What do the genetics of education tell us about learning?

Not necessarily what you might think

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DNA can now be used to predict the probability that a person will complete high school or college. Although it may seem that researchers have discovered the genetics of ease of learning, things may not be that straightforward. The genetics of educational attainment may reflect many different characteristics of individuals and the types of environments to which they are exposed. In fact, this genetic research may even reveal more about the role of the environment than that of the genes.

Perhaps the most successful endeavor in social science genomics has been a series of genome-wide association studies of the number of years of school that the participants completed in their lifetime. The premise behind these studies is relatively simple. Of the millions of genetic variants that exist, which are associated with how far people go in school, and how strong are these associations?

The most recent study of this sort used DNA from over 1 million participants and identified over 1000 education-associated genetic variants. Each variant accounted for a very small proportion of variation in years of educational attainment, but in aggregate their effects were more substantial. An algorithm based on results from this study can be used to create a polygenic score, a single numerical summary of how similar an individual’s DNA is to those individuals, from the original study, who went further in school.

Even in new samples, not included in the original study, this polygenic score accounts for over 10% of the variation in the number of years of completed education, and over 15% of the variation in school performance. This rivals some of the most important predictors in the social sciences, such as family socioeconomic status.

What does this tell us about learning? It seems intuitive that the genetics of educational attainment reflects the genetics of how easy learning comes for some individuals; why some individuals struggle and others excel in the classroom.

Indeed, many of the same genetic variants that are associated with educational attainment are also associated with intelligence test scores. However, this line of evidence is somewhat circular, as intelligence is itself sensitive to educational inputs.

Additional mechanisms, particularly environmentally-mediated mechanisms, are important to consider before concluding that education-linked genetic variants reflect the genetics of ease of
learning. This step is critical before educational policies begin taking such differences into account when designing personalized curricula.

Genetic nurture: when genes act through the family environment

Associations between individuals’ DNA and their educational outcomes may reflect opportunities provided to them by genetically-related individuals, e.g. their parents. This has classically been referred to as passive gene-environment correlation to reflect the fact that children passively inherit genetic material from their biological parents, who themselves are typically also responsible for providing them with their rearing environment.

Because of passive gene-environment correlation, genetic variants related to parents’ dispositions to invest in their children’s education and support their cognitive development will be related to those children’s outcomes. Because children inherit half of their genetic material from each parent, this association with child outcomes will hold when the genes are measured in the children themselves – even when the genetic mechanism does not operate directly through the children’s own biology.

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More recently, in the context of genome-wide association research, this phenomenon has been referred to as genetic nurture. Indeed, one major study of over 20,000 Icelanders found that genetic nurture may account for as much as 30% of the predictive power of an educational attainment polygenic score.

It seems intuitive to think that correlations between a child’s polygenic score and his or her educational outcomes operate directly through his or her own biology. Studies of genetic nurture show this is not the case. We live in a society that is stratified by educational opportunities and economic rewards. Social stratification is not something that simply occurs anew every generation. Rather, it has long-reaching historic causes. So long as parents have opportunities to support their biological children’s cognitive development and academic advancement in both extreme and quotidian ways, “genetic effects” on educational attainment have the potential to represent some mixture of direct biological processes and indirect environmental processes.

Genetic nurture is clearly not the whole story with respect to the genetics of education. When full siblings, who necessarily have the same family members, are compared, education-associated genetic variants continue to account for differences in educational attainment, albeit to a lesser extent than when unrelated individuals (who also differ in their family members) are compared.

Children shape their experiences and their experiences shape them

Associations between individuals’ DNA and their educational outcomes, even when comparing siblings, may still reflect environmental causation, because the education-linked genetic variants may operate through psychological characteristics associated with seeking out and evoking cognitively stimulating and educationally-relevant experiences.
For instance, parents and teachers may engage more deeply with curious and attentive children (i.e., evocative gene-environment correlation). Or, students intrinsically interested in chess might seek out very different social situations compared to students intrinsically interested in sports (i.e., active gene-environment correlation). To the extent that these environmental experiences have causal effects on child development, the predictive power of a polygenic score is driven by environmental factors.

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More broadly, these processes are consistent with transactional models in which the children shape their experiences and, in return, the experiences shape the children. Interestingly, active and evocative gene-environment correlations are leading explanations for developmental increases in the heritability of cognitive ability, pointing toward important environmental bases for differences that are colloquially referred to as “due to genes.”

Genes do not work in a vacuum

In conclusion, it is a remarkable scientific accomplishment to be able to statistically account for 10-15% of the variance in educational outcomes with genetic markers. At the same time, it is important to remember that these genetic associations may reflect many different characteristics of individuals and their parents (and other biological relatives): cognitive ability, noncognitive skills like self-control, curiosity, and enjoyment of learning, as well as all the myriad ways these individual characteristics intersect with children’s broader environmental contexts as they develop.

This complexity reveals exciting opportunities to use genetics to better understand developmental processes and identify environmental targets for interventions and policies to support child development in society at large. At the same time this complexity suggests that aspirations to use polygenic scores to select or make educational decisions for individual children are likely to be misguided. In many cases, polygenic scores may tell us more about children's circumstances than about the children themselves.

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