The Effect of Drugs and Exercise on Memory

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1. Abstract

In the medical space, methamphetamine is used to treat obesity and ADHD, and morphine for treating severe pain. Athletes or people who exercise often may be more prone to injuries or body conditions that require the uses of these drugs. However, their athletic performance and long-term health levels may be impacted by the use of these drugs. Our study investigates the effect of drug use and active exercise (to simulate the degree of athleticism for athletes) on cognitive ability (measured by memory performance), and follows a two-factor ANOVA design with interaction. With the results of this experiment, we may be able to contribute to further research surrounding the continued medical applications of methamphetamine and morphine for athletes.

2. Introduction

Methamphetamine is a powerful central nervous system stimulant primarily used to treat attention deficit hyperactivity disorder (ADHD) and certain cases of obesity. It facilitates increased release of dopamine, norepinephrine, and serotonin, which leads to more alertness, concentration, and energy. However, its high potential for abuse and addiction limits its medical use. Chronic use of methamphetamine can lead to severe cognitive deficits, including impairments in memory and executive function, due to its neurotoxic effects on dopaminergic and serotonergic neurons.

Morphine, on the other hand, is an opioid analgesic used extensively for pain relief in various medical conditions, including postoperative pain, cancer pain, and chronic pain conditions. It acts on the central nervous system to alleviate pain by binding to opioid receptors, leading to decreased perception of pain and increased pain tolerance. Morphine, however, can lead to physical dependence and addiction, and its chronic use can also impair cognitive function, particularly memory and learning, due to its depressant effects on the central nervous system.

In the context of athletes, who often experience acute and chronic pain due to injuries, the use of these drugs poses significant concerns. The potential cognitive side effects, such as memory impairment, could impact their performance and recovery. Moreover, the interaction between methamphetamine and morphine can have synergistic effects, leading to enhanced euphoric and analgesic effects, but also increased risk of adverse outcomes, including severe cognitive deficits and behavioral changes. Thus, our study aims to determine if either of these drugs, or their interaction, has significant effects on cognitive ability as measured by memory performance scores.

3. Methods

3.1 Participants

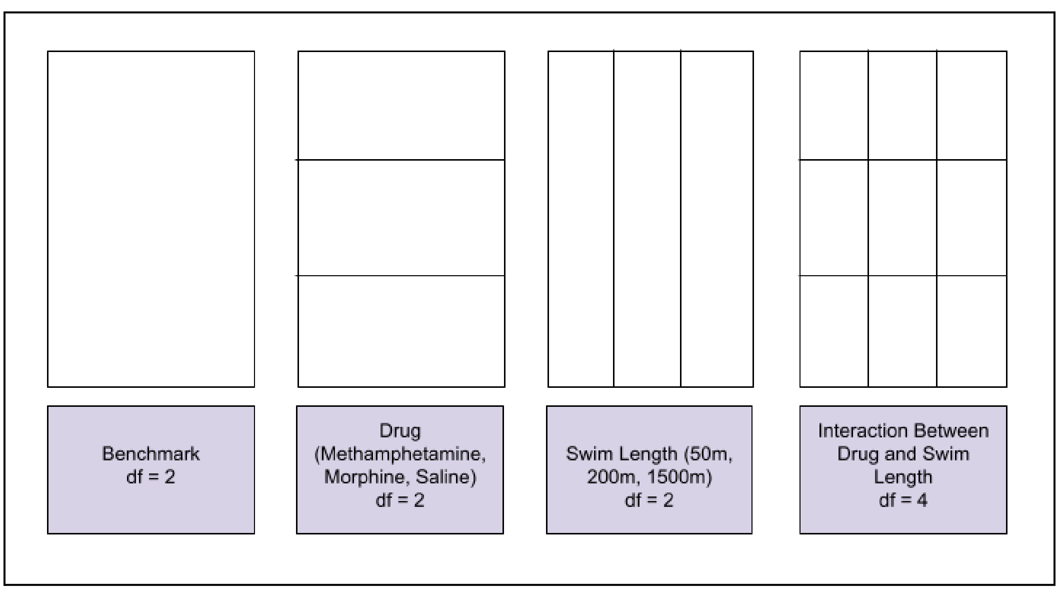
The participants will be islanders. Considering that variables like gender and age have a significant impact on athletic performance and physical activity, we restricted our sample to men in the age bracket 18-35. Given the nature of the island, we were unable to collect a truly random sample, and instead adopted pseudo-random methods. We randomly selected nine cities on the islands, three from each land. For each of these nine cities, we sampled the first nine men aged 18-35 that agreed to participate in our study, and assigned each of them one of the nine treatments.

3.2 Design

The design adopted will be a Two-Factor Random Basic Factorial Design. The design can be visualized in the following table:

Response Variable	*% Change in Memory Test Score*		
Treatment 1 (Drug)	Methamphetamine 50mg	Morphine 20mg	Saline 3mL
Treatment 2 (Exercise)	Swim Freestyle 50m	Swim Freestyle 200m	Swim Freestyle 1500m

The following factor diagram also details the design:



We specifically chose to evaluate morphine and methamphetamine (compared to a control, saline) based on their negative effect on cognitive function in past studies. We hope to determine if this remains applicable to individuals involved in exercise. We focused on exercise since a lot of athletes are prescribed drugs for recovery purposes, and wanted to evaluate any possible effects of this interaction as previous studies have mentioned exercise as a contributor to improvement in memory performance.

3.3 Instruments

Memory will be measured from the islanders using the Memory Test. Islanders are given two minutes to look at 10 cards drawn from a 52-card deck and then must write down all the cards they can remember in one minute. We chose to use the Memory Test as it measures the potential immediate effect on memory after drug use and exercise. The drugs (methamphetamine, morphine, and saline) are administered by injection.

3.4 Procedure

Step 1: Find male subjects, aged 18-35, willing to be a part of the study (selecting nine individuals from nine different regions for a total of 81 subjects).
Step 2: For the nine subjects in each region, randomly assign the different treatments. The different treatments are:

- Methamphetamine 50 mg — Swim Freestyle 50m
- Methamphetamine 50 mg — Swim Freestyle 200m
- Methamphetamine 50 mg — Swim Freestyle 1500m
- Saline 3 mL — Swim Freestyle 50m
- Saline 3 mL — Swim Freestyle 200m
- Saline 3 mL — Swim Freestyle 1500m
- Morphine 20mg — Swim Freestyle 50m
- Morphine 20mg — Swim Freestyle 200m
- Morphine 20mg — Swim Freestyle 1500m

Step 3: For each subject, administer the Memory Test.
Step 4: For each subject, apply their assigned treatment by either injecting 50mg of methamphetamine, 3mL of saline, or 20mg of morphine.
Step 5: Subsequently, apply the second component of their assigned treatment by having them swim freestyle for either 50m, 200m, or 1500m.
Step 6: For each subject, administer the Memory Test again.
Step 7: For each subject, compute the percentage change in Memory Test score before and after the treatment. Note that this will be the response variable in further analysis.

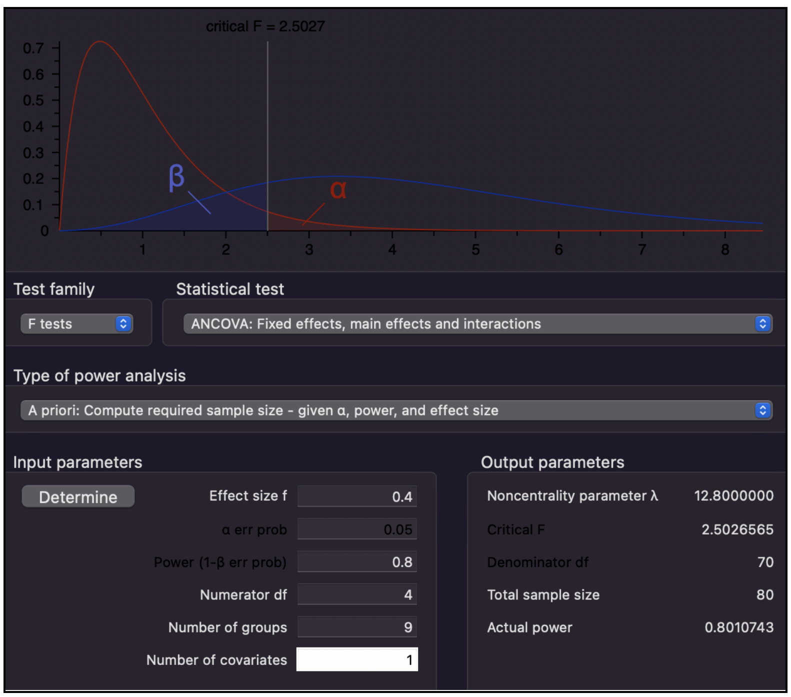
4. Data Analysis

4.1 Type of Statistical Analysis

Using R software, we intend to generate an ANOVA table on the data we collect, namely conducting a series of F-tests to determine if there is significant percent change in the Memory Test Score before and after the treatments, and if there is a significant interaction between drug type and exercise.

4.2 Sample Size Determination

We aimed to use a power of 0.80, which coincides with having 80% probability of correctly rejecting the null hypothesis. We evaluated all our data at a 0.05 significance level, and a medium effect size of 0.40. Given that we have two factors in our design (drug and exercise) with three levels each, we have a total of nine treatment groups. Inputting this information into G*Power software, we get that the required total sample size is 80. Since we have nine treatment groups, in order to have a balanced design we will round up the total sample size to 81 (achieving nine samples per treatment group).



5. Results

5.1 ANOVA Analysis

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Drug	2	3284.61	1642.30	1.17	0.3150
Exercise	2	627.81	313.91	0.22	0.7996
Drug:Exercise	4	4425.44	1106.36	0.79	0.5349
Residuals	72	100721.13	1398.90		

Table 1: Two-way factorial design with interactions ANOVA table. The p-values of 0.315, 0.7996, and 0.5349 of drugs, exercise, and the interaction between the two respectively are all quite large and are all greater than 0.05. These p-values indicate that none of the variables have a significant influence on the % change in memory score, especially that of exercise, which had the highest p-value out of drug and the interaction between drug and exercise (0.315).

5.2 Tukey HSD

	diff	lwr	upr	p adj
Morphine 20mg-Methamphetamine 50 mg	13.93	-10.43	38.29	0.36
Saline 3 mL-Methamphetamine 50 mg	0.88	-23.48	25.24	1.00
Saline 3 mL-Morphine 20mg	-13.05	-37.41	11.31	0.41

Table 2: Post-Hoc Analysis of Percentage Change In Memory Score Between Different Drug Types. Using Tukey's Honesty Significant Difference to correct against type I errors, comparisons between the average percent change between the different drug types were made. Looking at the table, we see that none of the percent changes in memory score between the different types of drugs were significant, the lowest being a p-value of 0.36. Therefore, there is not sufficient evidence to suggest that there is a significant difference in the percent change of memory score between any of the different drug types.

5.3 Residual Diagnostic

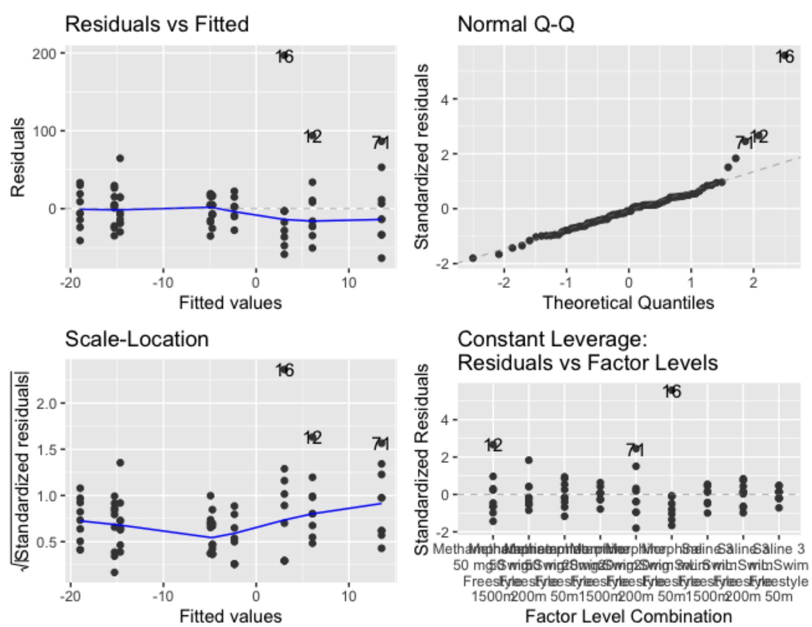


Figure 1: Summary Plots of Residuals for ANOVA Results. Looking at the residuals vs fitted plots, we can see that the points do not have a clear pattern, which suggests that the assumption

of constant variance is not violated. The points are also seemingly scattered randomly. The QQ norm plot also shows that the assumption of normality is not violated, as the points follow the line. Therefore, we can conclude that the model is a good fit for the data.

5.4 Interaction Plots

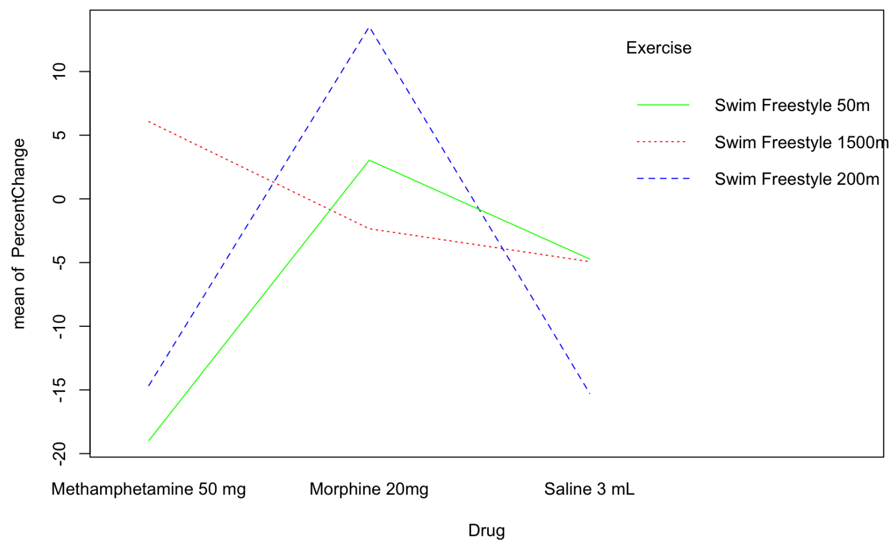


Figure 2: Interaction Plot of Drugs and Exercise with Percent Change in Memory Score as response. The interaction plot suggests that there are interactions between all of the variables, as they all intersect with each other.

5.5 Box Plots

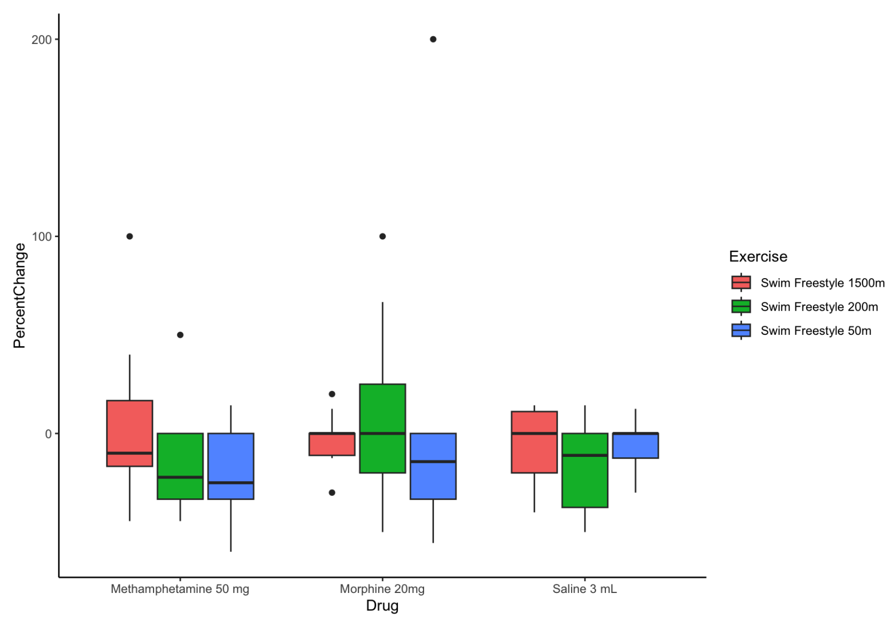


Figure 3: Box Plots Comparing Percent Change in Memory Score Between Drug Type and Exercise Distance. The median is represented by the black bar in the middle of the boxes. The 1st and 3rd quartiles are shown by the boxes, and any outliers are shown as points.

6. Discussion

The primary goal of our study was to determine if there was a significant effect of drugs and exercise in cognitive ability and memory performance. The results of our study refute the idea of memory deficit in athletes who are prescribed methamphetamine or morphine for rehabilitation purposes.

We intended to keep gender and age constant, choosing all males aged 18-35, and we also selected an equal number of islanders from nine random islands, ensuring that the differences in the islands wouldn't be a confounding factor in our experiment. We intended to have a sample size of 81 to achieve a power of 0.8. After running our experiment, the ANOVA analysis of our results concluded that there were no significant differences between the use of drugs on memory as well as exercise on memory. In fact, the p-values were all quite large. The smallest p-value, coinciding with the drug factor, was 0.315, so we looked into the factor with the post hoc Tukey HSD test to see if there were any significant differences between the different drug types.

Looking at the Tukey HSD test, we noticed that there again weren't any differences within the different types of drugs. The Tukey confidence intervals reflected that, as there were no factors that had a significant deviation from the overall mean. Therefore, there is no conclusive evidence that any of the drugs that we tested had a significant difference in the percent change of memory test score.

The interaction plot reveals the relationship between the different drugs we tested as well as the different distances we had the islanders swim. The plot shows that there are possible interactions, as all of the lines intersect each other. However, as noted above, after conducting the ANOVA analysis we see that the interaction between drug and exercise do not have a significant effect on memory test score.

When looking at the boxplot, we can see that there is no real difference between the three drugs and exercises. That is, for each factor the three levels appear to have around the same mean percent change in memory test score. This supports the conclusion that there were no significant differences between the factors and the response.

We acknowledge that there are limitations to our experimental design. One concern is the method of measuring memory. The method that we used was to have the islanders look at 10 cards for 2 minutes and write down as many cards as they could in 1 minute. The problem with this method of measurement is that it only allows for 10 distinct values that the response variable can be, meaning that we are unable to capture any changes between 4-5 for example. This could lead to inaccurate results and may skew the results and show that there was no significant difference when there may have been. Another potential limitation to our experimental design is lack of variety in drug dosage. While we concluded that the drug factor is not significant, this could be misleading as we only account for one particular amount of each drug. It is possible that increases in doses could show significant differences in memory test scores.

7. References

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