BEHAVIOR AND PERSONALITY: NATURE OR NURTURE?

IPSITA MANDAL
School of Molecular and Cellular Biology, University of Illinois Urbana-Champaign

ABSTRACT
While children share only 50% of their genes with each parent, the behavioral and personality resemblances often appear too strong to be coincidental. This paper explores the interplay between genetic inheritance and environmental influence in shaping human behavior. Through foundational behavioral psychology studies, scientists have demonstrated that genes play a significant role in behavioral traits, with heritability estimates suggesting that roughly 40% of behavioral variation is attributable to genetics. These findings are supported by Genome-Wide Association Studies (GWAS), which have identified specific genes linked to the Big Five personality traits. The paper also addresses the ethical implications of genetic manipulation in behavior-related therapies. While environment undeniably shapes personality, the evidence points to genetic influence as a dominant force in behavioral development.

INTRODUCTION

Imagine a father and son sleeping on their right sides with arms crossed across their chest, or a mother and daughter mirroring each other's short-temperedness. Only 50% of genes are shared between a parent and child, yet their behaviors match too well. Nature is full of moments like these that leave us questioning whether it is the genes or the observation and imitation of the parent that causes such a close resemblance in behavior and personality. In the world of behavioral psychology, the nature of genes and the nurture of the environment both play a role in a child's development, usually one more than the other. Even though we often only attribute genes to the expression of physical characters, genes also play a huge role in the passing of certain behavioral and personality traits from parent to child.

TYPES OF BEHAVIORAL STUDIES

How did psychologists discover the underlying genetic influence of behavior? They simply conducted different types of studies where they strategically controlled for genetic or environmental variability. The most crucial studies that contributed to the modern understanding of behavioral psychology are twin and adoption studies, which follow the Equal Environments Assumption (EEA). According to the National Institute of Health, the EEA states that monozygotic (MZ) and dizygotic (DZ) twins experience nearly identical environmental conditions relevant to the trait of interest, allowing us to attribute any of those trait differences primarily to genetic differences. Twin studies observe the behaviors between MZ (identical) twins and DZ (fraternal) twins. In a typical family tree, two siblings share 50% of their genes.

However, MZ twins share a full 100% of their genes with each other. If they share 100% of their genes and they are under the same environmental conditions, we expect them to be 100% identical in their appearances and mannerisms. This means that any observed behavioral differences can be attributed to their environment. In contrast, DZ twins share only 50% of their genes with each other. Under the EEA, or assuming that the twins grow up under nearly identical environmental and familial conditions, any differences in behavior between the DZ twins can be largely attributed to that remaining 50% of genetic variation.

Figure 1 demonstrates the similarity between the reading abilities of two monozygotic twins. The slope displays a strong, positive linear correlation between the reading ability of one monozygotic twin and the reading ability of the other twin. When looking at the graph that reflects the reading abilities of two DZ twins, who only share 50% of their genes, more points can be observed scattered further away from the best-fit line, indicating only a moderate but still positive linear relationship between their reading abilities. Using these two graphs as evidence, a reasonable prediction is that sharing a larger percentage of genes produces a stronger similarity in behavior.

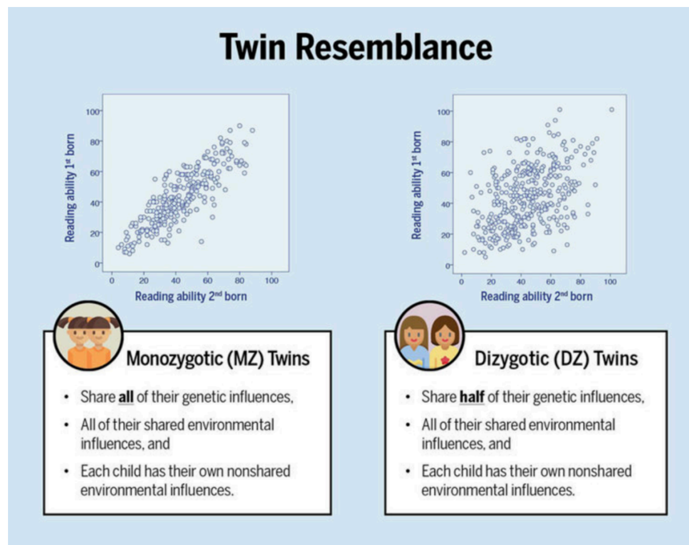

Figure 1: Two graphs showing the strength of concordance between the two twins, which is measured by the steepness of the slope of each graph. In other words, the slope of each graph represents the amount of similarity between the two twins' reading ability. The purpose of this comparison is to identify the role of genes in behavioral traits that are commonly believed to not have a strong correlation with genes (Hart, et al, 2021)

Adoption studies also played a huge role in understanding the genetic influence on behavior. They study behavioral similarities and the percentage of genes shared between a parent and their child, either biological or adopted. This type of study consists of the control group of a birth child and their birth parent. In this group, 50% of genes are shared, and their environments are identical.

This model resembles that of genetic x environment interaction models, where it is given that environmental conditions are kept consistent to eliminate the influence of a variable environment on behavior. According to such genetic x environment interaction models, most of their behavioral differences can be attributed to their difference in genes. The first experimental group consists of an adopted child and their biological parent. In this group, 50% of their genes are shared, but their environments are different. Thus any behavioral similarities between the adopted child and biological parents are still attributed to genes. The second and final experimental group consists of an adopted child with their adoptive parent. In this case, a very low percentage of their genes are shared, but their environments are identical. As such, any behavioral similarities between the two can be attributed to their environment. A study conducted by Myers and Dewall explored the child-parent correlation in verbal abilities scores, aiming to discover to what extent genetics and environment play a role in a seemingly inheritable trait.

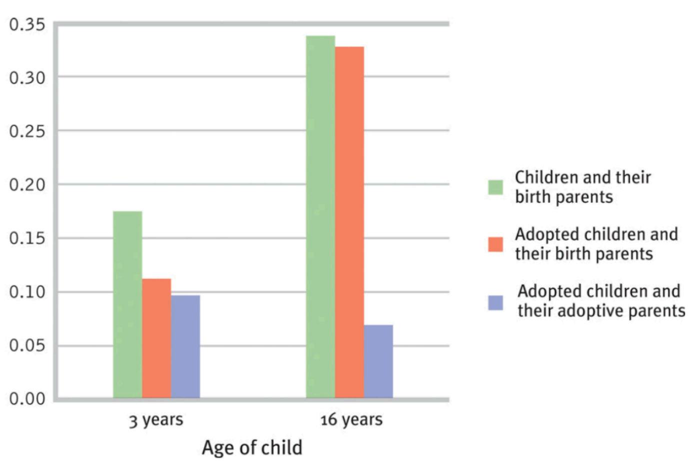

Figure 2: Data from Plomin and DeFries (1998) correlations between child and parents on verbal ability (Myers and Dewall, 2018)

In Figure 2, the graph aims to illustrate the strength of genetic influence compared to environmental influence by observing changes in a child's verbal ability score. According to the graph, the percentage of behavioral similarity between a child (whether birth or adopted) and their biological parents surpasses that between an adopted child and adoptive parents. These two groups, with an overwhelmingly high proportion of behavioral similarities, are the same ones that attributed behavioral similarities to genes, which then supports the claim that genes do indeed play a large role in the behavior of a child. However, that is not to say that the environment does not play a role at all; environmental factors will always have some influence on the similarities between a parent and child, yet statistically, genetic influence is stronger.

After examining the results of twin and adoption studies, scientists found that approximately 40% of behavioral differences can be attributed to genes. In other words, 60% of behavioral similarities can be attributed to genes. Within the twin studies specifically, researchers controlled gene-environment interactions, adjusting environmental factors between two individuals with similar genes to differentiate between genetically and environmentally influenced behaviors. This degree of caution leads into the concept of heritability.

HERITABILITY

Revisiting twin studies, heritability measures how much of the variability between individuals is really due to a difference in genes. In simpler terms, heritability measures the genetic degree of similarity between two individuals.

A high heritability means that differences in behavior are not explained by differences in genes. On the flip side, a low heritability means that the differences in behavior are better explained by differences in genes. Following this idea, monozygotic twins have a high heritability. Since they share close to 100% of their genes with each other, their behaviors are expected to be identical.

As such, their behavioral differences are better explained by environmental rather than genetic factors. On the contrary, dizygotic twins only share 50% of their genes with each other, so they have a low heritability, meaning their behavioral differences are better explained by that 50% difference in genes (Campos, 2019).

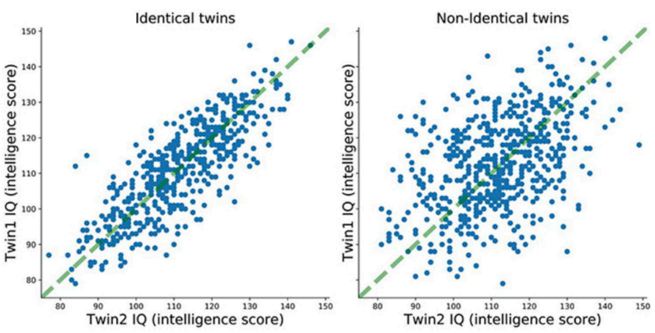

Figure 3: Two scatterplots that aim to identify the heritability of IQ by comparing similarities between monozygotic (identical) and dizygotic (fraternal) twins (Campos, 2019)

The graph measuring the IQ similarity between dizygotic twins does not have an obvious linear relationship, and the data points appear more random, thus indicating that there is a low correlation in IQ between twin 1 and twin 2. However, looking at the IQ scatterplot comparing monozygotic twins, we see a strong positive linear relationship between twin 1 and 2, indicating that there is a strong correlation in IQ scores between monozygotic twins. Thus, as these types of studies have discovered, we can conclude that IQ has a high heritability.

Beyond familial studies and the concept of heritability, genome-wide association studies tackle the cellular level of genetic influence on behavior and personality traits.

GENOME-WIDE ASSOCIATION STUDIES AND THE BIG 5

Genome-wide association studies (GWAS) intentionally search for single nucleotide variations within the same type of genes among different individuals that contributed to a particular trait, which includes those of behavior and personality. To be more exact, genes directly influence cognitive traits (mental capabilities of the brain), which in turn influence the behavior and actions of the person. GWAS has been used to identify specific genes that influence the Big Five personality factor model that covers neuroticism, extraversion, agreeableness, conscientiousness, and openness to experience (Lo, 2017).

The first trait, neuroticism, refers to people with emotional instability, psychological distress, low self-esteem, and negative emotions. The genes associated with this trait are MAGI1 and variants along the 8p23.1 chromosome and in the L3MBTL2 gene (Vinkhuyzen, 2012). The second trait, extraversion, refers to a person's inclination to involve themselves in social circles and positive emotions.

Surprisingly, extraversion correlates with ADHD, meaning that certain genes that cause ADHD also contribute to the personality trait of extraversion. Some of these genes include variants along the WSCD2 and near PCDH15 genes (Vinkhuyzen, 2012). The third is agreeableness, which mirrors a person's cooperativeness and compassion for others. The fourth is conscientiousness, or in other words, order and discipline. The KATNAL2 gene in particular contributes heavily to this trait (Lo, 2017).

Lastly, openness to experience implies intellectual curiosity and creativity, which in turn is also associated with schizophrenia and bipolar disorder. As such, some of their common genes include RASA2 and PTPRD (Lo, 2017). Figures 4 through 8 provide a visualization of which chromosomes each Big Five personality trait is most associated with (Lo, 2016).

The big five personality traits encompass multiple smaller traits we often associate with others and share a fine line with certain disorders, yet that only supports the argument that behavior and personality are heavily influenced by genes.

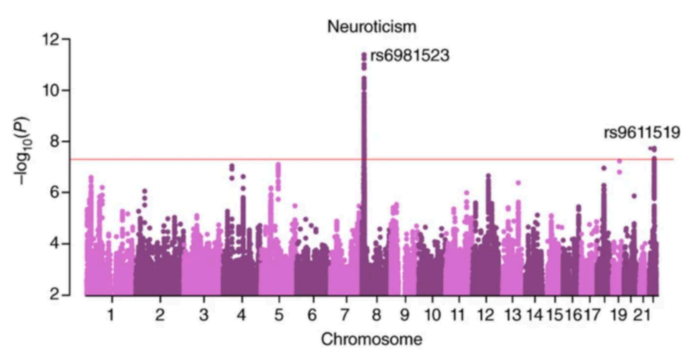

Figure 4: Manhattan plots for neuroticism. Higher peaks at a certain chromosome indicate a stronger association with that chromosome on which the genes listed previously are located on (Lo, et al, 2016)

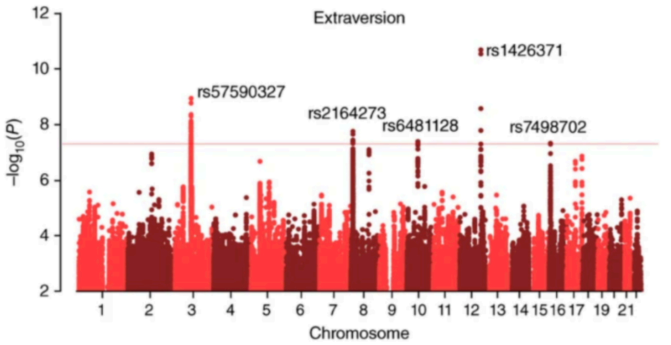

Figure 5: Manhattan plots for extraversion (Lo, et al, 2016)

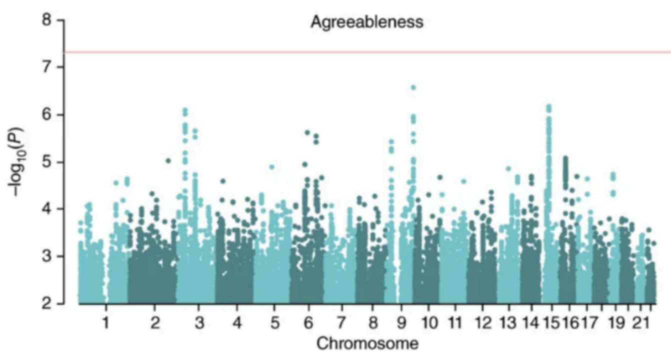

Figure 6: Manhattan plots for agreeableness (Lo, et al, 2016)

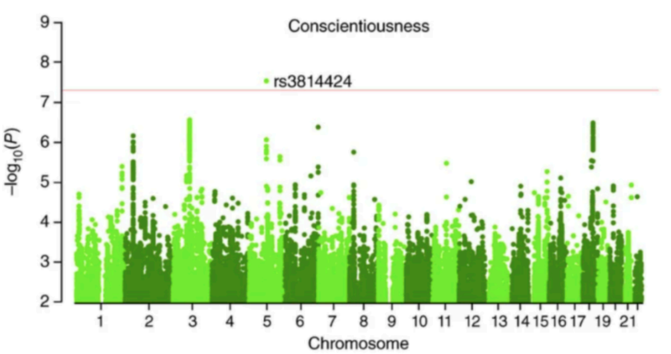

Figure 7: Manhattan plots for conscientiousness (Lo, et al, 2016)

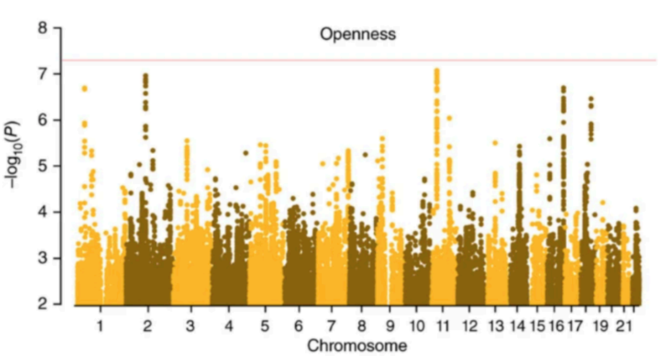

Figure 8: Manhattan plots for openness (Lo, et al, 2016)

THE FUTURE OF GWAS AND BEHAVIORAL GENETICS

Certain behaviors can evolve into active disorders that interfere with a person's daily life. By studying GWAS and the specific genes that are associated with specific behaviors, researchers can develop therapies that target those specific genes without causing extreme, unwanted adverse effects. However, the manipulation of these genes may arguably cross the ethical line of interfering with human nature and changing who the target is as a person entirely. While the purpose of these targeted therapies is to simply help those with severe disorders and improve their lives, future parents may take advantage of these therapies to create the "perfect" child, adjusting their child's genes until they exhibit the behaviors they deem desirable. As such, the development of target therapies should be carefully regulated and not easily accessible to the public due to its overwhelming risks and ethical complications.

CONCLUSION

Contrary to common belief, behaviors are more strongly influenced by a genetic predisposition compared to their environment effect, as explored through twin and adoption studies as well as the Genome-Wide Association Studies. However, both genes and environment will always play a role in determining the behaviors and personality traits of an individual. By recognizing and understanding how genes relate to the heritability of these behaviors, future generations can develop targeted therapies but also need to be wary of ethical concerns regarding potential misuse.

REFERENCES

1. Campos, Adrian I. Mitchell, Brittany L. Rentería, Miguel E. (2019). "Twins Can Help Us Understand How Genes and Environment Shape Us."

2. Harris, Julie A. Lang, L Kerry. Olson, James M. Vernon, Philip A. (2001). "The Heritability of Attitudes: Twin Studies." Attitudes and Social Cognition, vol 80. Journal of Personality and Social Psychology. pp 845-46.

3. Hart, Sara et al. (2021). "Nurture might be nature: cautionary tales and proposed solutions." Science of Learning.

4. Lo, Min-Tzy. (2017). “Genome-wide analyses for personality traits identity six genomic loci and show correlations with psychiatric disorders.” Nature genetics, vol 49, 1. pp 152-156.

5. Lo, MT., Hinds, D., Tung, J. et al. (2016). “Genome-wide analyses for personality traits identify six genomic loci and show correlations with psychiatric disorders.”

6. MedicinePlus. “What are genome-wide association studies?” National Library of Medicine.

7. Myers, David G., DeWall, C. Nathan. (2018). *Psychology 12e* (12th ed.).

8. Vinkhuyzen, AAE. (2012). “Common SNPs explain some of the variation in personality dimensions of neuroticism and extraversion.” Translational psychiatry, vol 2.