in Hofin with a 2^k factorial design. We then analyzed our data using a Two-Way ANOVA to see how dark chocolate and methamphetamine affected the memory score of the islanders.

2 Introduction

One might be surprised to hear that Switzerland, the country that consumes the most dark chocolate per capita also happens to be the country with the most Nobel prize winners. In recent years, there have been multiple studies that relate the consumption of dark chocolate to improved cognition. The research supports that flavonoids, a polyphenolic compound in which dark chocolate happens to be rich in, are linked to positive impacts on neurocognitive and neuroprotective performance. In our study, we decided to give the test subjects dark chocolate at a low level (40%) and at a high level (99%).

The drug methamphetamine has long been linked to harmful effects on the mind and body. This long-thought notion is challenged in a relatively recent study on rats. In this study, rats were exposed to methamphetamine and then were put in a radial arm maze to test the effects of the methamphetamine on the mice. The final results showed that over a long period, the rats had impairments in memory, but initially the exposure to methamphetamine actually enhanced working memory and increased performance. The explanation for the increase in performance was linked to spikes in dopamine and glutamate within the brain.

With these things considered, our group thought it would be interesting to see how these two substances would affect the memory score of humans. These two substances can both differently affect the brain and memory score. Dark chocolate with flavonoids, which are antioxidants that have been seen to increase blood flow to the brain. Methamphetamine with the surge of dopamine and norepinephrine it gives to the brain. These two chemicals have been linked to affecting the level of cognitive ability and alertness. With all things considered our group predicts that increasing the percentage of dark chocolate and the dosage of methamphetamine both individually and together will lead to an increased performance in memory scores among our test subjects.

3 Methods

3.1 Participants

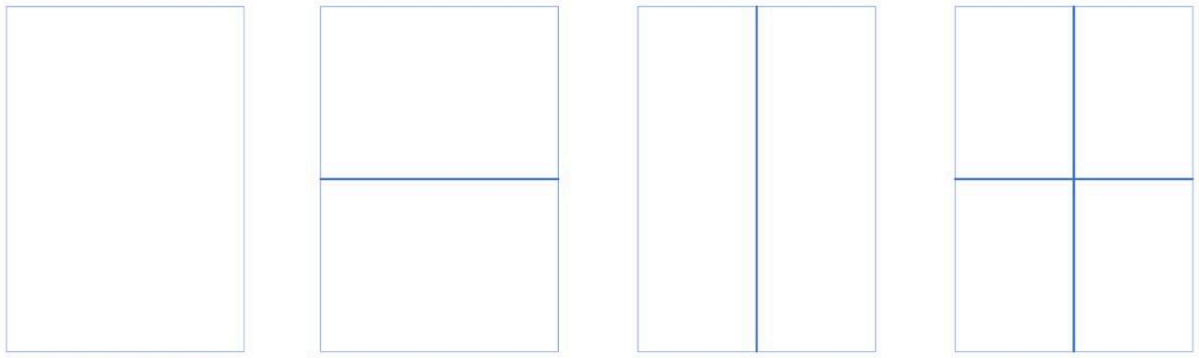
The participants in this experiment will be islanders from the town of Hofn, Ironbard to hold the location constant. We chose to hold constant gender by only sampling males as gender can have an effect on memory. We also only sampled between the ages of 22 and 31 as they will have similar performance on memory. We compiled a list of all eligible participants and then imported the list into R, where we used the sample function to randomly select participants. If a subject refuses to consent, a new participant is randomly selected using R.

3.2 Design

This study is a 2^k factorial design with k = 2. The levels of our treatments are detailed below:

Treatment	Levels	
Dark Chocolate	40%	99%
Methamphetamine	10mg	50mg

Below is the factor diagram for this experiment:



We chose methamphetamine and dark chocolate because of their known attributes of affecting memory. Our goal is to see whether there is a difference when you compare a high and low dosage of methamphetamine and a high and low percentage of dark chocolate. Additionally, we aim to see if there is any interaction between methamphetamine and dark chocolate that has a significant effect.

3.3 Instruments

Memory will be tested using a pairs memory game with 30 cards. Participants are timed on how quickly they can complete all pairs. Dark chocolate is given in 50g bars. The methamphetamine is injected using a saline solution. We opted for an injection rather than a pill because it goes directly into the bloodstream so we did not have to wait to record memory scores after the injection.

3.4 Procedure

Step 1: Obtain consent from the randomly selected subjects, and if consent is refused, randomly select a new participant.

Step 2: Randomly assign each participant to one of our four treatment groups. The different groups are:

1. 40% Dark Chocolate, 10mg Methamphetamine
2. 40% Dark Chocolate, 50 mg Methamphetamine
3. 99% Dark Chocolate, 10 mg Methamphetamine
4. 99% Dark Chocolate, 50 mg Methamphetamine

Step 3: Give participants their assigned percentage of dark chocolate and wait 15 minutes for it to digest.

Step 4: Administer to each participant their assigned dosage of methamphetamine.

Step 5: Record the time for each participant to complete the memory game.

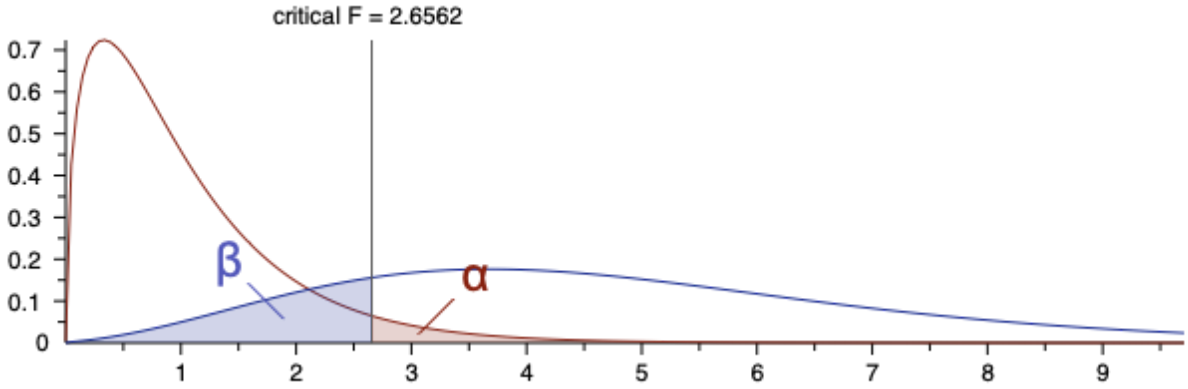
4 Data Analysis

4.1 Type of Statistical Analysis

For this experiment, we will analyze our data with an ANOVA using R. We will conduct an F test to determine if there is a difference between the different levels of our treatments. We will also test if there is an interaction between dark chocolate and methamphetamine and will be using a Tukey HSD test to determine whether the difference between any of the interactions is significant.

4.2 Sample Size Determination

We used G*Power to determine our sample size with a power of 0.8, an alpha of 0.05, and an effect size of 0.25. From the power, we know that the probability that we will correctly reject the null hypothesis is 80%. From the alpha, we know that the probability that we will incorrectly reject the null hypothesis when it is true is 5%. We chose a medium effect size because it will give us a good balance between practicality and significance. G*Power returned a total sample size of 179. To have a balanced design, we rounded up to 180 resulting in each group having a size of 45 participants.



5 Results

5.1 ANOVA Analysis

To evaluate the effects of dark chocolate, methamphetamine, and their interaction on memory retention, we performed a two-way ANOVA test.

	DF	Sum Square	Mean Square	F Value	P Value
Methamphetamine	1	249	249	1.638	0.202302
Dark Chocolate	1	4043	4043	26.547	6.85E-07
Methamphetamine:Dark Chocolate	1	2092	2092	13.738	0.000281
Residuals	176	26805	152		

Table 1: Two-way ANOVA table with interaction.
The p-value of 0.202 for methamphetamine suggests that methamphetamine on its own does not have a statistically significant effect on memory retention. Dark chocolate, however,has an extremely low p-value (<0.001), which suggests that it makes a statistically significant influence on memory retention. Similarly, we can see that the interaction between methamphetamine and dark chocolate also has a significant p-value. Therefore, we can conclude that a combination of both methamphetamine and dark chocolate plays a significant role in memory retention.

5.2 Tukey HSD Adjusted P-values

We will use Tukey's Honesty Significance Difference to correct against type I errors, and to analyze exactly which levels of dark chocolate and methamphetamine have the most significant effects on memory retention.

Methamphetamine Tukey HSD

Comparison	Difference	Lower	Upper	P Value Adjusted
50mg - 10mg	-2.354444	-5.985169	1.27628	0.2023023

Dark Chocolate Tukey HSD

Comparison	Difference	Lower	Upper	P Value Adjusted
99% - 40%	9.478889	5.848164	13.10961	7.00E-07

Table 2: Tukey HSD Post-Hoc Comparisons for Methamphetamine and Dark Chocolate.
This table further supports our claim that different levels of methamphetamine (10mg vs. 50mg) do not seem to have a statistically significantly different effect on memory retention, but the different levels of dark chocolate do seem to impact memory retention significantly differently.

Interaction Tukey HSD

Comparison	Difference	Lower	Upper	P Value Adjusted
50mg:40% - 10mg:40%	4.464444	-2.2838023	11.212691	0.218478
10mg:99% - 10mg:40%	16.297778	9.549531	23.046025	0
50mg:99% - 10mg:40%	7.124444	0.3761977	13.872691	0.0340965
10mg:99% - 50mg:40%	5.0850866	5.0850866	18.58158	0.000059
50mg:99% - 50mg:40%	-4.0882468	-4.0882468	9.408247	0.7365626
50mg:99% - 10mg:99%	-15.9215801	-15.9215801	-2.425087	0.0029991

Table 3: Tukey HSD Post-Hoc Comparisons for the Interaction Between Methamphetamine and Dark Chocolate.
This table further specifies that there is a statistically significant difference on memory retention between the following interactions:

- 10mg methamphetamine and 99% cacao vs. 10mg methamphetamine and 40% cacao
- 50mg methamphetamine and 99% cacao vs. 10mg methamphetamine and 40% cacao
- 10mg methamphetamine and 99% cacao vs. 50mg methamphetamine and 40% cacao
- 50mg methamphetamine and 99% cacao vs. 10mg methamphetamine and 99% cacao

We came to these conclusions since each of the p-values for these combinations is below 0.05, which we have chosen to be our significance level.

5.3 Residual Diagnostics

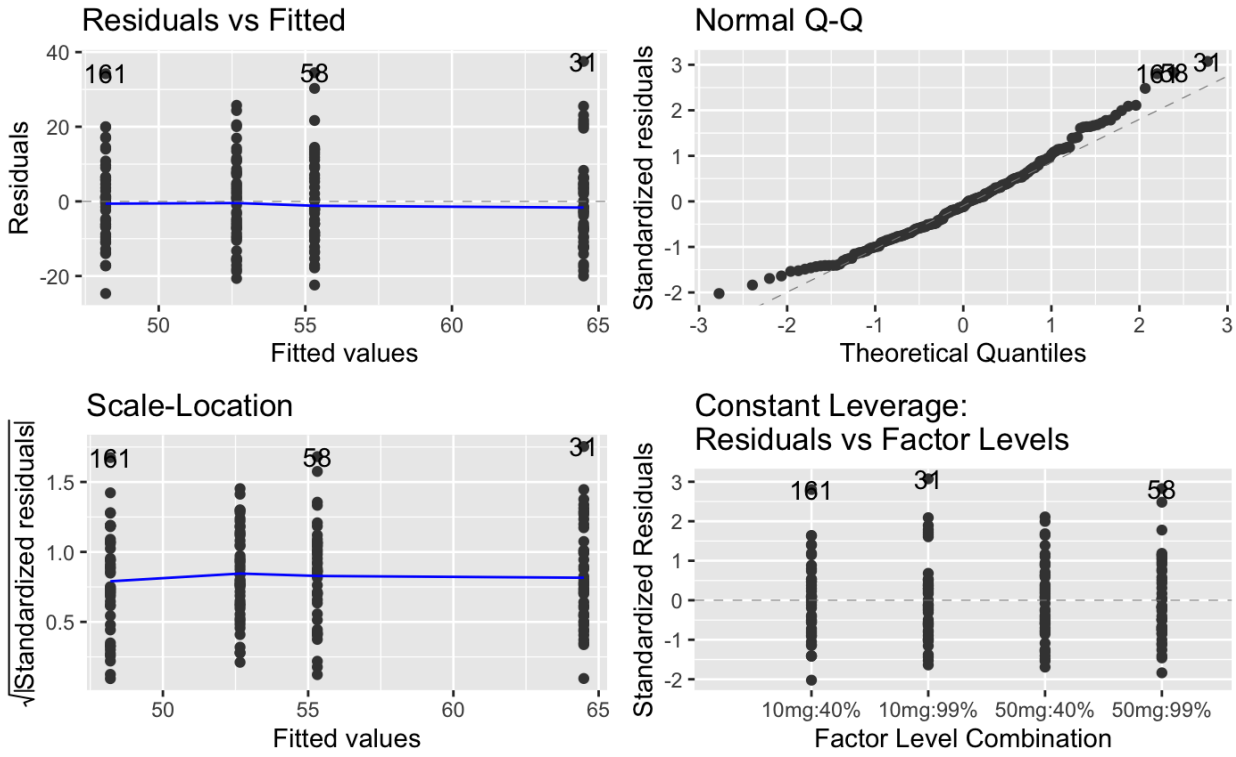


Figure 1: Summary Plots of Residuals for ANOVA Results.
Each of the four plots (Residuals vs Fitted, Normal Q-Q plot, Scale-Location, Constant Leverage) suggest that the residuals stay constant and that the assumption of constant variance is satisfied. The Residuals vs Fitted plot shows a linear relationship, and confirms that the average of the errors lies around 0. The normal Q-Q plot further suggests that the errors are approximately normal. Additionally, the Scale-Location plot further confirms that there is an approximately constant variance of the error term. Therefore, we can conclude that the model assumptions are satisfied.

5.4 Interaction Plots

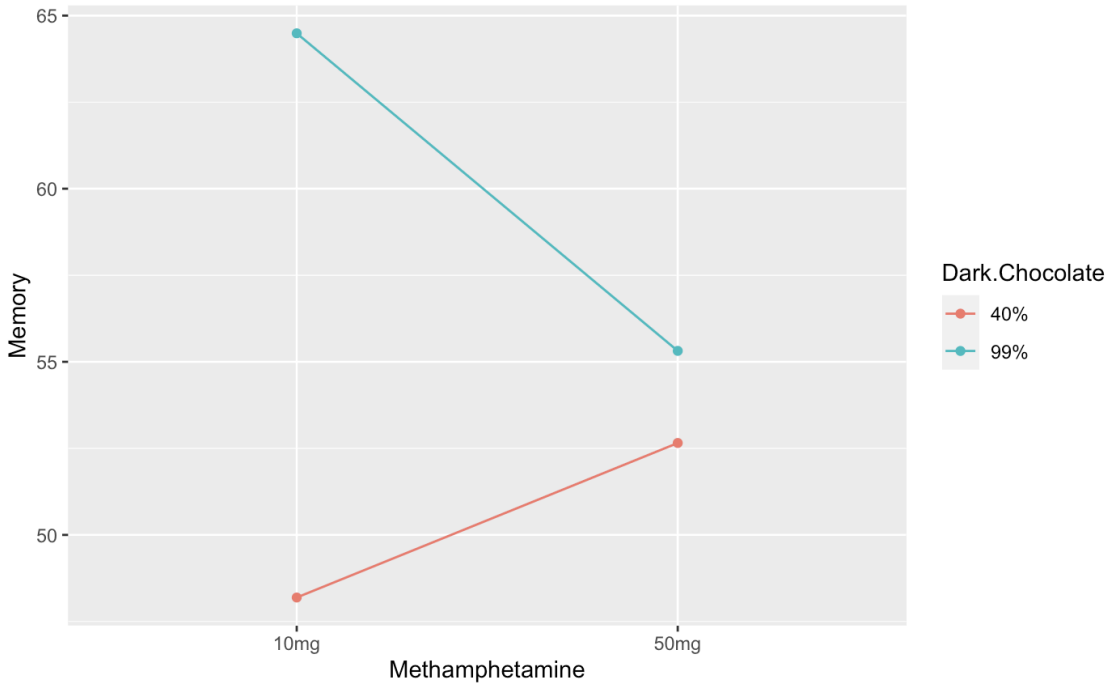


Figure 2: Interaction Plot of Methamphetamine and Dark Chocolate on Memory Scores.
The interaction plot tells us that participants who consumed 99% dark chocolate consistently obtained higher memory scores than those who consumed 40% dark chocolate, regardless of methamphetamine dose. This aligns with our conclusions from the ANOVA table. Additionally, we see that the memory scores for participants who consumed 40% chocolate increased with a higher dose of methamphetamine (from 10mg to 50mg). However, the plot also suggests that, for those participants consuming 99% dark chocolate, a higher methamphetamine dose significantly decreased their memory score.

There is an evident interaction between methamphetamine and dark chocolate, indicating a trend where the combined effect of methamphetamine and dark chocolate on memory performance depends on the levels of each factor.

5.5 Box Plots

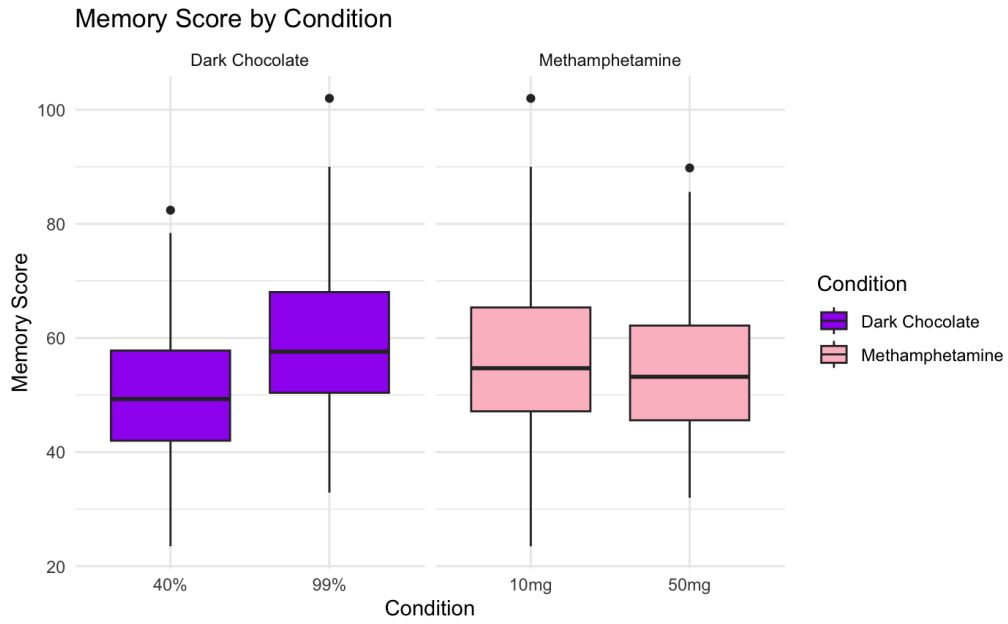


Figure 3: Box plots comparing Memory Score for different levels of Methamphetamine and Dark Chocolate.

The box plots for dark chocolate indicate that the memory scores are generally higher for participants who consumed 99% dark chocolate as opposed to 40% dark chocolate, the median for the 99% dark chocolate is higher than that of the 40% dark chocolate group.

The box plots for methamphetamine indicate that the median memory score for both 10mg and 50mg is relatively similar.

There seem to be high outliers in the memory scores for both levels of methamphetamine and both levels of dark chocolate, indicating that some participants had significantly higher memory scores than the majority.

6 Discussion

The aim of this study was to determine the effects of dark chocolate and methamphetamine on short term memory retention, as well as how those effects changed depending on the quantity of cocoa in chocolate and the concentration of dosage in methamphetamine.

In order to achieve a power of 0.8 for our study, we used a random sample of 180 people. We limited our sample to young adult males from one city on the island to limit the impact of other factors on the results. The participants were split into 4 groups and given dark chocolate, after which they waited 15 minutes and were injected with methamphetamine, and then they participated in a pairs memory card game. After collecting the data from the island, the Anova analysis that we did found that dark chocolate as well as the interaction between dark chocolate and methamphetamine had a

statistically significant impact on the performance of the subjects in the memory test, although methamphetamine on its own was not statistically significant. The Tukey HSD test further showed that while most of the differences between the interactions were significant, changing the dosage of methamphetamine was not very significant compared to changing the amount of cocoa in the dark chocolate. Our box plots showed that while the medians for the memory score after consuming chocolate were different depending on the percentage of cocoa with dark chocolate consisting of 99% cocoa having a higher memory score than dark chocolate with 40% cocoa, the medians of the memory score after receiving methamphetamine injections remained similar to each other regardless of the dosage amount, which is consistent with the results from the rest of the analysis.

These findings led us to the conclusion that the percentage of cocoa in dark chocolate had a significant effect on the memory performance of the participants in the study, with higher concentrations of cocoa leading to improved short term memory performance, but methamphetamine alone did not have a statistically significant effect on the memory performance.

There are however some limitations in this study, and further research is needed for more comprehensive conclusions that can be applied to a broader population outside of this study. For one, this study was conducted on the computer generated island, and the mechanics of the island as well as how different treatments affect the people living there may not necessarily accurately represent how these treatments impact people in real life. Another limitation is that this study only looked at one specific demographic - young adult males from one city, and it's possible that people from different demographics may react differently to the effects of varying dosages of cocoa and methamphetamine in their body. The study also only measured memory performance 15 minutes after the participants consumed dark chocolate and immediately after the methamphetamine injection, so it is possible that the results would be different if the memory performance was measured after a longer waiting time, which would mean the treatments would be in the body for longer, potentially leading to different effects. Another potential limitation of the study was that we measured memory through one type of memory card game, but it is possible that different types of memory tests would lead to different results.

For future research it would be beneficial to look at the long term impacts of both of these treatments, as this study was limited to the immediate results of taking dark chocolate and methamphetamine for one day only. It is possible that taking dark chocolate or methamphetamine over the course of several years has a long term impact on the memory performance of individuals which is significantly different from the short term impact. It is also worth studying and considering the side effects of dark chocolate and methamphetamine (which were not considered in the study) to fully understand the benefits and drawbacks of their use.

7 References

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