

Twin Study A Comparison of Nature Vs. Nurture on Cognitive Skills in Academic Achievement in Identical and Fraternal Twins

Amina Dada¹

¹Lapeer High School, Lapeer, MI, USA

ABSTRACT

This research study is looking at the academic achievement levels in identical and fraternal twins at the high school level through a measurable cognitive perspective. The purpose is to see if the data collected agrees with past research on how much academic achievement is due to genetics or environmental influences (nature vs nurture). Twins were asked to take three online cognitive tests and score differences were computed to determine statistical significance. I then drew connections on how much the scores were due to genetics while accounting for confounding variables in the environmental influence's aspect. Therefore, the study concludes that the majority of academic achievement is due to genetics in both identical and fraternal twin sets. This indicates my research supports past research that shows genetics plays the majority factor in academic achievement whether twins are younger or older in age. This study is purely correlational and analyzes data with the twin method which means it in no way proves anything but rather shows a connection between academic achievement and genetics. This research adds more support to the current body of knowledge, but also brings up an important point of how future research can study environmental influences in-depth to see how it influences academic achievement beyond what can be measured in the classroom.

Introduction

Twin studies are a very important tool that psychologists and scientists use to analyze a certain trait, and look to see how much of it is due to genetics or other environmental influences. Their findings are valuable in understanding psychological behaviors along with detecting and treating viruses and psychological disorders. Due to the rapid advancements in technology in today's current day and age we are able to go beyond just analyzing twin behavior but also delve deep into understanding the genetic makeup of twins and their behaviors. Twin studies involve looking at monozygotic or identical twins (MZ) and dizygotic or fraternal twins (DZ). Monozygotic twins are formed when one zygote (an egg and a sperm) splits into two resulting in two embryos, while dizygotic twins are formed when two eggs are fertilized by two separate sperm and are independent in the uterus (Duncan, 2013). When analyzing the results from twin studies we use the "twin method" which is the formal comparison of MZ and DZ twins on a specific trait (Mayo, 2009).

A majority of people assume that twin studies are not as important as they actually are because we can account the way that twins or singletons act to genes; however, many people fail to realize the importance of the environmental influences that play a major impact in the traits of twins which can explain other behaviors not impacted by genetics. Many also believe that the results from twin studies can only be applied to twins, but actually the results help scientists pick apart the genetics and environmental influences on a particular trait which is usually used to analyze why all different types of people behave the way they do.

Literature Review

Twin studies are a fairly recent concept to our society; however, with the research that has already been done, the results have brought a lot of new understanding to behavior that many psychologists in the past did not understand. The nature vs. nurture debate is examining if our behaviors are due mostly in part because of our genetics (nature) or because of environmental influences (nurture). The nature vs nurture debate has been long-standing and has been used to defend and analyze many studies besides twins. For example, it was used to analyze whether high blood pressure was a genetic issue or resulted from an unhealthy lifestyle. Nature vs nurture has also been used to analyze results in twin studies like comparing the cognitive abilities and mathematical performance in twins; the study states that 90% of the phenotypic correlation between math performance and general cognitive ability was due to heritable influences (Alarcón et al., 2000). Twins are a very influential part of behavioral research because they are an integral part of the nature vs nurture debate because of their genetic similarities and seeing if our behaviors are really due to genetics or environment.

Numerous studies are currently being done on twins, ranging from genetic tests to behavioral studies. Current research being done by professors in Moscow, Russia are looking at the environmental influences on academic achievement in twins. They found that gender and family structure are significant influences on academic achievement in elementary school-aged twins (Chertkova et al., 2014). Another study by multiple professors at King's College in the United Kingdom had results that Chertkova's research contradicts. This study involved the twin method, which allowed them to look more deeply into genetic influences. With the rapidly changing technology they were able to perform research that most people cannot. They found that their research results confirm prior research suggesting that academic achievement is substantially influenced by genetics (Walker et al., 2010). They found that this applied to both fraternal and identical elementary aged twins. Both of these sources prove previous research and pave the way for future research to be done. This is also a prime example of how the nature vs nurture debate is brought into twin studies and how research can focus so heavily on one side and not the other. Another research study, which agrees with Chertkova, involves using 11 different cognitive tests on twins ages 13-16. They found that academic achievement in twins is mostly due to environmental influences within the family (Foch & Plomin, 1980). These cognitive tests are not only looking at the academic capabilities of one's brain genetically but how far along one has come academically as an individual and then comparing that to your twin to see how similar or different they are.

A majority of twin studies are done on elementary aged children with very few being done on adults. This is most likely because younger twins are still developing and they are more alike, as they get older twins can develop their own personality from their other twin. One research article used the K-ABC method, which is a test to see how kids think, and found no statistically significant difference between identical and fraternal twins (Torre & Testa, 2012). However, another study done by professors in Taiwan on twins around their mid-to upper-twenties found that the twins performed poorly compared to singletons at a later age (Tsou et al., 2008). Despite both of these studies being done on drastically different age groups, it is clear that brain development and one's environment can dramatically influence twins' academic achievement.

Twin studies are now taking new approaches to test academic achievement beyond just basic genetic tests. A study done by professors in New Mexico conducted their research by blocking their research participants and only observing nine-year-old twin boys. They used the Qualifications and Curriculum Authority (QCA) assessment which is a more advanced way of testing the brain's academic abilities. They found that there was no statistically significant difference between the sexes at this age level (Haworth et al., 2008). They also included a future research section in their paper which discussed how they would like this same type of research to be done on high school aged (15-18 years old) twins, which leads directly into my gap. Using cognitive tests to measure academic achievement has been done in the 1970s and is still being used today. Professors at Boston College used cognitive and memory tests opposed to the standard IQ test on twins of all ages. They found that short term memory in both identical (MZ) and fraternal twins (DZ) is stronger than long term (Pezzullo, et al., 1972). Although all of the studies described use different

approaches to look at twins and their academic achievement Foch, Haworth, Torre and Pezzullo are the ones that led me to the gap I will focus on in my research.

In my research, I will attempt to show that the results of past research on twins and academic achievement can be applied to high school age twins. Academic achievement in twins is 70% heritable at younger ages (Rimfeld et al., 2018) and my hypothesis is that it will stay consistent as they are older. Previous research has focused on elementary aged twins or twins that are post-college, whereas mine will be focused on high school aged twins (16-18 years old), where a lot of research has not been done yet. This led me to my research question: to what extent do high school level twins (identical and fraternal) differ in academic achievement through a cognitive perspective? To test this, I will use cognitive tests (memory, etc) on both identical and fraternal twins and then analyze the results with the twin method. By comparing the results I get we will be able to see if there is a difference between identical and fraternal twins in academic achievement and see if that agrees or disagrees with past research. I will also be able to look and see if a difference can be accounted to heritability or environmental influences.

Methodology

I will be using a correlational research method to look at academic achievement and to see the association between heritability and environmental influences. I will analyze and apply my results using the twin method so I can compare the identical twins to the fraternal twins. My research is correlational because my design is non-experimental; therefore, I cannot prove causation I can only show association. The twin method is being used to apply the results of my research in the current body of knowledge because past research done by Torre (2012) and Haworth (2008) show using the twin method when understanding the results of their academic achievement in twins studies. The twin method is also a standard in twin studies as a way for researchers to easily interpret others research (Mayo 2009).

My participants are identical and fraternal twins 9th through 12th grade at a high school in a small rural Michigan town. I had 34 willing participants, 17 sets of twins, which will be referred to as twin 1A, twin 1B, and so on. I chose to look at these specific grade levels because as mentioned in my literature review studies on twins in this age range is something that previous research has noted for future research (Haworth et al., 2008). This is what led me to the gap I am focusing on. The sample I am using may limit my results because I can only apply the results in the context of my school and not a greater twin population.

The way in which I conduct my research allows me to look beyond GPA and explore academic achievement through a cognitive perspective. I do this by utilizing three online cognitive tests because Pezzullo's (1972) research through Boston College shows that this is a better way to analyze cognitive measurements such as memory. I chose the types of cognitive tests that I will use from reading Foch's (1980) research study: the first one is an online 10 question IQ test, the second is an online stroop task test which measures executive functioning, and the last one is a memory test which I found on washington.edu. The data I collect is primary and will allow me to analyze the cognitive levels of the twins. Haworth's (2008) research mentions the importance of looking into the twins' home environments and how that impacts their academics so I will also be collecting the grade point average (GPA) of all twins and asking them whether or not the set of twins live with each other. This will allow me to compare the results with long-term factors and draw conclusions on how the results of the study were influenced by nature and nurture variables. The quantitative items are data results and GPA. The qualitative items are grade level, and whether the twins are identical or fraternal, and whether or not they live with their twin pair.

Before contacting participants, my research method was approved by my school's Institutional Review Board (IRB). Once approved I received a list of the twins in grades 9-12 in my school along with their class schedules. I contacted the twins during their first-period class to explain the study and if they wanted to participate, I gave them an informed consent sheet (see Appendix A). The informed consent sheet clearly stated exactly what participants would be doing, how their confidentiality will be kept, any potential risks, and their right to leave at any time. The participants were required to have a parent signature along with their own because participants were part of a protected group (minors, and some with disabilities). The consent sheet also states that I will provide the opportunity for

participants to be debriefed following the analysis of the data I collect. There is also an incentive to participate in my research study as participants will receive candy at the end of taking the online tests, and will get to miss one class period to take the tests.

Once willing participants sign the consent sheet, I will receive their GPAs from the school, and arrange a date for testing. On test day, I will pull them out of their first-period class and take them to the computer lab which I have reserved ahead of time. I chose to split up the twins based on Torre's (2012) research so as the participants enter the room, one twin will be told to sit on the right side of the computer lab (twin A), and the other will be asked to sit on the left side of the computer lab (twin B) so that they are not near each other. At every computer station, there is an instruction sheet that I have made detailing the links for the online tests and exactly how to take them. This is included in Appendix B for reference. All the twins will take the tests in the same order. The first test is a 10 question IQ test (see Appendix C) once completed the participant will call me over so I can record how many they got correct out of 10 along with an IQ score. The second test is an attention/executive functioning test (see Appendix C) that is in the format of a stroop test. Once completed I will record the number of congruent vs incongruent items correct along with average time for each. A stroop test is where the spelling of a color is put on the screen, and the ink in which it is written is in the same color of the spelling (congruent) or a different color (incongruent). The third test is a memory test where participants will have to write down letters they remember after they flash off the screen (see Appendix C). For the memory test there are six trials and the sheet where the twins will write down what letter they remember is provided by the testing site.

All of the data I collect will be kept track of on an excel spreadsheet (see Appendix D). At the end of the third test, I will collect all the papers back from the twins to be placed in a confidential folder. Before they leave I will ask them if they live with their other twin pair and record their answer, and offer them a piece of candy if they would like. I will also explain to them what debriefing is and write down if they would like to be debriefed so I can set up a time to do so. This spreadsheet will be deleted along with shredding of any papers at the conclusion of the study to maintain confidentiality.

Results

First, the figures below (1-4) are showing descriptive data about the participants that were in my study.

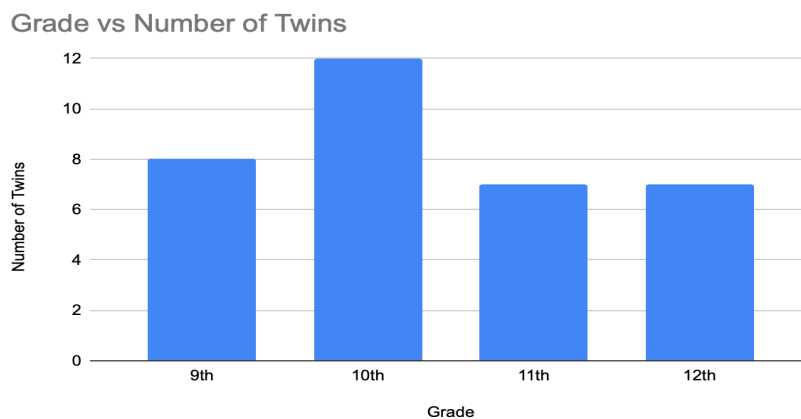


Figure 1. Number of twins in each grade level out of 34 total. One set of twins are in different grade levels so the number of pairs is not equal.

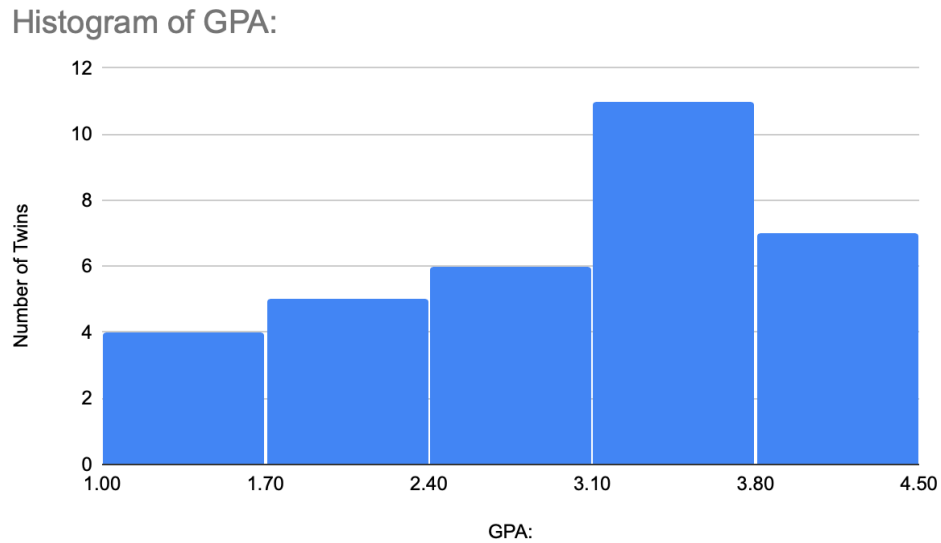


Figure 2. Number of twins in various GPA cutoffs at the time of testing. Note: The school system that the twins are from uses a GPA system that goes beyond 4.0. Also, twins at a younger grade level may have an advantage of having a higher GPA because they have taken less classes that count towards their GPA.

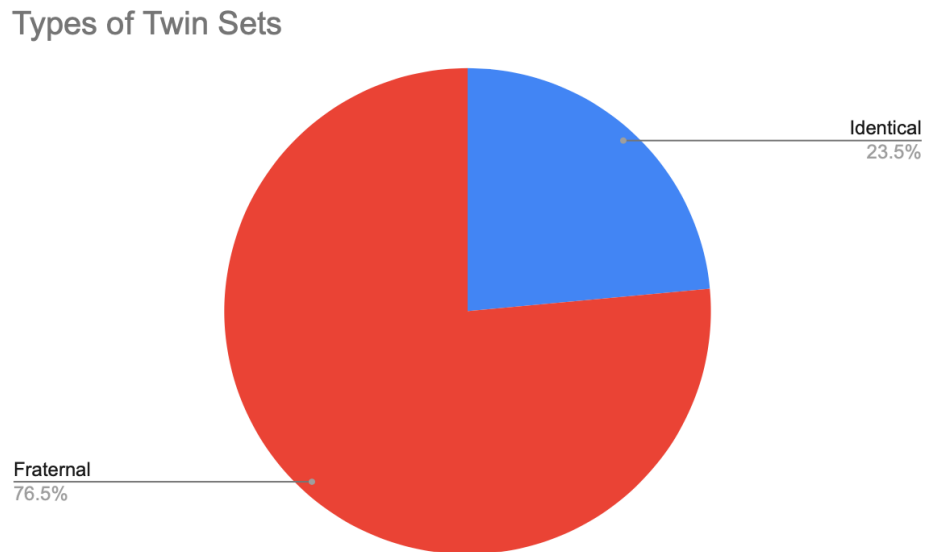


Figure 3. Number of Identical vs Fraternal twin sets

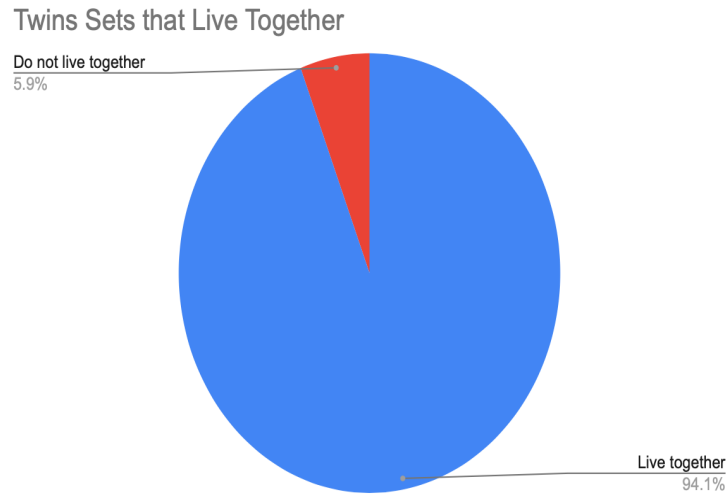


Figure 4. Percentages of twin sets that live together

Secondly, the figures (5-7) below represent the raw data from the three cognitive online tests for all the twins (34 twins).

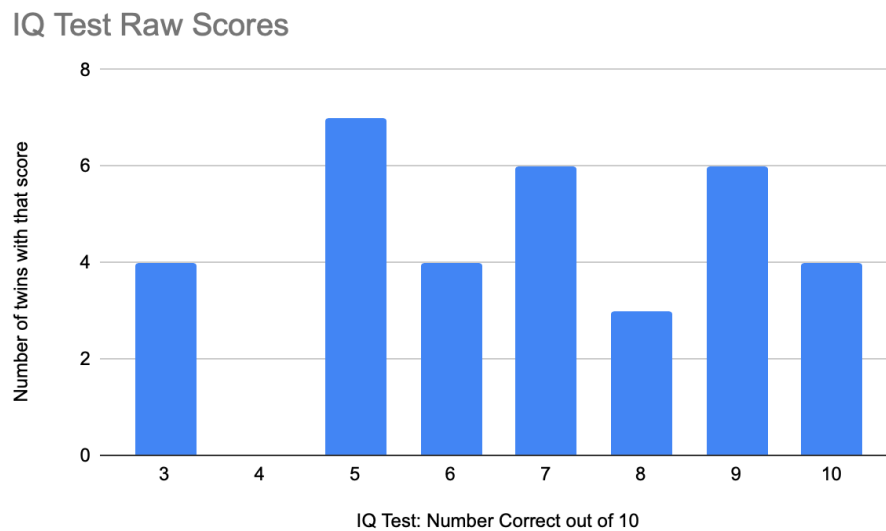


Figure 5. Twins scores on IQ test: Number correct out of 10

Note: I did not include the IQ score generated by the website in my results because the IQ score is given as a range of where the participant could fall instead of an exact score making it difficult to analyze.

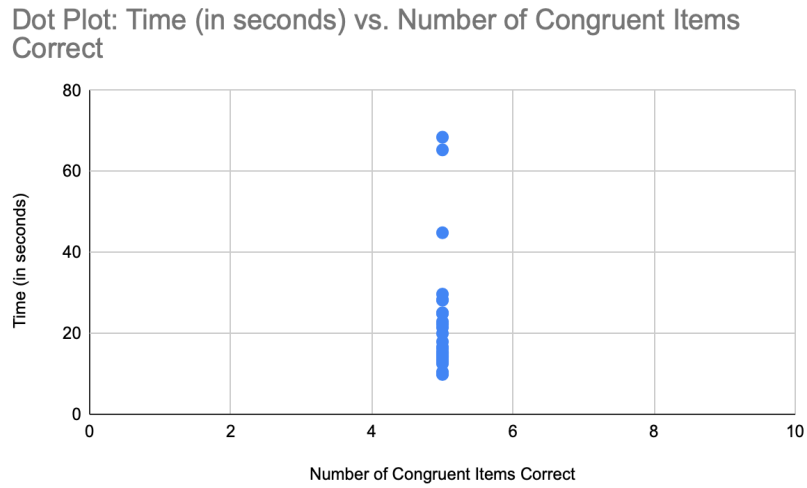


Figure 6.1. Stroop Test: Number of Congruent Items Correct with Time

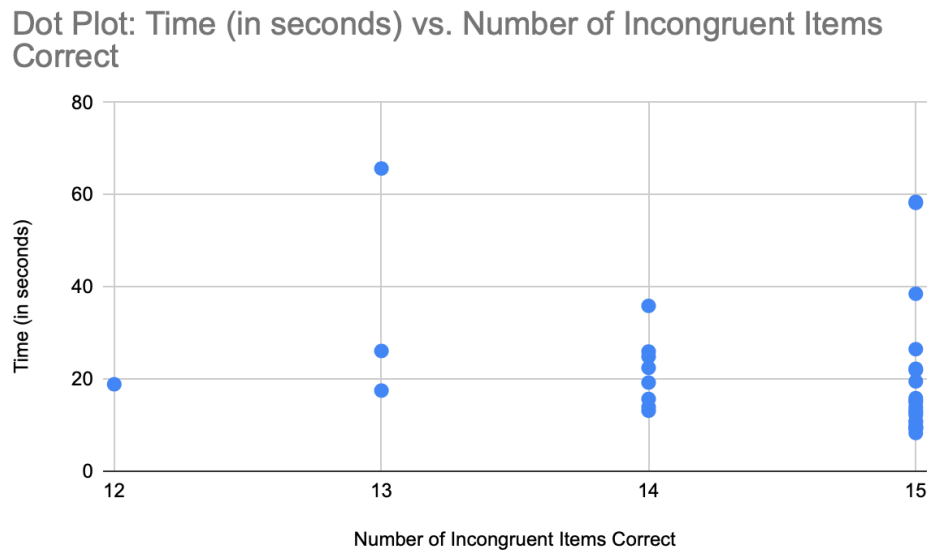


Figure 6.2. Stroop Test: Number of Incongruent Items Correct with Time

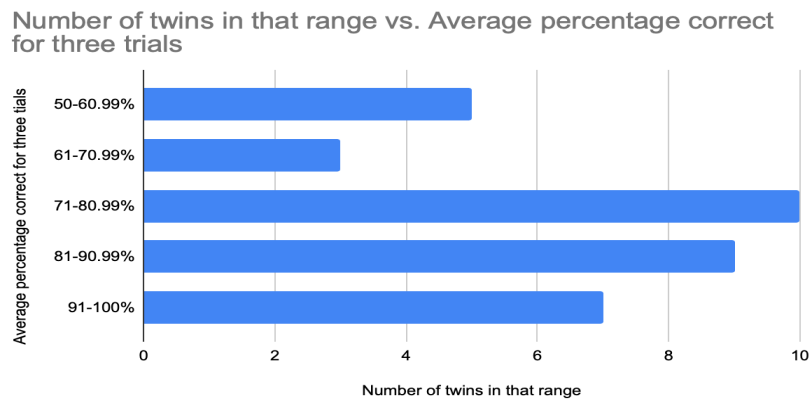


Figure 7. Memory Test: Average of number of letters correct for three trials

I chose to average the number correct for only three trials (trials three, four, and five) for this test because trials one and two almost always had a 100% success rate; on the other hand, trial six almost always had a near fail rate. After consulting with my school’s statistics teacher, I realized that I will be able to draw proper conclusions from only looking at the three trials where participants were average. Also, there were three students that scored a 100% average for all three trials and based on my observations during testing did not follow the directions to not write down letters until after they were removed from the screen. This had an impact on my results that will be discussed in the analysis section.

Finally, the figures below (8-10) show my calculations of the data. The calculations below are done within each twin set for each cognitive test so I can compare it with the group overall raw data. All calculations were recommended to me by my school’s statistics teacher. There are 17 twin sets (4 Identical, 13 Fraternal).

How the calculations were carried out: For each test and each twin set, I took the higher scoring twin and subtracted out the lower scoring twin to get the difference. Then for each test I entered the differences into List 1 on my calculator and had the calculator compute a one-sample t-test to give me the mean, standard deviation, and p-value of the differences. I did this for both the identical and fraternal twin sets.

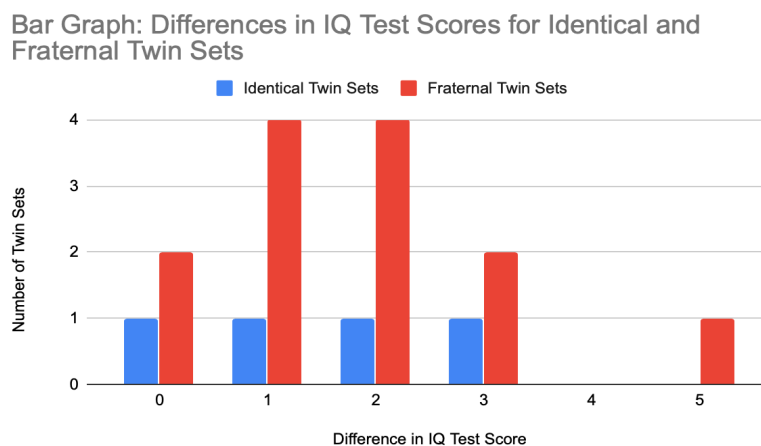


Figure 8.1. IQ Test: Differences in scores for twin sets

	Identical Twin Sets	Fraternal Twin Sets
Mean (\bar{x})	1.50	1.77
Standard Deviation (σ)	1.29	1.36
P-Value	0.051	2.67

Figure 8.2. IQ Test: One-Sample T-Test Results

Differences in Time for Congruent Items Correct for Identical and Fraternal Twin Sets

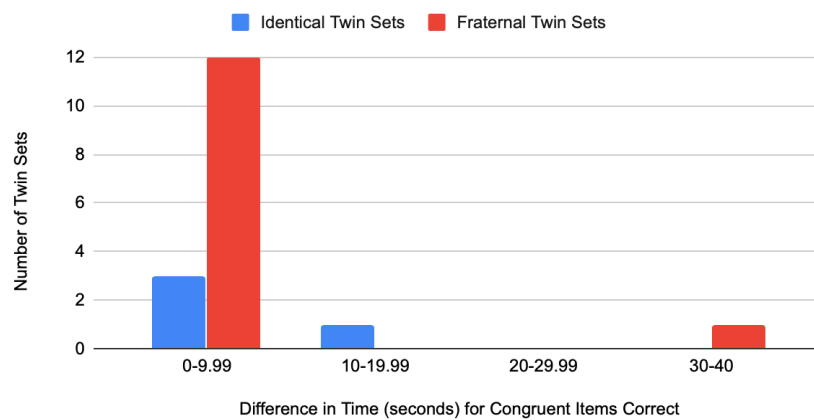


Figure 9.1. Stroop Test: Differences in Time for Congruent Items Correct

	Identical Twin Sets	Fraternal Twin Sets
Mean (\bar{x})	7.48	5.51
Standard Deviation (σ)	5.72	7.90
P-Value	0.40	0.01

Figure 9.2. Stroop Test: One-Sample T-Test Results for Differences in Time for Congruent Items Correct

Differences in Time for Incongruent Items Correct for Identical and Fraternal Twin Sets

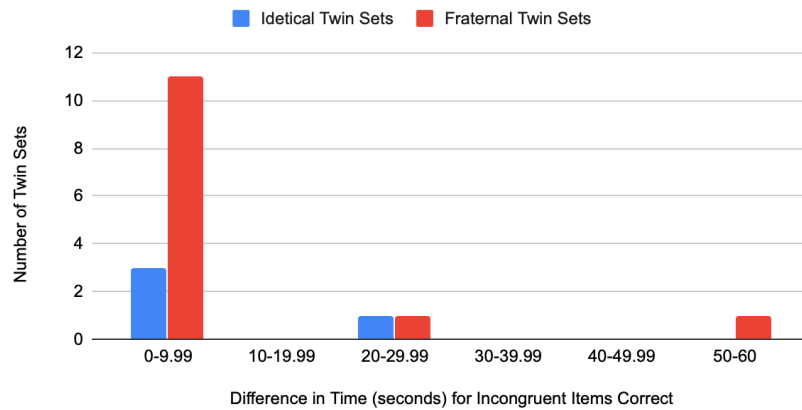


Figure 9.3. Stroop Test: Differences in Time for Incongruent Items Correct

	Identical Twin Sets	Fraternal Twin Sets
Mean (\bar{x})	9.60	8.35
Standard Deviation (σ)	9.90	14.70
P-Value	0.07	0.03

Figure 9.4. Stroop Test: One-Sample T-Test Results for Differences in Time for Incongruent Items Correct

Bar Chart: Differences in Average Percentage Correct for Identical and Fraternal Twin Sets

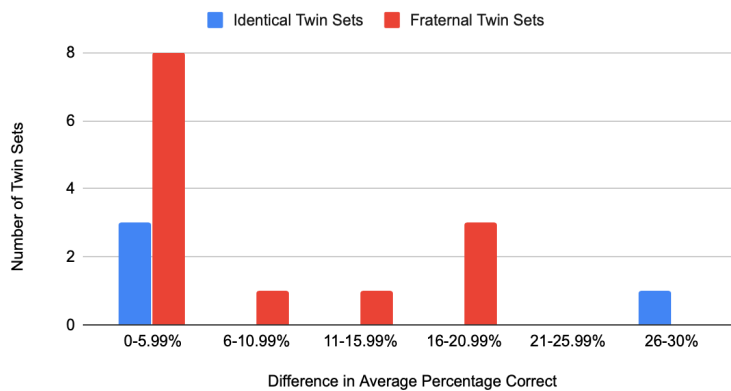


Figure 10.1. Memory Test: Differences in Scores for Twin Sets

	Identical Twin Sets	Fraternal Twin Sets
Mean (\bar{x})	9.04%	7.82%
Standard Deviation (σ)	12.31%	6.97%
P-Value	0.12	0.0008

Figure 10.2. Memory Test: One-Sample T-Test Results

Discussion/Analysis

My null hypothesis (opposite of my hypothesis) is that my data will show the majority of academic achievement is due to environmental influences. My alternate hypothesis (also known as my hypothesis) is that my data would match previous research that twins academic achievement is 70% due to genetics (Rimfield et al., 2018). The way that I can analyze this is by looking at p-values, a way to see how extreme the probability of results is for or against the null hypothesis, for the differences of each test and comparing them to a standard alpha level of 0.05. By formally comparing the statistical significance of identical and fraternal twins on the trait of academic achievement this is application of the twin method to the results. This is how my correlational research study can be applied and understood within the twin research current body of knowledge.

IQ Test:

Identical twin sets: The p-value is greater than the alpha level so we fail to reject the null hypothesis. There is no statistically significant difference.

Fraternal twin sets: The p-value is greater than the alpha level so we fail to reject the null hypothesis. There is no statistically significant difference.

Stroop Test:

Congruent Items-

Identical twin sets: The p-value is less than the alpha level so we reject the null hypothesis which means a statistically significant difference is present.

Fraternal twin sets: The p-value is less than the alpha level so we reject the null hypothesis which means a statistically significant difference is present.

Incongruent Items-

Identical twin sets: The p-value is less than the alpha level so we reject the null hypothesis which means a statistically significant difference is present.

Fraternal twin sets: The p-value is less than the alpha level so we reject the null hypothesis which means a statistically significant difference is present.

Memory Test:

Identical twin sets: The p-value is less than the alpha level so we reject the null hypothesis which means a statistically significant difference is present.

Fraternal twin sets: The p-value is less than the alpha level so we reject the null hypothesis which means a statistically significant difference is present.

A statistically significant difference means that the results are not attributed to chance so in my case genetics. Meanwhile no statistically significant difference means that the results are attributed to chance so in my study environmental influences. Beyond the calculated data, there are a few things I noticed that stood out to me. On the memory test, there were two fraternal twin sets who scored the exact same average which is interesting to me because genetically they are more different than identical twins and no identical twin sets got zero difference in the memory test. On the other hand, there was a set of identical twins that score exactly the same on the IQ test which is a direct example of what my research is showing. Because I compared the p-value of my data to the alpha level of 0.05 this means that I have a 95% confidence level in my results.

Conclusion

Overall, my data proves my hypothesis that past research is correct in the majority of academic achievement can be attributed to genetics. This is with the exception of the IQ test which shows it is more attributed to environmental influences; however, this could be because the types of questions on the IQ test were meant to trip you up and, in the end, did not give an accurate measure of the twin's academic achievement. To answer my research question, with the data I collected identical and fraternal do not differ in academic achievement (cognitively) as much as one would have thought. Despite fraternal twins not being as genetically similar as identical twins their score ranges were within the same ranges as identical twins. Besides minor differences which could be accounted to a multitude of confounding variables the data shows that for both identical and fraternal twins their achievement is quite similar and mostly due to genetics.

There are multiple limitations in this study that need to be accounted for. One, that I was not expecting, was the retrieval of informed consent sheets from participants. Every participant has a different home situation and I did not account for this when realizing how difficult or long it would take some participants to get parent or legal guardian signatures. A second limitation is being unable to account for a vast majority of the twin's environmental influences besides asking if they lived with each other due to confidentiality reasons. This potentially could have skewed my data or accounted for certain scores because environmental influences are confounding variables that I could not control or test for. Another limitation that came up during the testing sessions that I did not account for was technology glitches. A couple of the computers would not let participants open up the adobe flash player even after the troubleshooting I mentioned to participants in the directions (see Appendix B). This resulted in having participants move to a different computer which was a distraction mid-testing. Finally, a limitation in analyzing the results is that this cannot be applied to other twin sets because the sample was taken from one high school.

There are many future directions for this research that many researchers can take advantage of with the proper supplies. First, doing the same study as I did with the same age range for twin participants but gathering a much larger randomized sample size. There are many twin registries across the country where participants can be pulled from and this will allow the results to be applied to a greater population. Another future direction could be to delve deeper into the environmental influences on twin's academic achievement. With the proper confidentiality being maintained researchers could study twins' home life and study habits to get an idea of how much of an impact it really has while also being able to account for those confounding variables. Finally, another future direction could be to conduct a wider range of cognitive tests with more reliability and then use statistical programs to analyze scores and get more accurate results; however, this would need a proper amount of funding and technological lab space. All of this would allow twin researchers to have a deeper understanding of what outside factors impact twins and how they perform academically.

References

- Alarcón, M., Knopik, V. S., & DeFries, J. C. (2000). Covariation of Mathematics Achievement and General Cognitive Ability in Twins. *Journal of School Psychology, 38*(1), 63-77. [https://doi.org/10.1016/S0022-4405\(99\)00037-0](https://doi.org/10.1016/S0022-4405(99)00037-0)
- Chertkova, Y., Egorova, M., Zyrianova, N., Parshikova, O., & Fominykh, A. (2014). Academic Achievement in Twins: Extreme Group Analysis. *Journal of School Psychology, 146*(1), 209-215. <https://doi.org/10.1016/j.sbspro.2014.08.116>
- Duncan, G. (2013). Identical Twins vs Fraternal Twins. Retrieved from <https://wstwinregistry.org/for-twins/zygosity/identical-vs-fraternal-twins/>
- Foch, T.T., Plomin, R. (1980). Specific cognitive abilities in 5- to 12-year-old twins. *Behavior Genetics, 10*(6), 507–520. <https://doi.org/10.1007/BF01066220>
- Haworth, C. M., Dale, P., & Plomin, R. (2008). A Twin Study into the Genetic and Environmental Influences on Academic Performance in Science in nine-year-old Boys and Girls. *International Journal of Science Education, 30*(8), 1003-1025. <https://doi.org/10.1080/09500690701324190>
- Mayo, O. (2009). Early Research on Human Genetics Using the Twin Method: Who Really Invented the Method? *Twin Research and Human Genetics, 12*(3), 237–245. <https://doi.org/10.1375/twin.12.3.237>
- Pezzullo, T. R., Thorsen, E. E., & Madaus, G. F. (1972). The Heritability of Jensen's Level I and II and Divergent Thinking. *American Educational Research Journal, 9*(4), 539–546. <https://doi.org/10.3102/00028312009004539>
- Rimfeld, K., Malanchini, M., Krapohl, E., Hannigan, L., Dale, P., Plomin, R. (2018). The stability of educational achievement across school years is largely explained by genetic factors. *NPJ Science of Learning, 3*(16), 1-10. <https://doi.org/10.1038/s41539-018-0030-0>
- Torre, L. V., & Testa, S. (2012). Assessing intelligence in children: A research study on twins using the K-ABC. *BPA - Applied Psychology Bulletin (Bollettino Di Psicologia Applicata), 263*(1), 3–15. <http://search.ebsco-host.com/login.aspx?direct=true&db=asn&AN=76099894&site=ehost-live>.
- Tsou, M. T., Tsou, M. W., Wu, M. P., Liu, J. T. (2008). Academic achievement of twins and singletons in early adulthood: Taiwanese cohort study. *The British Medical Journal (BMJ), 337*(1), 1-5. <https://doi.org/10.1136/bmj.a438>
- Walker, S. O., Petrill, S. A., Spinath, F. M., & Plomin, R. (2010). Nature, nurture and academic achievement: A twin study of teacher assessments of 7-year-olds. *British Journal of Educational Psychology, 74*(3), 323–342. <https://doi.org/10.1348/0007099041552387>