Education Research Brief

The Fallacy of the Genetic Determination of Inherent Cognitive Abilities

Professor Ian Morgan

Save Our Schools

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https://saveourschools.com.au

twitter.com/SOSAust

saveourschools690@gmail.com

Inequity in education is the key challenge facing Australian education policy. One of the fundamental premises of the approach by Save Our Schools is that the mean and range of intrinsic abilities, however they are defined and measured, should be the same across different social groups, whether defined in terms of social class, ethnicity, or any other broad characteristic. As the Gonski Report stated as justification for its definition of social equity in education:

> Central to the panel's definition of equity is the belief that the underlying talents and abilities of students that enable them to succeed in schooling are not distributed differently among children from different socioeconomic status, ethnic or language backgrounds, or according to where they live or go to school. (1)

This has been a controversial area over many years, with a consistent pattern of assertions that genetics determines class and ethnic/racial differences, through differences in intrinsic cognitive ability, and that, as a result, interventions cannot change differences in educational outcomes by social group. (2) These claims have consistently been contested, often hotly given their social importance, on both direct scientific and practical grounds (3-5). In addition, there has always been evidence that there are major environmental impacts on IQ (6) and that social change and intervention programs can change outcomes, (7) particularly for equity target groups.

A key part of the case for genetic determination was the claims that IQ or intelligence were predominantly inherited, and thus educational outcomes could not be improved. It is important to stress at this stage, that this argument never had any validity, because as pointed out by Visscher et al (8) in their review of heritability in the genomic era, high heritability does not imply genetic determination, precisely because the environment can be changed or manipulated to change phenotype. Our experience over the years is that in the minds of many people there are often vague memories that this issue may has been resolved by the review carried out by the American Psychological Association (APA), which concluded, based on twin studies, that IQ, or cognitive ability, had a significant heritability (50 to 80%), (9) with the implication that there was, at least potentially, a significant genetic basis to social differences. Most of the evidence was obtained with ancestry/ethnic groups predominantly of European or white ancestry and were thus most relevant to class differences. It was generally accepted, albeit not universally, that these conclusions could not be generalised to differences between racial/ethnic groups, (1,8) though this did not prevent some arguing that there was a genetic deterministic difference between racial groups.

In the Australian context, the position based on heritability has been argued by Gary Marks, one of the most trenchant critics of the Gonski approach. Marks argues that the Gonski funding formula cannot succeed because the primary determinant of student achievement is parental abilities that are genetically transmitted to their children. (10) Putting it bluntly, he claims that people from "lower classes" have lower intelligence.(11) While his general argument is that disadvantaged groups are disadvantaged due to their genetic inheritance, he has admitted that this argument specifically applies to socio-economic disadvantage. He has not been so forth-coming about other defined equity groups. It is up to him to explain whether he thinks his arguments apply to other social groups and specifically whether they apply to the low outcomes achieved by Indigenous students.

Over the years, Marks has produced many variations on this theme, using the argument that when "prior student achievement" is included in the analysis of educational outcomes, the contribution from socioeconomic status declines, and often becomes negligible. (12,13) The problem is that if socioeconomic status significantly determines prior student achievement, then the challenge becomes to determine which of the two variables is in fact causally involved. But for Marks, the answer is clear, because his view is that prior student achievement is genetically determined.

Recent progress in research on this topic has further undermined the relevance of heritability as defined by twin studies and has reached the point that estimates of heritability based on more powerful and direct molecular genetic analysis show that the genetic contribution to prior performance or cognitive ability (or IQ) is quite small, with abundant room for environmental factors to play a major role.

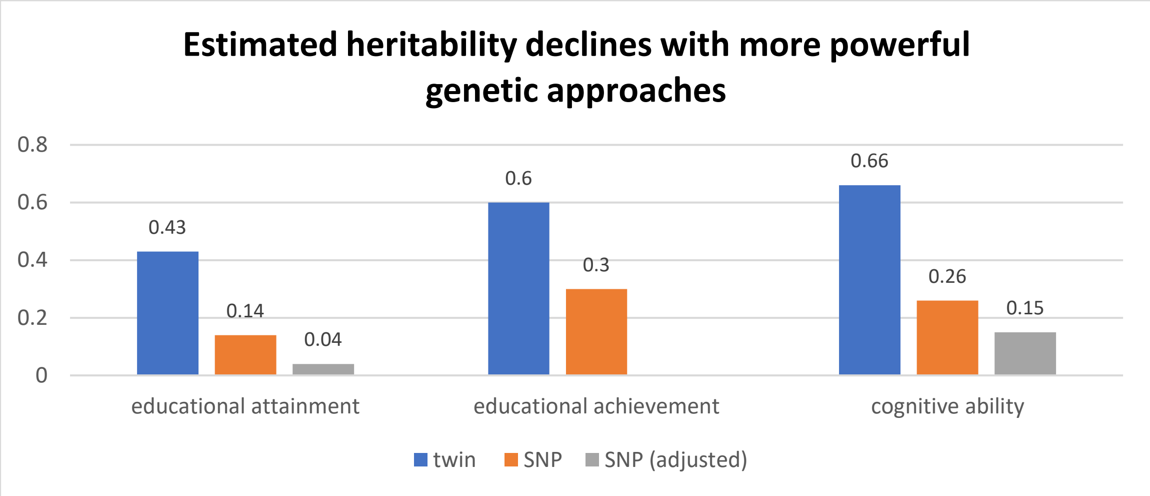
Heritability estimates originally were based on analysis of twin studies. Their logic is that since identical twins are effectively 100% identical genetically, while non-identical twins are on average 50%, if identical twins are more similar in a particular characteristic or trait, such as educational outcomes, then this difference could be explained by genetic differences. This logic rests on the assumption (often known as the common environment assumption) that parents treat non-identical twins as identically as they treat identical twins. (8) The common environment assumption is rarely tested, and is somewhat implausible, given that identical twin pairs are always of the same sex, whereas non-identical twins are half the time of different sexes. In addition, parents are frequently observed to treat identical twins very similarly. If parents do tend to treat identical twins more similarly than they treat non-identical twins, then the possible genetic contribution would decrease, at the limit to zero.

Subsequent research has shown that twin studies often over-estimate the genetic contribution to complex traits. To determine how valid twin study estimates of heritability are, a vital step is to find variation at the molecular genetic level that corresponds to the estimated genetic contribution. This has become possible with advances in molecular genetics, using analyses known as genome-wide association studies (GWAS), (14) which associate genetic differences that are known as single nucleotide polymorphisms (SNPs) with variations in the trait under study. It rapidly became clear that in many cases, there was not nearly enough associated genetic variation to explain the twin heritability estimates – a problem that has become known as missing heritability. (15) As a generalisation, the gaps were particularly large for more complex traits that could plausibly be affected by environmental/social variation.

GWAS traditionally uses tight statistical criteria for establishing an association, and generally very large samples are studied to increase the chance of finding statistically valid associations. Many studies now use sample sizes in the hundreds of thousands, if not millions. An alternative approach abandons the need for statistical significance, in an attempt to close the gap between expectation based on twin heritability and effects of SNPs, (16) but the gap remains large for many complex traits.

The largest study of the genetic contribution to educational attainment and cognitive performance used a sample size of 1.1 million and has been able to account for 11-13% of the variation in educational attainment and 7-10% of the variation in cognitive performance (17) – still well short of the APA-endorsed 50-80% estimate for IQ from twin studies. In many cases, increasing the sample size tends to produce diminishing returns, suggesting that a full explanation is unlikely to be achieved, even with exceptionally large samples. For example, with educational attainment, an increase in the sample size to over 3 million, lifted the percentage of variation explained to 12-16%. (18)

Even with this level of sophistication, there are still problems. These SNP-based estimates can be inflated by population stratification, assortative mating, and by effects based on family environments, rather than the child's genetics. These can be allowed for by limiting variation in population ancestry, and by limiting analysis to comparisons of siblings within families, where family environments are controlled. Once this is done, the genetic contribution to variation in educational attainment drops to 4%, and that of cognitive ability (essentially what Marks claims is genetically inherited from parents and is the basis of differences between social groups) drops to 15%.(19) Genetic variation is at best a minor contributor to both traits. The impact of these new methods can be seen in the following Figure.



Note:

Heritability was initially estimated from twin studies, which required significant assumptions about aspects of the data., most notably the common environment assumption. Molecular approaches are based on determining associations between SNPs in population samples, but the assumptions made in twin studies are not required. The SNP-heritability is derived from analysis that treats any association detected as valid, even if it fails to reach statistical significance, and gives an upper limit to the heritability that can be based on SNPs determined in GWAS. In a general population, these estimates can be inflated by population stratification, assortative mating, or non-genetic transmission within families. Many of these problems are minimised by determining within-family SNP-heritability, by comparing differences in SNPs and the trait under study within large numbers of sibling pairs.

Estimated heritabilities have declined markedly for complex traits, such as, but not limited to educational attainment (defined as years of schooling), educational achievements (defined as academic results at a specific level of education), and cognitive ability, which is much the same as intelligence, although there are many technical details and disputes in this area. As the more precise molecular techniques have been applied, the proportion of variation in each trait that could be attributed to genetic variation has declined, often reaching very low levels. The recent within-family analysis has not yet been applied to educational achievements, and a further decline using within-family analysis would be expected.

The genetic determinist argument is that a high heritability means environmental (and more easily modifiable) factors have little role to play, implying that environmental interventions may be difficult to implement. However, the large role played by non-genetic factors means that this argument no longer has validity. Some geneticists argue that the missing heritability will one day be found with different types of genetic analysis. Irrespective of the outcome of future studies, while some additional genetic variation may be discovered, the fact that some environmental interventions have been shown to improve outcomes in a number of cases is proof of the principle that appropriately designed environmental interventions can work, refuting arguments based on the genetic inheritance of cognitive abilities.

Data source:

Data taken from refs 19, 20, 21 and 22. Haworth et al (2010) (Molecular Psychiatry 15:1112-1120), Schwabe et al (2017) (Frontiers in Genetics 8:160, Howe et al 2022 (Nature Genetics 54:581-594) and Silventoinen et al (Science Reports 10:12681)

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The implications of these more penetrating analyses of genetic contributions for the arguments put forward by Marks are profound. Far from being genetically determined, factors such as educational achievements and cognitive ability appear to have only minor genetic contributions, and socioeconomic status remains as a potentially important determinant of student abilities and school performance. The idea that genetic inheritance of cognitive ability sets fundamental limits to student performance for most of the population simply has no scientific legs to stand on.

We should note that some, such as Marks (13), continue to rely on twin study heritability estimates. Others, such as Plomin (23) assert their confidence that molecular studies will eventually find the missing heritability, even though the potential of GWAS in relation to massive sample sizes now seems to be exhausted. It is certainly true that other molecular approaches may improve the fit somewhat but given that the limitations of twin study analysis are increasingly understood, and that environmental effects and interventions are clearly working in areas where twin heritability has been interpreted as meaning that they should not, we believe that the Panel should reject any arguments, based on out-dated analysis, that suggest that there is a major genetic limitation to improving educational outcomes for students, irrespective of their "socio-economic, ethnic or language backgrounds, or where they live or go to school."

This article is a revised version of a section of the SOS submission to the Independent Review of the National Schools Reform Agreement.

Professor Morga is. is a former president of the Australian Council of State School Organisations and the ACT Council of Parents and Citizens Associations and a mem er of Save Our Schools. he is a Visiting Fellow at the Australian National University In that capacity, he has done extensive research on the causes of myopia, which is in part caused by intensive educational pressures, and has overturned the once prevailing dogma that myopia was genetically determined, by finding that environmental factors play a major role in determining the prevalence of myopia, despite the high heritability values consistently reported in twin studies.

Endnotes

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