The Effects of Strategy-Based Video games on Word Memorization

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Abstract

In a society that has become increasingly geared towards playing video games as a pastime, it is important that we fully explore all the effects that playing these games can have on our bodies and minds. In my experiment I divided a group of 40 subjects equally into an experimental and control group. Each group was tested on their ability to memorize a list of terms over several trials through a memory game called Word Order [4], while taking a break in between rounds to simulate a study break. The experimental groups study break was to play a video game, while the control group simply walked around and stretched. Through this experiment I was able to track the effects of each study break on the groups successfulness with word order.

The results I obtained from tracking their successfulness with Word Order showed mixed results between groups. While the experimental group did score marginally higher each round, a statistical analysis comparing the results from each group showed that only the results of the second round are to be considered significantly different from one another. While my hypothesis was not necessarily correct, playing video games as a break did have an equal effect on the subjects short term memory as the study break of walking around.

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1 Introduction

Computers are an ever increasing part of our society as new advances in software and technology become integrated into our everyday life. Many academic institutions have begun to trade in their blackboards for Smart boards, textbooks for laptops, and penmanship for typing speed[16][18]. In fact, for almost every form of education in our culture, there is an electronic counterpart that attempts to accomplish the same goal using computers[18].

One of the biggest changes in our society is the introduction of video games as a pastime. Studies show that about 42 percent of Americans play video games for at least three hours per day, and four out of five American households contain a device used for video games[11]. The advent of video games has also brought with it the concept of "pathological gaming", a growing issue in our society where people become so engrossed in playing video games that the social and academic aspects of their lives are negatively impacted[12]. With so many people involved in this relatively unexplored frontier of gaming, there should be more research done on the overall effects that gaming can cause, both positive and negative. Many researchers have come to the conclusion that the effects of playing video games are mostly negative[2, 9, 10, 13, 16, 12]. These studies have shown that violent video games can have a correlation to violent behavior[9], as well as cause societal dissociation from extensive solitary gaming [10]. It appears as though video games can be quite harmful when it comes to our younger generations academics. However, is that truly all that has to be said on the topic?

Many of the experiments conducted regarding video games were designed to study the negative effects they caused, and many left out any results that determined otherwise[18]. Just because there is evidence that shows something is bad, does not mean it cannot also do good. Begona Gross [15] found that the complexity of a virtual learning environment such as a video game can improve ones ability to learn from a digital source. By learning how to beat a game in the game's environment, gamers are also developing their ability to learn information through a digital source. With a growing amount of our society's learning occurring from digital sources [15], it would appear rather useful to develop this skill, or even integrate it into our education. In Isabela Granic's [14] experiments, she was able to determine that playing video games for extended periods of time can benefit users on a cognitive, motivational, emotional, and social level in ways that are relevant to everyday life. In addition, many researchers have been unable to draw a correlation between academic performance and gaming, and instead came to the conclusion that the effects of playing video games are negligible on their subject's lives [1, 12].

Clearly, there is still research to be done on the effect video games can have on the human condition. One area I am specifically interested in is how video games can affect study habits, and our ability to retain information. One major aspect of studying is how one spends their time during study breaks. Studies have shown that the manner in which an individual takes their study break can have a significant impact on the retention of the material[8]. Because video games have only recently become a global pastime, playing video games as a study break is a topic with little scientific research done to analyze its effects. This thesis examines the impact this form of media can have on a users memorization capabilities. Does playing video games before and during work increase learning productivity? Do video games actually have the ability to increase short-term memory retention or cognition? To analyze the effects that video games can have on memory retention I conducted an experiment using a game that I designed. Participants will play my game, Gnomes and Homes, during a word memorization game called Word Order to see how gaming impacts their ability to memorize a list of words. This data is contrasted with a control group that walks around between rounds of word order instead of playing Gnomes and Homes. By examining the effects my video game has on the subject's memory retention with respect to the control, my thesis helps to determine whether video games should have a permanent place in education, and further study the idea of there being beneficial applications of gaming for society. I believe that using video games as a study break will increase subject's memory retention skills more than that of traditional breaks. As the results from this experiment show, while the experimental group did perform slightly better than the control, the difference was considered insignificant after a statistical analysis of the data.

2 Background and Related Work

There has already been extensive research on the effects of gaming with respect to education. In this section I will go over relevant studies that pertain to my experiment.

To begin, Vivek Anand [1] completed an experiment that focused specifically on how video games can affect an adolescent's GPA and SAT scores. Anand found that the amount of time a student spends playing video games has a negative correlation with students' GPA and SAT scores. However, he also expressed the difficulty of proving cause and effect between gaming and bad scores due to the complex nature of student life and ones academic performance. Douglas Gentile has published several papers on the topic of gaming and our youth, and found that pathological gamers, people who have an unhealthy obsession

with gaming, have a much higher chance of having bad grades than non-pathological gamers [12, 13]. In his 2004 experiment [13] Gentile found that adolescents who expose themselves to large amounts of video game violence become more hostile, get into arguments with teachers more frequently, were more likely to be involved in physical fights, and performed worse in school. Based on these results one can determine that playing excessive amounts of video games can lead to poor performance in academics, and playing violent video games can lead to violent verbal and physical behavior.

However not all experiments were able to come to such concrete conclusions as those mentioned above. Christopher Ferguson[9] conducted an experiment in 2015 on the influence that video games have on an adolescents' aggression, mental health, pro social behavior, and academic performance. Based on results from 101 child subjects, he found the effects from video games with respect to these topics to be negligible, and inconclusive. Anderson's experiment from the late 1980's [2] on college age students attempted to draw a correlation between violent video games and violent behavior, but found the results to be inconclusive. One common theme for these experiments was the inconclusive nature of their results, and the difficulty to draw a definitive correlation between video games and negative behavior. It is also important to note that many experiments [2, 9, 10, 16] were designed with the intention of finding results that portrayed negative behavior such as poor grades and social skills. Potential positive effects such as increased motivation and self-esteem were not covered in these experiments.

While there are plenty of experiments that have determined their negative effects, several experimenters have found that video games can have a positive impact[15, 18, 14]. Begona Gross created a pedagogical model for incorporating video games into education that increases student interest and productivity [15]. Annetta also explored the idea of incorporating video games into our education, and found that gaming can increase the subjects engagement by using a gaming environment to learn information [3]. Pasternak-Salonius studied the effects of video games on adolescents from a psychological perspective, and found that video games can be therapeudic and beneficial to ones mental fortitude [18].

Due to the nature of my experiment, it was important to research information on memory retention with regards to psychology and neuroscience, and the manner in which others were able to measure and quantify such data. In order to study his subjects memory retention, Piribabadi had subjects of varying ages attempt to memorize a list of uncorrelated words over a period of time and tracked their progress across several runs[17]. Based on the data he collected he was able to compare the different age groups to see how age affects our memorization skills. Fergus Craik used this manner of testing to determine his subjects

memory retention in his experiment as well [6]. I used this method in my own experiment for the same purpose of analyzing my subjects memorization skills, but will use the data to answer different questions than the previously mentioned experimenters.

In addition to finding a method for collecting data, I also needed to understand what activities have been tested to be "good" study breaks for students, and what conditions students need to learn effectively. This was important for not only determining what activity the participants in the control group would be doing as their break, but also to help me better understand the results from my data later on. Patricia Desiderato found that anxiety plays a major role in students ability to learn, and their overall success on tests [8]. Students that are more stressed have a higher chance of doing poorly in academics than those who are not. While this was not directly tracked or measured during my experiment, many subjects commented on the stress they felt while playing my video game, which could have had an effect on their performance with Word Order. Marcus Crede also came to this conclusion in his own experiment, and went on to state that the subjects motivation to do well also has a large impact on students academic performance [7]. I intended to use this in my experiment by giving incremental rewards for completing each level of Gnomes and Homes, but due to time restraints no reward was given besides advancing to the next level. Finally, Diane Christophels experimental results showed that the more interactive the studying is the better students learn [5]. This information was extremely useful in determining how I would build my game to keep subjects actively involved and motivated with the task at hand, and led me to add music to the games atmosphere.

3 Experimental Design

In this section I describe my experiment, the types of information I will be gathering, and my rationale behind my experimental design.

To measure the effects that video games can have on short-term memory and cognition, I conducted my experiment on a group of 40 Union College students. While the sample size was relatively small, the population of students was diverse both with respect to age and fields of study. I used the game Word Order 1 with and without the inclusion of my game Gnomes and Homes depending on the subjects experimental group. Participants in the control group were asked to walk around for two minutes for their study break in between rounds. The experimental group played Gnomes and Homes as their break from Word Order. The results collected from the control group were used a baseline for students study habits

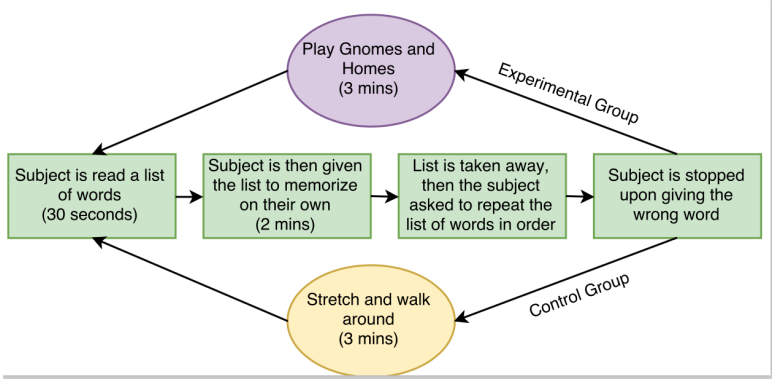


Figure 1: Word Order Game

and were considered the "expected values" for someone playing Word Order under regular conditions. the experimental group's results were used as my test data since the populations scores were influenced by the playing of Gnomes and Homes.

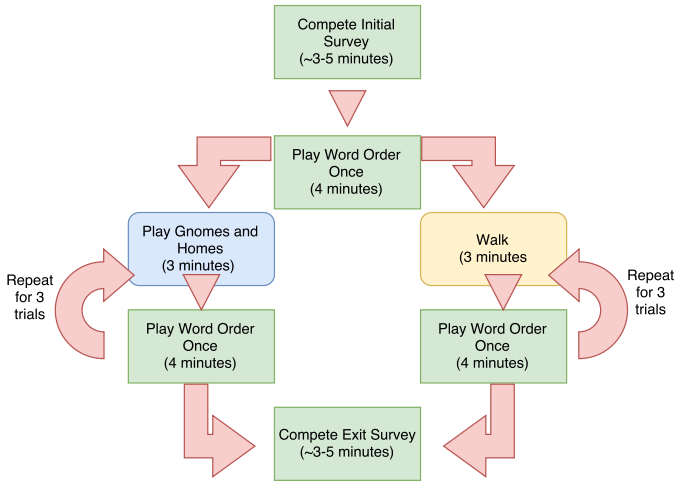


Figure 2: Experimental design flowchart

I decided to use the game Word Order due to its direct correlation with short-term memory [17], and the ease of learning the game. Even if the participant had never played it before, the concept of memorizing a list of words is a familiar one to many, and is easy to understand with little instruction. The list of words is as follows: disease, vase, fork, shirt, watch, celery, persuasion, knee, glue, chair, monitor, stone, fridge, cheese, store, animal, water, desk, automobile, attention. By studying how well they remember the list of words, I was able to study how well people can retain information they have recently learned when they are playing video games versus traditional study breaks. This type of learning can be paralleled by someone memorizing terms for an exam while intermittently taking breaks to blow off steam, and is therefore repre-

sentative of results in the real world. From this game I collected data on how many words the participants are able to memorize each round before getting one wrong, and then plotted each populations progression to see each group's respective learning curve.

4 Gnomes and Homes

I created the game "Gnomes and Homes" (GaH) for use in my experiment as an example of a video game that a student might play while studying. The first reason I chose to use Gnomes and Homes over existing video games is the method at which it is played. While many other games can serve this role just as well if not better, by using a web page I designed for playing my game I can have the game record results automatically and remove some of the subjects awareness from the experiment. Not only is the information gathered by the game autonomous, but useful in determining the meaning behind other data I gather during the experiment. In addition to this, I am also interested in game development, and wanted to better understand what it takes to create my own game.

Figure 3: Title screen of Gnomes and Homes.

4.0.1 Game Description

Gnomes and Homes is a real-time strategy game based around navigating a garden gnome from a third person perspective. As a living garden gnome, it is important to keep your livelihood hidden so that you

can continue living in secret in the backyard. To complete each level, you must travel across the yard to get to your home (a shed) while avoiding a slew of obstacles both moving and stationary. In addition to reaching your home, you also must collect 3 garden gnomes per level before being able to enter your home. To beat the game the player must successfully complete all 15 levels.

Gnomes and Homes uses a grid based map with only forward movement and turning left and right, also known as tank controls. While navigating each level, the player must guide their garden gnome through precarious obstacles to reach his home on the other side of the map. These obstacles include water, sprinklers, and fire, and require you to move into them to lose. In addition, the player must make sure their gnome is never seen by the humans or animals in their yards, or his cover is blown and he will lose. While the player is busy dodging obstacles to get to the end of the level, he will also have to worry about time, as each level will have a time limit to complete the level or else they lose. This is to ensure that the player has to make decisions under pressure as well as keeping them actively playing the game in real time. To add a challenge, there are always three garden gnomes on each level that the player must pick up before they can finish. These additional objectives force the player to enter much more dangerous situations then they would be exposed to otherwise in order to reach the end of the level.

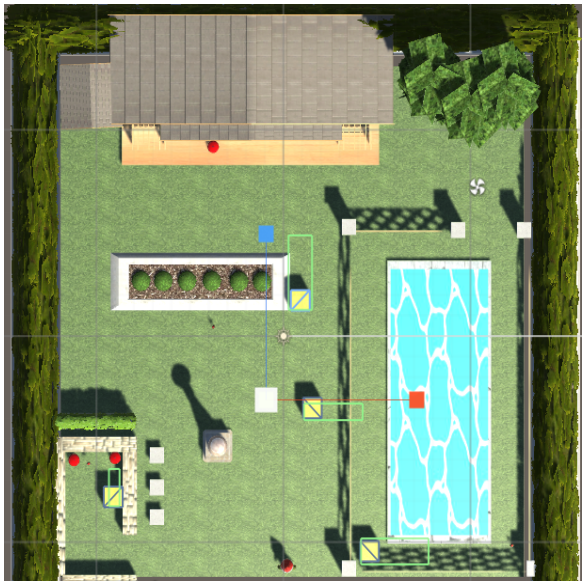


Figure 4: A top-down view of level 5 in Gnomes and Homes.

4.0.2 Design choices

While I touched on the design choices I made during this game above, here is a more in-depth description as to why and how I created the game as I did. When setting about creating my game, the first thing I had to decide was what game engine to use. Upon doing some research, I found that Unity was best suited to my needs as it was free and had plenty of documentation on how to use it online. Also, having to do both the front and back end development for my game, it was useful to have access to forums and the Unity Store to help me along the way. Before I began making my project I first went through all of Unity's tutorials until I felt comfortable understanding what I wanted to do.

In the early stages of development I was torn between making the game turn-based, 2D, or 3D, but eventually decided on the last of the three with real time action. With the goal to make my game as mentally immersive as possible, I figured a real-time, three-dimensional game would require the most attention to play. Also, with Unity's built-in physics and rendering engine it was easy enough to implement a 3D environment.

I decided to make the plays controls "tank controls", where the character can only move forward and turn to make it harder for the player to control their gnome. With most gamers being used to being able to move in any direction they please, I figured this old set of controls would disrupt those with prior experience in gaming and help level the playing field. When creating these controls I toyed with the idea of making the gnome move forward a set distance on each click, but decided on using a constant velocity for its movement instead. If the player could move a set distance at the click of a button, it would be easier for them to outrun the enemies in the game, making it easy to stay alive. There is also a time limit for each level, forcing the player to make quick decisions in order to reach the end in time. I added a music soundtrack to the game as well to make it more immersive for the player, adding hearing to the senses that are occupied by the game.

When creating each level in such a way that it could be seen as a backyard, I found it difficult to make reaching the end of the level hard. With each level being relatively small, a skilled player could reach the end in a matter of seconds, forcing me to add a new objective to the game in collecting the three gnomes. By adding three side objectives that must be completed before leaving the level, the player is forced to fully navigate the backyard, and take dangerous paths that would not need to be taken otherwise. This inclusion of extra gnomes added to the difficulty of the game immensely.

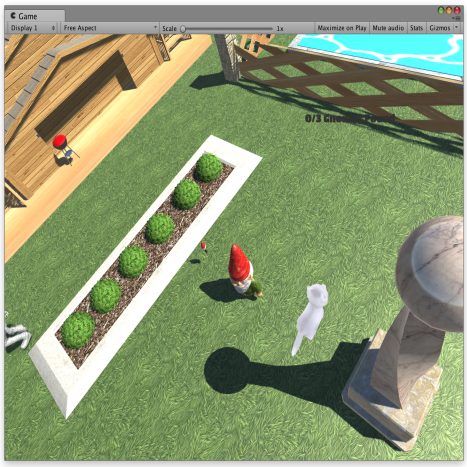


Figure 5: In game view level 5 of Gnomes and Homes.

Finally, I decided to make the level on a computer platform for several reasons. First, if I were to create it for the mobile phone market, I would have to pay a fee as well as implement a touch screen interface for the user controls. Secondly, creating games for these two platforms requires different coding implementations, and would have required me to make two versions of my game. For something that was being used only for the purpose of my experiment, it seemed excessive to do something so elaborate, so I chose a web page as the platform.

5 Data

This section covers the data I collected and how it was analyzed to draw my conclusions. To begin, I had a sample size of 40 Union College students between the ages of 17 to 22. The population was then split into a control 9 and test group 10, described in the experimental design section above.

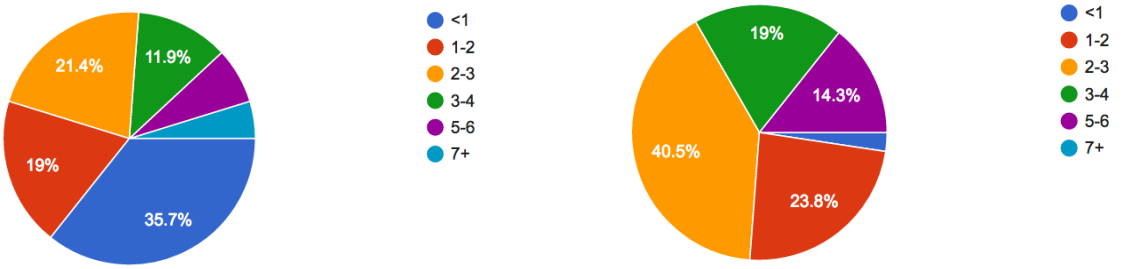
For the most part, the data I collected from each group was the same. Each participant filled out the same survey at the beginning of the experiment to identify basic information such as age, gender, and background with video games and study habits. This information was collected to classify what demographics of people took my experiment. Based on the survey results I was able to flesh out the lifestyles of my sample population, and learn more about how they study.

An example of this is that around one third of my test subjects play as little as one hour of video games per week 7a. In addition, less than a quarter of the population plays more than 3 hours per week, meaning

(a) Subject Gender Distribution

(b) Subject Age Distribution

Figure 6: Survey Data



(a) Distribution of Weekly Gaming Habits

(b) Average Time Spent Studying at One Time

Figure 7: Survey Data

that a majority of my test subjects do not consider themselves gamers.

The information collected on the subjects study habits was quite enlightening as to how Union college students carry out their academic endeavors. Over forty percent of the sample population studies for 2-3 hours at one time 7b. This means that students study periods are relatively short, and based on the amount of coursework a college student has it is likely that these study periods have little to no breaks put into them. This idea is further enforced by another question asked in the survey where subjects were asked if they take breaks while studying and eighty percent answered no.

Finally, the last question from the survey asked what kind of breaks the subject takes while studying. Unsurprisingly, the most frequent breaks consisted of browsing social media, eating, and engaging in social behavior, with about 70 percent of participants saying they do at least one of those breaks. This was contrasted by the least frequent study break which had only 6 percent of the sample population saying they read books. This information helped give character to the results collected from the experiment, and gave insight on how the average college student spends their time.

After conducting 40 experiments, I decided my sample size was sufficient to begin an analysis of the

data collected. The main information collected was the number of words correctly memorized in order per round of subjects playing the game Word Order 9 10. Each subject played four rounds in succession with breaks in between that differed depending on the test group they were in. As a way of performing an initial evaluation of the results, I took the mean of each round by group, and compared them to one another using a line graph 8. The mean results per round showed that the group that played Gnomes and Homes as their study break did slightly better overall than that of the control group.

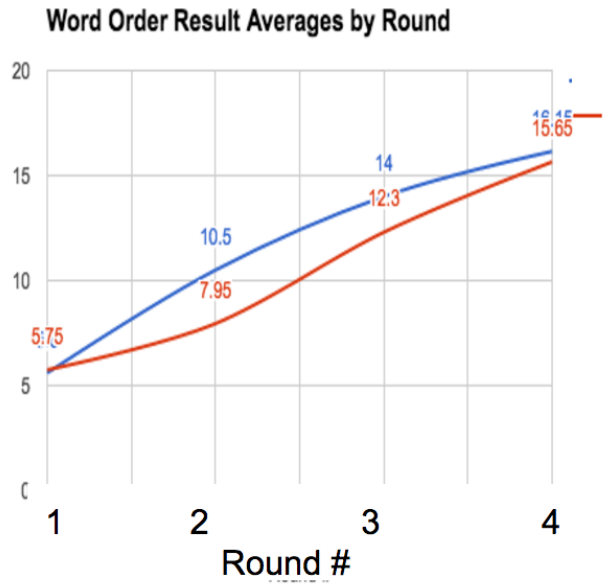


Figure 8: Mean Results by Round

For the first round, the mean scores of both groups were almost identical. This makes sense since the first round of Word Order for both groups was played before a study break was taken. This also means that the two groups were standardized enough that they all scored within the same proximity before they were influenced by the study break. Interestingly, after they took their first break, the experimental groups mean was significantly higher than the control group by an average of almost two words. While this does not hold true for the remaining two rounds, it is still important to note the populations first study break had a significant impact on that rounds scores. Round 3 showed a 50 percent drop in difference between the groups means, and by the end of round 4 the two groups were back to being within one standard deviation of one another.

Table 1: Chi-Square Test Results

Bucket Size	Degrees of Freedom	Critical Value	P value R1	P value R2	P value R3	P value R4
By 2	9	16.19	.93	.17	.79	.26
By 4	4	9.49	.52	.013	.37	.22

6 Results

Even though the means of the experimental group were higher across the board, this was still not enough to prove a significant difference between the groups results. In order to determine whether the results proved my hypothesis I did a statistical analysis of the data through both a chi-square test as well as a two sample t-test. The results of these tests would determine whether the two groups came from the same distribution, or if the two groups had an outside variable influencing their scores.

6.1 Chi Square Test

The Chi Square Test is often used in statistics to determine whether there is a significant difference between the expected and observed data sets. This directly relates to this experiment, as I am trying to determine whether the act of playing a video game can create a significant difference in results with respect to the control group. My null hypothesis for this test was that the results of the two groups could be considered to have the same outcome, and disproving this had the potential for proving my experimental hypothesis.

Before I performed the chi square test, I first augmented the data to limit the amount of outcomes each subject could have. With 20 different scores per round, I bucketed the outcomes into groups of four and two, making only five and ten possible outcomes respectively. This allowed me to use the chi square formula and made the results easier to interpret as well.

I first used the data that was bucketed by groups of two. With a total of nine degrees of freedom (i.e ten possible outcomes), I calculated the critical value of the data to be 16.919. Any chi-square value below this threshold would prove the null hypothesis, while anything above would disprove it. The chi square value for each round accepted the null hypothesis, meaning that there was no significant difference between the observed and expected values.

Still undeterred, I performed the same test but with the data bucketed by 4, giving a possible 5 outcomes per round and 4 degrees of freedom. For this test, 9.488 was the critical value that would reject or accept the null hypothesis. This time, the second round results rejected the null hypothesis, meaning that the data had some outside variable influencing the observed groups outcome. This mirrors the results I noted when

Table 2: T-Test Results By Round

Round #	R1	R2	R3	R4
P Value	.822	.0201	.2326	.6867
T statistic	0.22	2.43	1.21	0.40
Null Hypothesis	accept	reject	accept	accept

calculating the means, as the success gap between each groups round two was the most significant.

6.2 T-Test

To confirm the results collected from my previous tests, I ran a two sample T-Test to determine if the two groups were close enough in proximity to be considered from the same distribution. A T-Test uses a T-statistic, also known as the test statistic, a T-distribution, and degrees of freedom to determine the probability of difference between populations. T-Tests are also extremely useful in analyzing small amounts of data, and was therefore perfect for my experiment. I also had to formulate a null hypothesis for this test, which stated that if the result accepts the null hypothesis, then the two groups are considered to be from the same distribution.

The results from each round mirrored that of the second chi-square test, where every round accepted the null hypothesis except for the second. Having run two analyses of the data that had the same results, I was ready to draw a conclusion on the data I collected.

7 Conclusion

The purpose of this experiment was to determine the effect that playing video games can have on short-term memory with respect to word memorization. I hypothesized that playing video games would keep the mind active and alert, and therefore have one ready to continue learning when their break was over. By extension, I believed that this form of study break would be superior to traditional types of breaks such as walking, stretching, and contrasted the two throughout my experiment.

Even though the mean average score for the ”game group” was higher for each round than the control groups results, a statistical analysis proved that this difference was to be considered negligible for all rounds except the second. While this result does mean I failed to prove my hypothesis, there are many conclusions that we can still draw from this outcome.

The second round appears to be quite the anomaly when attempting to draw a concrete conclusion on the effects that the different study breaks had on the user. The groups initial introduction to their study break had the largest impact on the difference between their scores out of any round, and there seems to be no obvious reason why this is. While round three also showed a large gap between the successes of each group, it along with the first and last round were considered to be from the same distribution of data. It is possible the initial playing of the video game got the subjects in the experimental group to become more engaged in the experiment than that of the control group simply waiting for their next round. Unfortunately for this theory, the control group quickly caught up during the final two rounds, meaning any impact the video game initially had on the groups scores was quickly buried. Another possibility is that with such a small sample size, it could be likely that the experimental group was simply better overall at memorizing words than the other. With a population size of 20 each, it only takes 3 to 4 participants to have a significant effect on their groups mean scores. However, it is also important to point out that the round 1 and 4 results of each group were almost identical to one another, so this option seems less likely. It appears as though it may just be luck that made the round two results so different from one another, and unless I gather a larger sample size and redo this experiment there is no way to know for sure how these results came to be.

Even though I failed to prove my hypothesis, there is still something to be learned from this experiment's results. When I first began researching the effects of video games on academics, I found an overwhelming number of studies that showed the negative effects that playing video games can cause on grades, mood, and social behavior. While there were several experiments that had results proving otherwise, it was clear that a majority of the scientific field believes that the effects of video games are detrimental to everyday life. The results from my experiment showed that while the video game groups results were not necessarily considered "better" than the control group, they were considered equal. This means that in a side by side comparison, the results of playing video games versus traditional study breaks were considered to be from the same distribution. Do video games have a negative effect on academics? It is certainly possible, and more experiments need to be done to draw that type of conclusion, but the results I collected show they do not.

Person #	Experimental Group	Gender	Age	Study Type	R1	R2	R3	R4
4	1	Female	20	Silent	1	1	14	17
5	1	Male	21	Aloud	2	2	12	12
6	1	Male	19	Aloud	10	1	11	20
7	1	Female	19	Silent	3	2	3	11
8	1	Male	19	Silent	4	6	4	14
10	1	Male	19	Aloud	5	8	16	19
12	1	Female	18	Aloud	4	12	17	20
15	1	Male	21	Aloud	7	11	18	20
17	1	Male	21	Silent	9	13	15	14
19	1	Male	18	Aloud	6	8	11	14
21	1	Female	17	Aloud	4	7	8	12
23	1	Male	19	Silent	6	9	14	18
25	1	Male	20	Aloud	7	8	13	15
27	1	Female	19	Silent	6	9	8	13
29	1	Female	21	Aloud	4	7	10	15
31	1	Female	21	Aloud	9	13	18	20
33	1	Male	20	Silent	7	10	11	15
35	1	Female	22	Aloud	10	15	20	20
37	1	Male	21	Silent	7	9	13	13
39	1	Male	19	Silent	4	8	10	11

Figure 9: Raw data collected from Word Order Game for the control group

Person #	Experimental Group	Gender	Age	Study Type	R1	R2	R3	R4
1	2	Male	20	Aloud	5	14	20	20
2	2	Male	20	Silent	4	10	19	20
3	2	Male	18	Aloud	3	10	12	11
9	2	Male	21	Silent	4	14	2	5
11	2	Female	20	Silent	6	9	15	18
13	2	Female	17	Silent	7	13	18	20
14	2	Male	21	Aloud	6	12	15	17
16	2	Male	19	Aloud	3	9	11	15
18	2	Female	21	Aloud	8	13	18	20
20	2	Male	19	Silent	5	10	14	18
22	2	Male	20	Aloud	6	9	15	19
24	2	Male	21	Aloud	7	8	12	16
26	2	Female	18	Silent	5	11	17	20
28	2	Female	18	Aloud	4	9	13	15
30	2	Female	19	Silent	8	13	17	18
32	2	Male	21	Silent	7	8	9	9
34	2	Female	21	Silent	6	11	17	20
36	2	Female	17	Aloud	5	4	7	9
38	2	Male	18	Silent	6	11	13	15
40	2	Female	21	Silent	7	12	16	18

Figure 10: Raw data collected from Word Order Game for the experimental group

Appendices

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