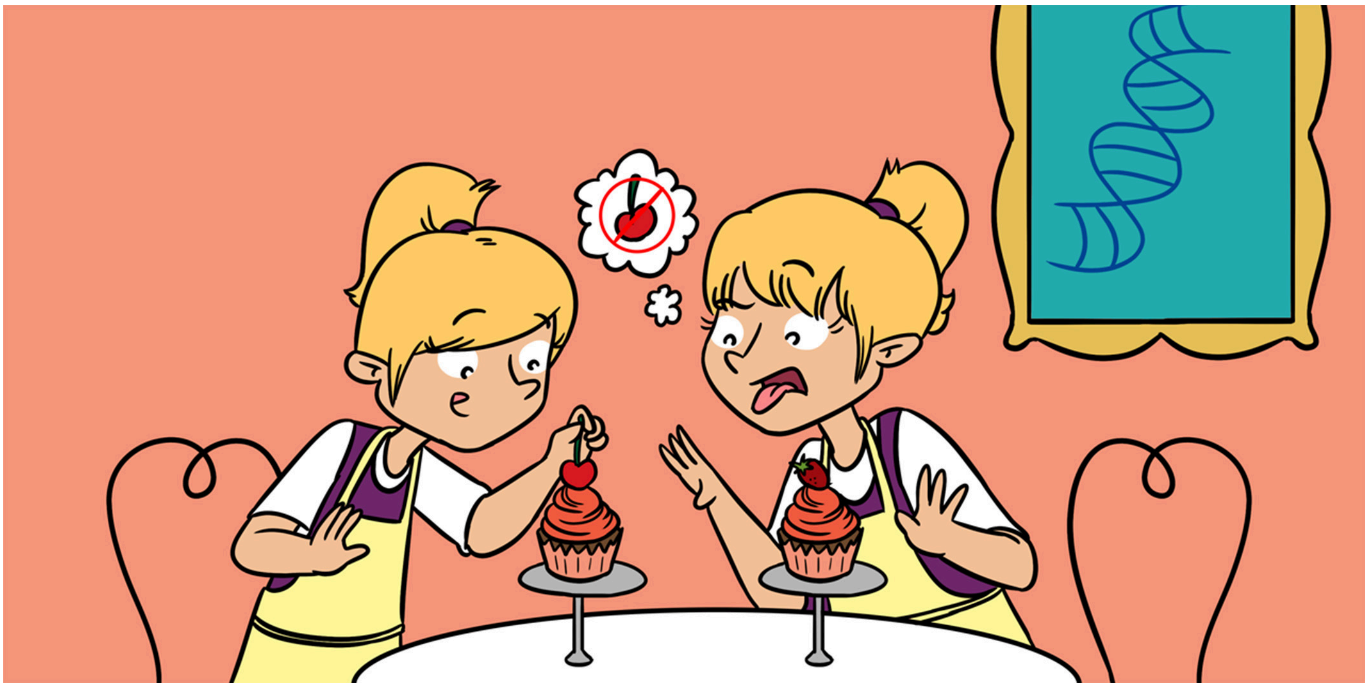
frontiers FOR YOUNG MINDS

HEALTH
Published: 24 April 2019
doi: 10.3389/frym.2019.00059



TWINS CAN HELP US UNDERSTAND HOW GENES AND THE ENVIRONMENT SHAPE US

Adrian I. Campos[1,2†], *Brittany L. Mitchell*[1,3†] *and Miguel E. Rentería*[1,2,3*]

[1] *Department of Genetics & Computational Biology, QIMR Berghofer Medical Research Institute, Herston, QLD, Australia*
[2] *Faculty of Medicine, The University of Queensland, Herston, QLD, Australia*
[3] *Institute of Health and Biomedical Innovation, Queensland University of Technology, Brisbane, QLD, Australia*

YOUNG REVIEWERS:

ASHTYN
AGE: 10

A. Y. JACKSON S. S. (TORONTO DISTRICT SCHOOL BOARD)
AGE: 13–15

SUN TONG SCIENCE CLASS
AGE: 14–15

Have you ever wondered why you look different from other people? Differences, such as height and hair color can come from differences in your genes called mutations. Understanding how mutations shape us can be a bit tricky, because we are also affected by the world around us. Twins and siblings can help us understand whether people are different because of genetic differences or because they live in different environments. Identical twins share the same genes, while non-identical twins share, on average, half of their genes with the other twin. We can measure and compare the degree of similarity in a trait between pairs of identical and non-identical twins, to understand how much of the difference in a trait between people is caused by genes and how much is caused by the environment.

TRAIT

A specific characteristic or feature of a person. For example, someone's hair color or height.

MUTATION

A form or version of a gene. Mutations can arise suddenly at any time and are usually neither good nor bad for you.

GENE

A piece of DNA that is passed from parents to children. Genes contain information about your traits.

DNA

Molecule inside your cells that stores all of your genes. Your DNA contains one copy of each of your parent's DNA, making you similar to both of them.

Every person in the world is different from every other. You may have different colored hair, skin, or eyes, or a different height, along with a whole bunch of other **traits** that make you look unique. On the other hand, you share very similar traits with members of your family. You might have the same hair color as your dad and the same eye color as your mom. You might look a bit like your brother or sister. This is because families share some variations (also called **mutations**) in their **genes**.

We could say that genes are small pieces of biological information, passed from parents to their children, encoded in the **DNA**. Think of genes as a recipe with instructions that list ingredients, amounts, and steps for how to make food. In this example, *you* are the food, and your DNA is both the paper and the letters used to write the recipe. Although our genes are like recipes, keep in mind that it is a very difficult recipe, with many (many!) ingredients and steps that we are still trying to discover and understand. Now, there are many types of food in the world, just like there are many types of people. Cupcakes are different from cookies because their recipes are different. People are different from each other because of differences in their genes (recipes). Some people are more similar than others (for instance, you and your brother or sister look more alike than you and your friends). This would be like cupcakes and muffins—they are not the same, but they are pretty similar. This is because their recipes are alike but not exactly the same. Sometimes certain mutations in your genes can be bad for you and make you sick, while other mutations can protect you from disease. Some mutations may even be good or bad depending on the environment! In our analogy, a mutation that causes a disease would be like using the wrong recipe. If you put salt in your cake mix instead of sugar, your cake will not come out well. While you may think that a mutation is something bad (or maybe something cool that some superheroes have), the truth is that most mutations are neither good nor bad—they are called neutral.

A recipe is not the only thing that affects how a cake comes out. The **environment** also plays an important role. If you make the oven too hot the cake will burn, but if it is not hot enough, it will not cook and will flop. But wait! Using the wrong ingredients, or the correct ones in the wrong amounts, can also make a cake flop! [1]. If you find a flopped cake, you will not always know what caused the flopping. Was it a mistake in the recipe? Or was it cooked the wrong way? This is an important difference between genes and recipes. Although you can see the symptoms of a disease just like you can see a flopped cake, the *recipe* in the DNA is written in a different language and we cannot easily go back and read it to find the mistake.

The environment has a big effect on people's traits. Think about skin color, for example. You might be born with the same skin color as your friend. If your friend enjoys playing sports outside and you like reading indoors, the sun will make your friend's skin darker while yours stays untanned. You will look different, even though your skin color genes are the same. Then again, genes can *also* make people have different skin colors. When you see people with different skin colors, it is hard to tell whether those differences are caused by genes (genetic), caused by sun exposure (environmental), or even caused by a combination of both genes and the environment! Actually, all of the differences between you and all the people around you come from differences either in your genes or your environment, or a combination. For example, you might be very smart because your parents make you read a lot (this is an effect of your environment). Or you might be very smart because you have genes that affect your brain, allowing you to read more quickly or understand things more easily [2].

DIABETES

Is a condition that occurs when the body cannot use glucose (a type of sugar) normally.

HERITABILITY

The amount of change in a trait that is due to genetic differences.

Understanding how mutations affect a specific trait in a group of people is very important, because it helps us find out why we are all different. Also, understanding mutations can help us study the way that genes cause some diseases. On the other hand, finding out how the environment affects a trait is also useful, because the environment can sometimes be changed. For example, scientists found out that the disease **Diabetes** is only influenced a little by genes (it has a **heritability** of 26%; [3]). Knowing this, doctors can help people to avoid getting the disease through environmental changes (like eating a healthy diet or exercising more), even if they have *the genes* for Diabetes!

To understand the effects of genes vs. the environment on a particular trait, we could examine a group of people and compare the differences in their genes and the differences in the trait of interest. This would be like comparing all the recipes used for different cakes to see if any specific ingredient is common to all the floppy cakes. If there is a common ingredient in floppy cakes, and that ingredient is not present in non-floppy cakes, then that specific ingredient is probably the cause of the cake flopping. In the same way, we can see if people with differences in a trait also all have specific mutations. We can then use maths to understand how much of the differences in a trait are explained by the mutations. The problem with this method is that reading the DNA of lots of people can be very expensive and complicated. Luckily, almost a 100 years ago, scientists found a powerful way to study the effect of genes vs. the environment without needing to read the DNA. This method uses twins [4].

Twins are a special type of siblings because they are born at the same time. There are two types of twins. Identical twins look very similar and are always either both boys or both girls. Non-identical twins may look different, and may even be a boy and a girl. Identical twins share all of their genes, while non-identical twins, just like non-twin siblings, share half of their genes. So, we can assume that any differences in traits between identical twins come from the environment, and not from differences in their genes. By measuring a trait (such as skin color) in large groups of twin pairs and siblings, we can understand the effect of

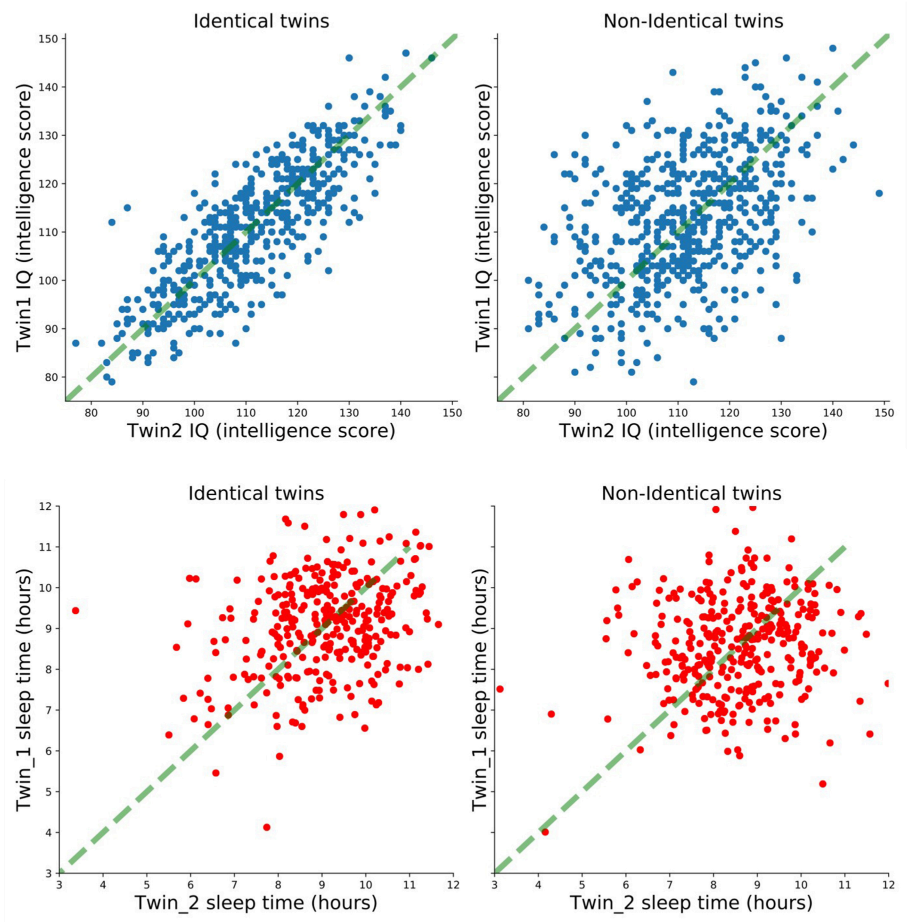


Figure 1

Figure 1

Twin data help us understand genetic and environmental effects. Results of two real-world twin studies. The two on the top are the results for IQ (a measure of intelligence), while the ones on the bottom show the results of sleep time. In the graphs, each dot is a pair of twins. The X axis represents the score (or sleep hours) the first twin got, and the Y axis represents the score the other twin (brother) got. If both twins are very smart, the dot representing them will be in the upper-right corner (they both got a high score). When a pair of twins share the exact same measurements (IQ or sleep hours) they will lay on the green line. If their measurements are very different, their dot will be far from the green line.

genes vs. the environment on a trait without actually looking directly at people's genes to see their mutations.

An example of results from two twin studies is shown in Figure 1. In one study, Australian twins (both identical and non-identical) had intelligence measured using an IQ (intellectual quotient) test. In the other study, twins were asked how many hours per night they typically sleep. Both studies aimed to find out how much genes contribute to the traits of interest (IQ and sleep time). To get an idea of how genetic a trait is, they compared how similar the pairs of identical twins were and how similar the pairs of non-identical twins were. Because identical twins share all of their genes, their measurements of IQ and sleep time will be more similar the bigger role genes play in it (i.e., differences between two identical twins must be caused by the environment because their genes are the same). On the other hand, we expect non-identical twins to be less similar than identical twins, but we still expect them to be somewhat similar because some of their genes are shared. Keep in mind that what is being compared is not the trait measurements, but rather how similar the twins are (both with high IQ, or both sleeping the same amount of time). In Figure 1, **similarity** can be observed by how close the dots (twin pairs)

SIMILARITY

A score that measures how alike things are. In this case, we measure how alike each twin is with his co-twin.

are to the green line in the middle (the perfect similarity line). These studies showed that IQ is very heritable (although the environment still plays a role in determining your IQ). We can tell this because the IQ of identical twins are almost always the same and non-identical twins are only sometimes the same. On the other hand, the graph for sleep of identical twins shows a big spread from the middle green line. This means that identical twins show big differences between them, and because they have the same genes this big differences are caused by the environment. This means that sleep length has a low heritability.

Studies like this have identified that personality, intelligence, poor eyesight, and even mental diseases, such as bipolar disorder and schizophrenia have a medium to high heritability (i.e., they are strongly influenced by genes). There is almost no limit to what kind of trait or disease can be studied. If it can be measured or classified, we can estimate its heritability! We study twins to understand how much of the difference in a trait between people is caused by genes and how much is caused by the environment. These studies are important because they help scientists quantify genetic and **modifiable environmental factors** that increase the risk of certain diseases. Scientists have done many studies like these. Around 18,000 human traits, including height, body weight, and several diseases, have been studied so far [5]. So, when you see a pair of twins, remember how genetically special and valuable they are for science and health research.

MODIFIABLE

Something that can be changed. For example, the amount of exercise you do.

REFERENCES

1. Moore, J. 2018. *Rise to the Occasion: How to Keep a Cake from Falling*. Retrieved from: https://www.craftsy.com/cake-decorating/article/how-to-keep-a-cake-from-falling/
2. Joshi, A. A., Leporé, N., Joshi, S. H., Lee, A. D., Barysheva, M., Stein, J. L., et al. 2011. The contribution of genes to cortical thickness and volume. *Neuroreport*. 22:101–5. doi: 10.1097/WNR.0b013e3283424c84
3. Poulsen, P., Kyvik, K. O., Vaag, A., and Beck-Nielsen, H. 1999. Heritability of type II (non-insulin-dependent) diabetes mellitus and abnormal glucose tolerance–a population-based twin study. *Diabetologia*. 42:139–45.
4. Liew, S. H. M., Elsner, H., Spector, T. D., and Hammond, C. J. 2005. The first 'classical' twin study? Analysis of refractive error using monozygotic and dizygotic twins published in 1922. *Twin Res. Hum. Genet.* 8:198–200. doi: 10.1375/1832427054253158
5. Polderman, T. J., Benyamin, B., De Leeuw, C. A., Sullivan, P. F., Van Bochoven, A., Visscher, P. M., et al. 2015. Meta-analysis of the heritability of human traits based on fifty years of twin studies. *Nat. Genet.* 47:702. doi: 10.1038/ng.3285

SUBMITTED: 27 August 2018; **ACCEPTED:** 05 April 2019;
PUBLISHED ONLINE: 24 April 2019.

EDITED BY: Suzanne Phelan, California Polytechnic State University, United States

CITATION: Campos AI, Mitchell BL and Rentería ME (2019) Twins Can Help Us Understand How Genes and the Environment Shape Us. Front. Young Minds 7:59. doi: 10.3389/frym.2019.00059

CONFLICT OF INTEREST STATEMENT: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

ASHTYN, AGE: 10

I love sports and art. I currently play softball and basketball, and I love playing with all of my friends. My favorite subject in school is art. My favorite hobby right now is building with legos. I want to be a zoologist when I grow up!

A. Y. JACKSON S. S. (TORONTO DISTRICT SCHOOL BOARD), AGE: 13–15

A. Y. Jackson Science Club promotes fun and challenging science initiatives through monthly events.

SUN TONG SCIENCE CLASS, AGE: 14–15

Our class is made up of school children between 13–15 years old. We are creative and resourceful to nurture the love and understanding of science among these children. The young reviewers this time are Shan Yuan, Matthew, and Hong Huan. We appreciate the opportunity to participate in the reviewing process.

AUTHORS

ADRIAN I. CAMPOS

Adrián graduated with honors with a Bachelor's in Genomic Sciences in 2016 from the National Autonomous University of Mexico. He performed a research internship at the Swiss Federal Polytechnical Institute studying antibiotic combination therapies. Currently, he is working toward a Ph.D. in genetics at the QIMR Berghofer Medical Research Institute, where he is working on finding the genetic and environmental risk factors for certain mental disorders and treatment response.

BRITTANY L. MITCHELL

Brittany completed her M.Sc. in Genetics in 2016 at the University of Pretoria, South Africa. She is now in the first year of her Ph.D. in at QIMR Berghofer Medical Research Institute, where she is examining the genetic and environmental risk factors behind dementia and cognitive impairment. She is currently working on a large twin study that aims to understand the genetic and environmental correlations between vitamin D, skin color, and sun exposure.

MIGUEL E. RENTERÍA

Miguel is a human geneticist at the QIMR Berghofer Medical Research Institute. He is interested in understanding how genes explain individual differences in brain structure and predisposition to brain diseases. Previously, he obtained his Ph.D. from the University of Queensland and conducted postdoctoral training in both Australia and the United States. *miguel.renteria@qimrberghofer.edu.au

[†]These authors have contributed equally to this work