Dextroamphetamine: A Study of Individual Performance on the Most Common Mental Performance Enhancer

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ABSTRACT

This study aims to examine the effects of dextroamphetamine, the most prevalent ingredient in the infamous “Adderall” drug, on people’s mental ability in solving difficult problems. Many people have been known to abuse the drug in order to gain a higher sense of focus and enhance their abilities to think critically in high pressure situations. In order to determine if this is an effective way to boost mental capacity, our study took a sample size of 93 people on the virtual Island and split them into three groups based on low, average, and high IQ scores. Using a repeated measures design, we were able to collect our data by recording each subject’s baseline score on a difficult mental arithmetic exam and then giving each subject doses of 10 mg, 20 mg, and 30 mg. We then had them retake the exam after each dosage increase, giving the subjects one full day to recover after each exam. Our results showed that there is a statistically significant relationship between the dosage of dextroamphetamine and scores on the exam administered by our team. There was no significance in the interaction of IQ level and dosage amount, demonstrating that it cannot be concluded that the effects of the amount of the drug differ for individuals of different IQ levels.

1. INTRODUCTION

The modern world is becoming an increasingly competitive one. College acceptance rates are at an all time low (Korn). Workplace stress levels have risen nearly twenty percent in the last thirty years (Workplace). In this environment, it is unsurprising that individuals looking to gain an advantage on the playing field are turning to self-medication in an attempt to artificially boost their capabilities.

One such medication is Adderall. A mixture composed primarily of dextroamphetamine salts usually prescribed as a treatment for Attention Deficit Hyperactivity Disorder (ADHD), Adderall has also been abused as a “smart pill” for decades. Non-prescription users without ADHD report that the drug helps them achieve a heightened level of focus, allowing them to absorb information faster, work at an accelerated pace, and maintain performance for longer periods of time, though existing studies have not substantiated the existence of these perceived effects (Schwartz; Lakhan and Kirchgessner).

As a result of these purported off-label benefits, Adderall (and other similar drug) abuse has been steadily on the rise. A study by Johns Hopkins University found that nonmedical use of Adderall increased by 60% between the years of 2006 and 2011 (Chen et al.). An article published in Psychology Today reports that the number of Adderall, or equivalent, prescriptions tripled between 2008 and 2012 (Sack). Such rising rates of abuse are cause for significant concern. Along with the possibility of a potentially fatal overdose, long term Adderall abuse comes with side effects including aggressive behavior, paranoia, anxiety and seizures (Lautieri). Additionally, studies have shown that overuse of the "smart pill" may be associated with memory and/or coordination loss in the long term (Berman et al.).

With so many serious side effects, it is important to examine the root cause off-label use of stimulants such as Adderall: the belief that they will increase productivity and cognitive ability. The purpose of this study is to examine these anecdotal benefits of Adderall to test if there is any validity to the claims. If there is, the drug may, under controlled circumstances, have additional prescription uses. If there is not, then experimental evidence showing the ineffectiveness of stimulants for boosting performance may help curb the rising rates of their abuse.

2. METHODS

2.1 Participants

We selected islanders from the simulated Island program. The sample size was determined the sample size using the G*Power applet with a power setting of 0.8 for 3 groups and 4 treatments. The individuals were selected without regard for location or gender under the assumption that these factors should have little to no effect on our subject's ability to take our initial IQ test or their eventual performance on a mental arithmetic test. We decided to limit age to under 70 years old, even though the IQ test takes this factor into consideration, to minimize the variability of the potency of drugs given. A sample size with power of 0.81 is 84 people.

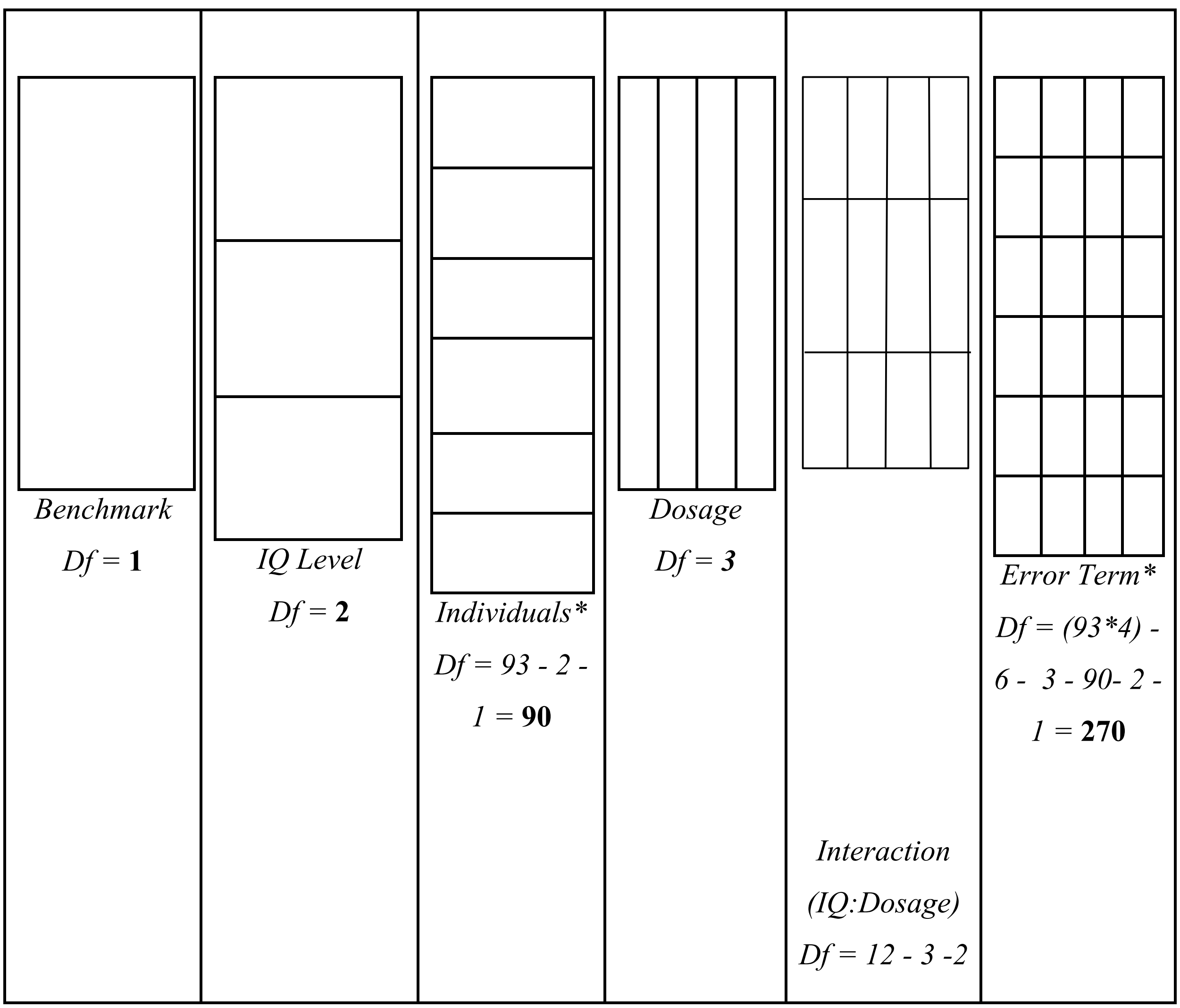
After splitting the subjects into 3 blocks, we added a few extra subjects for a total of 31 subjects per block (93 all together).

2.2 Design

To study the effect of dextroamphetamine, we utilized a repeated measures experimental design. The Islanders' respective IQs served as blocks. The dextroamphetamine treatments were applied to each block in succession.

Each individual underwent successive treatments, allowing one day to pass between each larger dosage for recovery. We sought to measure the effect of drug dose on the cognitive ability of the subjects, as well as examine the interaction between the effects of dextroamphetamine and baseline IQ scores. This was also compared to a placebo treatment.

This experiment design can be represented with the factor diagram:



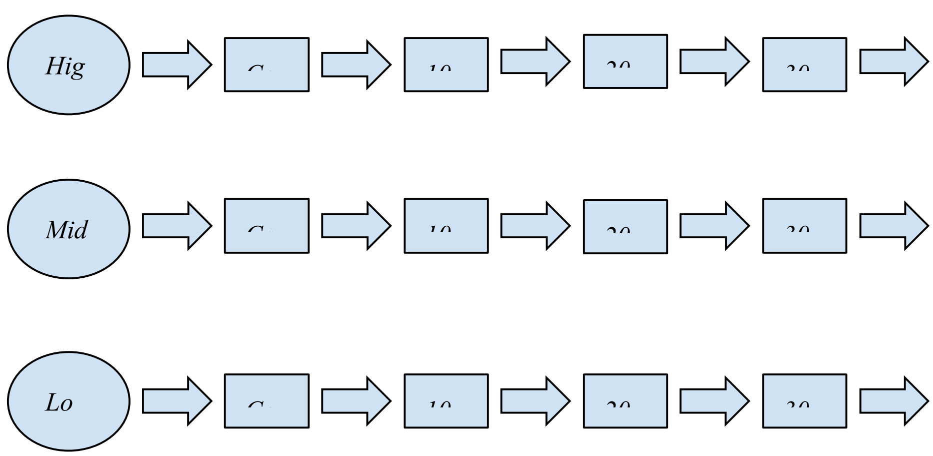
				- *1* = **6**	

*boxes not to scale

It may also be expressed with the effects model:

$$y_{ijk} = \mu + \alpha_i + \beta_{ij} + \gamma_k + (\alpha\gamma)_{ik} + \epsilon_{ijk}$$

2.3 Material and Procedure



To begin the experiment, we selected islanders who agreed to participate in our study from different cities. After finding the appropriate sample size, we split the subjects evenly into three different groups by giving each subject an IQ test and sorting them by their scores into blocks, designated as “low”, “average”, and “high”. “Average” was defined as scores within one standard deviation of the mean. “Low” and “high” were defined as scores one standard deviation or more below and above the mean, respectively. We then proceeded to give each subject an initial diagnostic test to measure their mental ability based on the “Difficult Mental Arithmetic” test. Once we had each subject’s baseline scores, we gave them their first dosage of dextroamphetamine consisting of 10 mg, wait about 30 minutes for the drug to take effect, and then have each subject retake the “difficult mental arithmetic” exam. After recording their scores for this dosage, we repeated the same process on each subject with 20 mg of dextroamphetamine and then 30 mg of dextroamphetamine following that, all spread out with a day of recovery for each dosage increase. Once each subject’s scores had been measured for each dosage of dextroamphetamine, we then compared the results to see if, in reality, there was a difference in their arithmetic scores after taking the dextroamphetamine and, if so, if that difference is more prevalent in those with lower, average, or high IQ’s.

2.4 Instruments

A study of this magnitude with this design required a few different types of materials. First, we needed to have IQ tests for the subjects to take in order to find an initial placement for the subjects. The IQ test served as the benchmark for how “intelligent” the subjects included in our experiment are. In addition, we required multiple doses of dextroamphetamine (Adderall) ranging from 10 mg, 20 mg, and 30 mg, as well as having a “no dosage” control for the experiment. Another material used was the “Difficult Mental Arithmetic” exam to observe how well the subjects performed based on their differing IQ levels and dosage of dextroamphetamine.

The IQ test itself is determined reliable because most subjects will score the same or very close to the same score each time the test is taken in a relatively short period of time. Although the IQ test is not a valid representation of one’s overall capabilities, it serves as a valid test when measuring a subject’s short-term memory, analytical thinking, mathematical ability and spatial recognition. In the same way, the “Difficult Mental Arithmetic” test is determined to be reliable and valid in terms of measuring the subject’s mental problem solving, as well as testing ability of performing calculations with whole numbers and fractions. Using these two exams, it is then possible to examine if their scores on the “difficult mental arithmetic” exam will change when increasing each subject’s doses of dextroamphetamine.

Each of these required materials were made available to us by the organizers of the Island.

2.5 Data Analysis

Data analysis was performed in RStudio. After sorting and transformation of the data, the data was analyzed based on the mathematical model seen in Section 2.2.

Using the G*Power software to determine the needed sample size for the analysis, we noticed that the required sample size varied significantly with different effect sizes. After carefully examining the relationship between the effect size and the sample size, we performed tests on 31 individuals per each IQ level block to randomize the result for each variable. The associated alpha would be 0.05 and power set to 0.80, given an initial estimate of an average effect size.

We began by creating the linear models for our variables in RStudio. By plotting graphs with respect to our variables, we examined the relationship between the residuals and variances to ensure some fundamental assumptions like the normality of residuals and constant variances. After checking the validity of our models, we further analyzed our collected data to see if there are any differences in arithmetic exam scores based on different dosages of dextroamphetamine given and the subject’s initial baseline arithmetic and IQ test scores.

Analysis of variance (ANOVA) was performed several times to determine if there exists a statistically significant explanation of the observed variation between subjects’ exam scores after different doses of dextroamphetamine.

We then looked at the sum of squares, the mean sum of squares, degrees of freedom, corresponding F values, and the p-values for our predictors and other variables. The ANOVA test allowed us to draw a conclusion based on whether or not we saw a difference in exam results for our subjects when consuming different doses of dextroamphetamine. We also generate different plots for easier visual interpretation of the data..

3. RESULTS

3.1 Plots to Evaluate Validity of Model

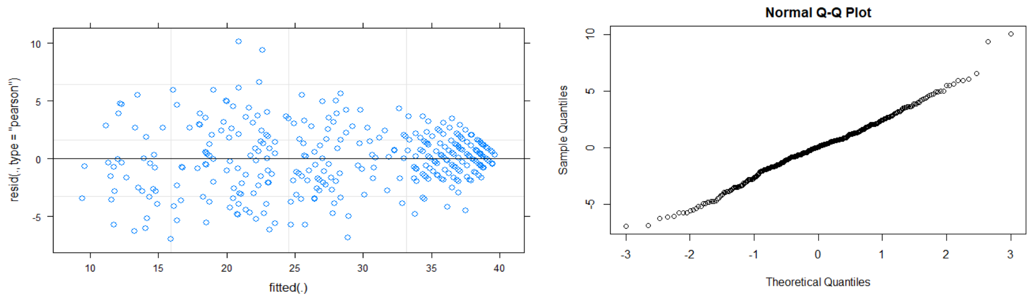


Figure 1: Validity Plots (Constant Variance and Normality)

3.2 ANOVA Tables

Error: Between

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
IQBlock	**2**	**22231**	**11115**	**162.3**	**<2e-16 *****
Residuals	**90**	**6162**	**68**		

Error: Within

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Dose	**3**	**81.8**	**27.264**	**2.967**	**0.0324 ***
Dose:IQBlock	**6**	**68.0**	**11.340**	**1.234**	**0.2889**
Residuals	**270**	**2480.9**	**9.189**		

Figure 2: ANOVA

3.3 Graphs and Visualizations

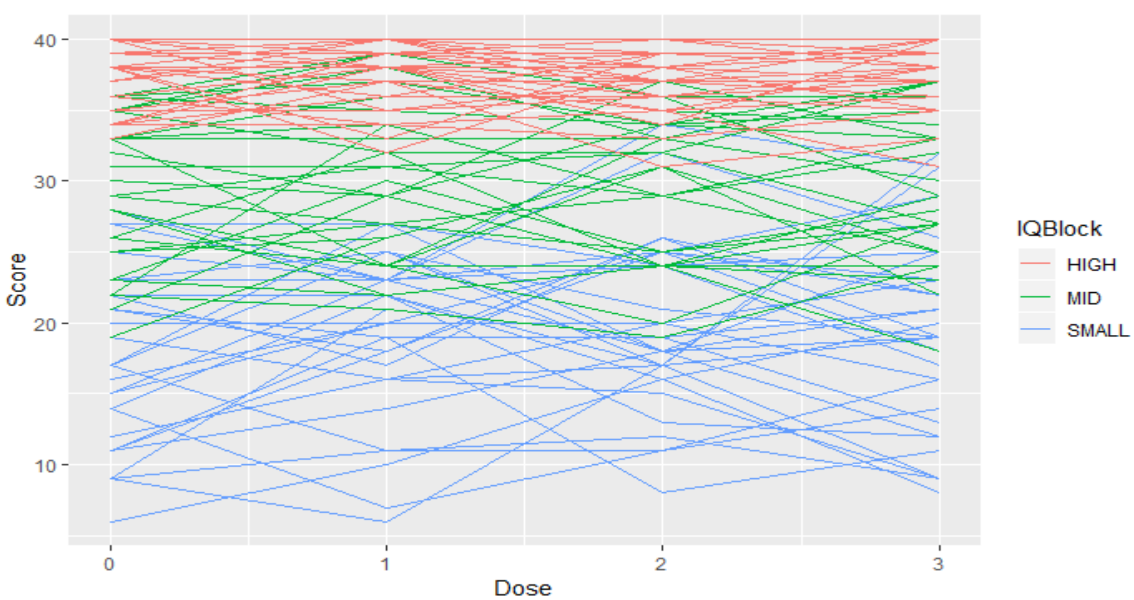


Figure 3: Each Individual's Exam Trajectory

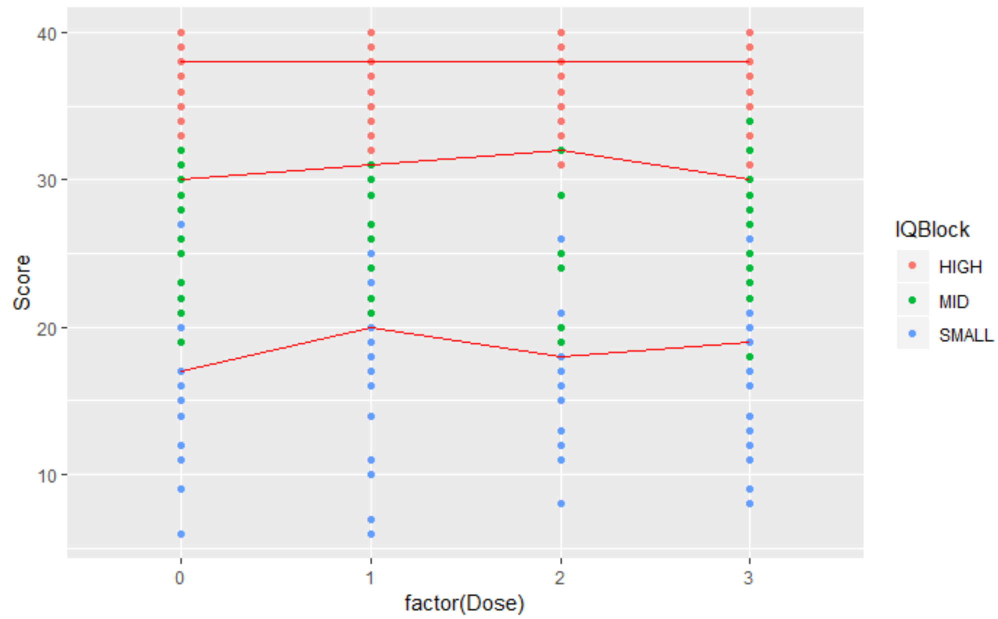


Figure 4: Comparing Means of Each IQ Level

4. DISCUSSION

Our team used two graphs to validate the model. The Q-Q plot plot looks normally distributed and the constant variance plot looks evenly distributed above and below the 0 horizontal line. We can see points following a straight line in the Q-Q plot. This provides strong evidence that the numbers truly did come from a normal distribution.

We used a residuals versus fitted values plot to check the assumption. The errors have constant variance, with the residuals scattered randomly around zero. Therefore, we can assume that the variance in the error terms is constant.

When looking at our ANOVA tables, the factor we are most interested in looking at is Dose to see if there truly is a difference in the performance of our subjects when they are given dextroamphetamine. There is some statistically significant evidence for dosage with an F value of 2.967 and a P value of 0.0324. Our ANOVA also shows that the interaction between Dosage and IQ level is not significant with respect to arithmetic scores with an F value of 1.234 and P value of 0.2889. Not surprisingly, arithmetic scores increase as IQ levels increase, giving us a large F value and P value of nearly 0.

In Figure 3, we gathered the information on the changes in score for each individual across doses. With more than 90 selected subjects, the measured difference in score across doses demonstrated significant variation. Mid and low IQ individuals demonstrated changing performance, with general consistency within the high IQ block.

In Figure 4, we compared the median scores of participants across the three IQ blocks for each level of dose. This is aggregated information from the previous plot, demonstrating the stratified median across each IQblock. As expected, IQ range is strongly indicative of test score across all ranges and doses. The median score flatlines for the high IQ block, given the limitations of the administered test. For the lower two blocks, the median score appears to increase slightly with the introduction of the adderall. This increase is not strongly consistent across multiple doses, with a drop in scores from the low IQ block upon the third dose.

5. CONCLUSION

Some possible issues were encountered during the experiment that may have affected the results, which will be discussed here.

Firstly, results for the high IQ block (score of higher than 120 on IQ pretest) are likely skewed due to limitations of the available tests on the Island. The chosen test, “Difficult Mental Arithmetic” had a maximum score of 40/40, which many members of this group achieved during the control (no dextroamphetamine) test. Because of this, there was no room for these individuals to score better on tests with subsequent doses, thus biasing the effects to be smaller than they likely should be. This, additionally, creates some issues with violations of the homoskedasticity assumption for ANOVA (see plots in section 3.1). While this is an issue, the problem does seem to be contained to only the very upper extremes of the data.

Secondly, the nature of these “Difficult Mental Arithmetic” tests is unclear. It is not known where the test is administered using a randomly selected set of different, but equally difficult questions, or using the same questions every time. If the former is true, the tests can be thought of as a true measure of performance. If the latter is true, however, then differences in scores during each subsequent test may, in fact, reflect participants’ increasing familiarity with the questions.

However, our results showed a statistically significant effect for the dosage, meaning that there is a small difference in exam scores on subjects when they are given stronger versions of dextroamphetamine. In addition, for the interaction we observed no significant evidence of dosage having a difference in effect for the higher vs lower IQ blocks. Therefore, it seems as though the dosage increase has an equal effect on all different types of people with different IQs. It is common for people to use dextroamphetamine as an enhancer even if they aren't prescribed the drug. Our study shows that this effect is similar for group of people with all types of IQs and that increasing dextroamphetamine dosage will result in little to no difference in effect for these subjects. There is a difference in arithmetic exam scores with different doses, yet this is a very small difference which could have something to do with our unexplained variance. As it stands, it seems that while taking some amount of dextroamphetamine is significant over not taking any, the exact dosage is not significant. Based on these results, it may be concluded that Adderall, and other drugs containing dextroamphetamine, do indeed provide some amount of advantage in a specific type of activity and can increase performance under specific circumstances. However, if one chooses to use these drugs for these purposes, one should aim for the smallest possible dosage.

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