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Family Background Buys an Education in Minnesota but Not in Sweden

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Abstract

Educational attainment, the highest degree or level of schooling obtained, is associated with important life outcomes, at both the individual level and the group level. Because of this, and because education is expensive, the allocation of education across society is an important social issue. A dynamic quantitative environmental-genetic model can help document the effects of social allocation patterns. We used this model to compare the moderating effect of general intelligence on the environmental and genetic factors that influence educational attainment in Sweden and the U.S. state of Minnesota. Patterns of genetic influence on educational outcomes were similar in these two regions, but patterns of shared environmental influence differed markedly. In Sweden, shared environmental influence on educational attainment was particularly important for people of high intelligence, whereas in Minnesota, shared environmental influences on educational attainment were particularly important for people of low intelligence. This difference may be the result of differing access to education: state-supported access (on the basis of ability) to a uniform higher-education system in Sweden, versus family-supported access to a more diverse higher-education system in the United States.

Keywords

educational attainment; intelligence; gene-environment interaction; gene-environment correlation; genetic and environmental influences

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Greater educational attainment is associated with important life outcomes, including higher income, more professional and skilled occupations, less antisocial behavior, and better health and longevity (Bronfenbrenner, McClelland, Wethington, Moen, & Ceci, 1996; William T. Grant Foundation, 1988). The advantages to greater educational attainment can be observed at both the collective social and the individual levels (Brody, 1997): Societies with well-educated populations tend to be healthier, be more productive, and have higher standards of living than societies with less educated populations. Within societies, the same appears to be true of individuals. Although all individuals benefit from receiving an

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education (Gottfredson, 1997), there is large individual variation in how much benefit is obtained through education.

For all these reasons, most nations have accepted the responsibility of providing public access to schooling. In addition, because education is expensive, most nations aim to provide a uniform minimum level of education to all, and higher levels of education to some individuals. The allocation and distribution of access to higher levels of education varies across societies. In general, however, societies differ in the emphasis placed on an individual's ability to benefit from higher education versus the individual's ability to pay for the education. It is important to understand these balances across societies, in order to investigate the consequences of various policies and systems and determine how to attain the most desirable balance.

A dynamic quantitative environmental-genetic model (Johnson, 2007; Purcell, 2002) can help to document the effects of these social allocation patterns. The model can therefore shed light on the population-level effects of policies regarding allocation of a valuable social commodity that is highly variable at the individual level. The dynamic quantitative environmental-genetic model measures the extent to which a specific personal trait or environmental factor moderates the environmental and genetic influences on another trait or factor. For example, a study using this model showed that higher income was associated with lower genetic vulnerability to physical health problems in a U.S. population sample (Johnson & Krueger, 2005). Where such moderating factors are present, the model also makes it possible to infer distinctions between environmentally created constraints on individual outcomes and outcome selection processes that are driven by characteristics intrinsic to individuals (Johnson, 2007). For example, in the same U.S. population sample studied by Johnson and Kruesger (2005), genetic influences on physical health problems were strongly associated with genetic and environmental influences on income only when income levels were high, which suggests that environmental consequences of low income, or environmental factors associated with low income, led to a greater expression of genetic vulnerabilities (Johnson & Krueger, 2005). In the study presented in this article, we used this environmental-genetic model to estimate the moderating effects of general intelligence on environmental and genetic influences on educational attainment in young adults in Sweden and compared our findings with those of earlier studies in Minnesota in the United States (Johnson, Deary, & Iacono, 2009).

We considered general intelligence to be an appropriate moderating variable to use in our study because, historically, measures of general intelligence were created to identify individuals who would benefit from education. In addition, the ongoing association between general intelligence and educational achievement is well established (Neisser et al., 1997). We selected Sweden as a geographical area suitable for comparison to the state of Minnesota in the United States, as both are developed Western regions with generally high standards of living, long histories of democracy, and respect for education. Also, similar research data were available for these two regions. Moreover, because of patterns of immigration to the United States, a large percentage of the population in Minnesota is of Swedish origin, and this minimized the possibility that our findings were influenced by genetic differences between the two populations. However, the regions have marked differences in their systems of providing higher education and in the relative socioeconomic benefits associated with higher education. Results and inferences from these two regions may not generalize to Europe more broadly, or to the United States as a whole.

Method

Participants and measures in Sweden

The Swedish data we used in this study came from a nationwide Swedish database created by linking records of the Multi-Generation Register (MGR) with several other national registers. The MGR includes all Swedish citizens born since 1932 who were alive and residing in Sweden after 1961. Male twin pairs in the MGR were ascertained by identifying full brothers born on the same day between 1951 and 1976. Data on zygosity were obtained by linking the Swedish Twin Register and the Swedish Young Male Twins Study, using DNA sequence information, when available, and standard telephone and mail survey questionnaires about childhood similarity when genetic information was not available. The efficacy of the childhood similarity method was verified in a pilot study of 199 adult pairs using 13 DNA markers, and found to be over 99% accurate (Lichtenstein et al., 2002).

The MGR was linked to the Military Service Conscription Register for the period between 1969 and 1976, and to the Longitudinal Database on Occupation, Education and Income for the period between 1990 and 2004. The two latter sources provided data on general intelligence between the ages of 18 and 19 years, and educational attainment by the ages of between 28 and 53 years, depending on year of birth. The general intelligence tests used were consistent between 1969 and 1994. Thus, for this study, we included 7,739 male twin pairs born between 1951 and 1976, or a total of 15,478 individuals. Of these, 7,316 individuals had not participated in other studies and were therefore of undetermined zygosity. This left 3,740 members of monozygotic (MZ) pairs and 4,422 members of dizygotic (DZ) pairs. For the 3,740 MZ-pair members, general intelligence data was available for 3,316 (89%) individuals, and educational-attainment data was available for 3,409 (91%) individuals. For the 4,422 DZ-pair members, general intelligence data was available for 3,971 (90%) individuals and educational-attainment data was available for 4,118 (93%) individuals. Between 7% and 11% of data were missing because of death or emigration prior to age 18 or failure to conscript or complete education records.

Until 1994, four basic mental-ability tests were administered to individuals to estimate general intelligence for military conscription (for a detailed description of these tests, see David, Malmberg, Brandt, Allebeck, & Lewis, 1997). The four tests included a logic-reasoning test, a verbal test of synonym detection, a test of visuospatial-geometric perception, and a test comprising mathematics and physics problems. The conscription administration derived a global intelligence score ranging from 1 (low intelligence) to 9 (high intelligence) from the combined scores on these four tests. We did not use these global scores in our study. Instead, we used principal-axis factor analysis to extract a single general intelligence factor that accounted for 68% of the variance, and calculated its regression-based factor scores. The MZ and DZ twin data included 143 people with only global intelligence scores (from 1 to 9). For these individuals, we used the mean factor scores for the individuals with full data in each global-score group.

Education was recorded on a scale ranging from 1 (less than 9 years of education) to 7 (doctoral studies), with 4 indicating a full secondary education (12 to 13 years of study). Overall, the average level of education in our sample of individuals was 3.95 (SD = 1.45), but average levels of education increased over time, from a low of 3.43 (SD = 1.58) for birth year 1951, to a high of 4.64 (SD = 1.19) for birth year 1975. There was a significant correlation between birth year and education level, $r = .26$ ($p < .001$). There was a much lower but still significant correlation of .04 between general intelligence factor scores and birth year. We thus regressed the secular variation over time in age and age-squared from both the intelligence and the education measures to remove the effects of these secular trends.

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Participants and measures in Minnesota

Minnesotan data were obtained from the Minnesota Twin Family Study (MTFS), an ongoing, population-based longitudinal study of same-sex male and female twin pairs born in Minnesota. In our study, we compared results from analysis of the Swedish data with results from a similar analysis (Johnson, Deary, & Iacono, 2009) of MTFS data, so we describe the MTFS sample and measures only briefly. We made use of the older MTFS cohort, originally assessed at age 17, with a follow-up assessment at age 24. The targeted birth years for this cohort were between 1972 and 1978 (males) and between 1975 and 1979 (females). Over 90% of twins born in these years were located, and over 80% of those eligible to take part in our study agreed to participate. The twins were generally representative of the Minnesotan population during the period in which they were born.[1] Like the Minnesotan population, 98% of the twins were Caucasian. A complete description of geographic location, recruitment, assessment procedures, and analysis of nonparticipants has been provided by Iacono, Carlson, Taylor, Elkins, and McGue (1999). At age 17, the sample included 411 MZ pairs (54% female, 46% male) and 430 DZ pairs (53% female, 47% male). Over 92% of individuals who participated at age 17 returned for the follow-up assessment at age 24.

At age 17, participants took four subtests (Vocabulary, Information, Block Design, and Picture Arrangement) of the Wechsler Adult Intelligence Scale (Wechsler, 1981). Participants' scores ranged from 69 to 151 (M = 99.5, SD = 14.1). At age 24, each participant's educational attainment was measured on a scale ranging from 0 (failure to complete high school) to 12 (completion of a professional degree, such as a Ph.D., J.D., or M.D.). This scale also recognized ongoing enrollment in educational programs, with scores given according to the level of enrollment (e.g., enrollment in a Ph.D. program = 11). The average level of education was 6.3 (SD = 2.4), corresponding to the completion of slightly more than a community-college degree. By way of comparison, a score of 8 corresponded to the attainment of a 4-year college degree, and a score of 4 corresponded to the completion of a post-secondary-school vocational training program.[2] As some individuals continue their education or return to complete their education after the age of 24, variance in education in this sample in particular was likely to be somewhat restricted at the higher end. It is unclear how this affected our results.

Analysis

The dynamic quantitative environmental-genetic model we used to estimate the moderating effects of intelligence on environmental and genetic influences on attained education is an extension of the standard Cholesky decomposition used to estimate the extent to which environmental and genetic influences are correlated across two variables (Johnson, 2007; Purcell, 2002). Significant genetic correlations provide evidence for genetic influences common to the two variables. Similarly, significant shared and nonshared environmental correlations provide evidence for shared environmental and nonshared environmental influences common to the two variables. The standard Cholesky decomposition is based on the observation that MZ twins share all of their genes, whereas DZ twins share on average half of their segregating genes in the absence of assortative mating. In this standard model,

[1]Twins with disabilities that precluded completion of the study assessment were not eligible. These exclusion criteria were similar to those exempting people from conscription in Sweden.

[2]The educational scales differed in ways reflecting differences in the underlying educational systems. In Sweden, it is common for students pursuing secondary vocational training rather than further academic studies not to complete secondary academic education. This is uncommon in the United States and particularly in Minnesota, where students pursuing vocational training typically complete secondary education and then enroll in vocational training programs. The mean educational level in Minnesota was 2 years of postsecondary education, and the mean educational level in Sweden was slightly less than the completion of a full academic secondary education, which was consistent with this pattern. The education scales used differed in the number of intervals measured, but the ratio of representation of completion of vocational training to university degree were identical (3:6 in Sweden and 4:8 in Minnesota).

the genetic and environmental influences on the trait considered to be the outcome (in this case, educational attainment) are considered to be fixed across the range of the moderating variable (in this case, intelligence). The extended model we used in our study relaxes this assumption, allowing for the possibility that genetic and environmental influences on educational attainment vary linearly with level of intelligence (Fig. 1). In our analyses, all paths were freely estimated, though Figure 1 shows parameter labels only for paths contributing to educational attainment, on which moderation by intelligence was considered. Moderation could take two forms: moderation of environmental or genetic influences common to intelligence and educational attainment, and moderation of environmental or genetic influences unique to educational attainment. Problems with unique parameter solutions are noted in other studies using this model, particularly when the model indicates moderation of environmental or environmental influences common to the two traits in question (Rathouz, van Hulle, Rodgers, Waldman, & Lahey, 2008). However, this condition was not of relevance to our study.

We estimated the model parameters using maximum likelihood analysis as implemented in the software Mx: Statistical Modeling (Neale, Boker, Xie, & Maes, 2003), as the data were approximately normally distributed. We had significantly more estimation power when analyzing the Swedish data than when analyzing the MTFS data, because of their respective sample sizes. The Swedish data were, however, limited to males. To validate our comparisons, we conducted our analyses of the MTFS data using data for males alone, as well as data for females and males together. The resulting parameter estimates were nearly identical, although the moderating effects were not significant in the smaller sample consisting only of males. We thus compared the results from the Swedish data with the results from the full MTFS sample.

Results

In the Swedish data, we found a significant correlation between educational attainment and intelligence (r = .56, p < .001), In the MTFS data, we also found a significant correlation (r = .32, p < .001). Table 1 includes raw twin correlations for the study variables. Genetic influences were indicated by greater MZ correlations than DZ correlations, shared environmental influences by DZ correlations that were greater than half the MZ correlations, and nonshared environmental influences by MZ correlations less than 1.00. We found that all correlations were greater in the Swedish data than in the Minnesotan data. Overall, shared environmental influences were more important in Sweden than in Minnesota. This difference was much more marked for educational attainment than for general intelligence. Table 2 shows the model fit statistics we used to determine whether all moderating terms estimated were needed to describe the Swedish data parsimoniously. Using standard information-theoretic fit statistics (Akaike's information criterion—Akaike, 1983; Bayesian information criterion Raftery, 1995), we determined that the best model for our study was one that allowed moderation of genetic and nonshared environmental influences unique to educational attainment, with small moderating effects of genetic and shared environmental influences common to intelligence and educational attainment.

The parameter estimates from this model indicated that in Sweden, genetic variance in educational attainment increased with greater intelligence (Table 3, Fig. 2). The variance components were raw across the intelligence range, so that at any given level of intelligence variance components did not necessarily add up to 1. Across the intelligence range, from 2 standard deviations below the mean to 2 standard deviations above the mean, shared environmental variance increased sharply from .13 to .42 across the 4-standard-deviation range of intelligence. Genetically influenced variance more than doubled, from .31 to .73. Nonshared environmental variance increased as well, but much more modestly, from .21 to .

29. Shared environmental influences were completely correlated: All shared environmental influences on intelligence also influenced educational attainment. The moderate-to-large genetic correlation between intelligence and educational attainment varied little across the range (.53–.56)[3], indicating the presence of substantial genetic influence common to the two traits. Nonshared environmental influences (which included measurement error) were significantly but not substantially correlated (.16–.14; see Table 4). By definition, the components of variance in intelligence did not vary. Genetic variance was .56, shared environmental variance was .25, and nonshared environmental variance was .16.

Figure 3, the right-hand columns of Table 3, and Table 4 show analogous results for MTFS. Both similarities and differences were apparent. Some of the similarities were superficial. Within each region, we standardized the intelligence and educational-attainment variables. The variables for the two samples were thus placed on the same relative scale, and it is impossible to determine whether there was more absolute variability in one sample or the other. It would have been interesting to be able to do this, but because the scales on which the variables were measured differed, there was no good way to accomplish such a comparison. Within the standardization, however, it was possible to compare relative levels of environmental and genetic variance components in the two samples.

Overall, nonshared environmental variance in educational attainment was very similar in the two samples. There was a small increase in nonshared environmental variance across the range of intelligence in the Swedish group and not in the MTFS group, although this probably reflected the greater statistical power in our analysis of the Swedish data. The biggest difference between the two sets of results was in the shared environmental variance in educational attainment. In Sweden, the shared environmental variance was roughly half the genetic variance across the intelligence range, increasing across that range in a manner very similar to the increase in genetic variance. In sharp contrast, in the MTFS group, shared environmental variance was very large (.70; almost 6 times the genetic variance) when the intelligence level was low, and decreased dramatically to .07 (about 10% of genetic variance) when the intelligence level was high.

There were also similarities and differences in the environmental and genetic correlations between intelligence and educational attainment in the two samples. In both, the shared environmental correlation was 1.00 across the range of intelligence. In other words, all sources of shared environmental variance in intelligence also contributed to variance in educational attainment. This indicated a direct contribution from shared environmental influences on intelligence to educational attainment. In both cases, nonshared environmental variance was almost completely unique to educational attainment. Of course, nonshared environmental variance included measurement error, which is by definition unsystematic and therefore unlikely to be correlated with any other factors.

The patterns of genetic correlations in the two samples differed. In Sweden, genetic correlation was steadily in excess of .50 across the range of intelligence, indicating a genetically influenced direct effect of intelligence on educational attainment that was weaker than the shared environmental effect on educational attainment. In the MTFS population, however, genetic correlation was in excess of .50 when level of intelligence was low, but was halved at higher levels of intelligence. This indicated that genetic influences on

[3]Many people find the concept of genetically influenced covariance between one trait and another at a fixed point (so that the second trait has no phenotypic variance) difficult to comprehend. The key to understanding this concept is to recognize that, for polygenic, multiply determined traits, there can be relevant genetic variance in people who all manifest the same level of the trait. The same is true of environmental variance.

intelligence tended to limit educational attainment when the level of intelligence was low, but not when the level of intelligence was average or high.

Discussion

Our results document the effect of patterns of allocation of social resources in Minnesota and Sweden. A broad interpretation of our results would be that intelligence and educational attainment are more closely related in Sweden than they are in Minnesota. The association of these two factors in Sweden appeared to be driven by shared environmental and genetic influences common to the two traits. We found that for the Swedish population, these common influences were of approximately equal importance[4], working in tandem across a 4-standard-deviation range of intelligence. Although proportions of variance attributable to environmental and genetic influences were relatively constant across this range of intelligence, accounting for 67% to 80% of the total variance in educational attainment, the total variance more than doubled (from 0.65 to 1.44, see Table 3). The increasing total variance suggests that shared environmental and genetic influences on intelligence-related factors (such as admission and achievement requirements) that were also involved in high educational attainment were consistent in limiting educational attainment in individuals with lower levels of intelligence, rather than encouraging educational attainment in individuals with higher levels of intelligence. In Minnesota, the overall association between intelligence and educational attainment was weaker, apparently because shared environmental and genetic influences had a less coordinated effects. Moreover, total variance in educational attainment decreased by about 30% across the 4-standard-deviation range of intelligence (from 1.38 to 0.98). Within this decrease in total variance, however, there was a greater increase in genetic variance and sharper decrease in shared environmental variance in the Minnesotan population than in the Swedish population. Genetic variance in educational attainment was more closely linked with genetic variance in intelligence in individuals with lower levels of intelligence than in those with higher levels of intelligence.

This finding indicates that genetic influences common to intelligence and educational attainment may have been more effective in limiting educational attainment in individuals with low levels of intelligence than in encouraging educational attainment in those with high levels of intelligence. As in Sweden, shared environmental influences on intelligence and educational attainment were completely linked, indicating a direct contribution from shared environmental influences on intelligence to educational attainment. The decrease in shared environmental variance with higher intelligence, however, indicated that shared environmental influences were more effective in encouraging educational attainment in higher-intelligence individuals than in limiting educational attainment in lower-intelligence individuals. In other words, in populations in which shared environmental influences such as family history and values encouraged high levels of educational attainment, individuals were able to surmount limitations in intelligence.

The significant differences in educational attainment that we observed in Minnesota and Sweden may be attributed to differing social allocation systems of providing higher education and differing socioeconomic benefits associated with higher education in the two regions. In Sweden, 9 years of education is compulsory (between 7 and 16 years of age), and the educational curriculum and grading standards are close to uniform throughout the country. There are substantial differences among upper secondary educational programs for students who continue beyond the requisite 9 years of education.

[4]Although the shared environmental correlation was about twice the genetic correlation, there was throughout the range about twice as much genetically influenced variance as shared environmentally influenced variance.

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Application to university takes place through a single national system, and admission is based on grades received in upper secondary school, although it is possible to supplement these grades with good performance on a national examination. No admission preference is given to the offspring of graduates. Students entering university are usually academically well prepared for university-level work. In addition, university students do not pay tuition, and graduate students are supported by education stipends. Although well-educated parents in Sweden tend to encourage their children also to become well educated, education in Sweden is only moderately linked to household level of income, because of the relatively small differences in incomes among professional and vocational occupations, as well as high income taxes.

In Minnesota and the United States more generally, the length of compulsory education (up to 16 years of age) is similar to that in Sweden. In the United States, high school students approximately 14 years of age and older have available to them a wide range of programs, ranging from practical and vocational programs to academic university-level courses. However, all high school students receive the same diploma upon graduation from secondary school. The biggest difference in the educational systems of the United States and Sweden involves university admission. Grades are important in the United States, but the educational systems available to would-be students are so varied that standardization on this basis is difficult, and reliance by college and university admissions officials on the nationally administered achievement-aptitude tests is mixed. Many of the most highly regarded U.S. colleges and universities are private and have subjective as well as objective criteria for admission, including parental alumni status. There are many local and community colleges that accept all or most high school graduates into 2-year programs, and many of these colleges have transfer arrangements with 4-year universities for students who complete the 2-year programs with acceptable grades. Colleges and universities also vary considerably in the levels of achievement required for degree attainment. It is important to note that college and university students pay tuition, which is often very expensive, and leaves many students and parents with large debts. Scholarship programs for individuals who demonstrate financial need are available, but not in sufficient quantity to meet demand. Most of these scholarships are awarded on the basis of academic or athletic achievement. University education is considered very important in obtaining good occupational prospects in a nation with relatively large differences in available income across the population, and many well-educated parents strongly urge their offspring to obtain higher education.

Our analysis does not permit the conclusion that these differences in educational systems cause the differences in environmental and genetic influences on educational attainment observed in this study, but it is reasonable to hypothesize that this is likely. In particular, the greater expense of higher education and greater subjectivity of admission standards in the United States compared with Sweden may partially explain the very different patterns of shared environmental influences in the two population samples. Regardless of the causes underlying the differences we observed, the results of our study make clear that the degrees of environmental and genetic influences can vary substantially between groups with different circumstances, and even within such groups. Our results also suggest that the ways in which social systems are organized may have implications for how and to what extent environmental and genetic influences on behavior will be expressed.

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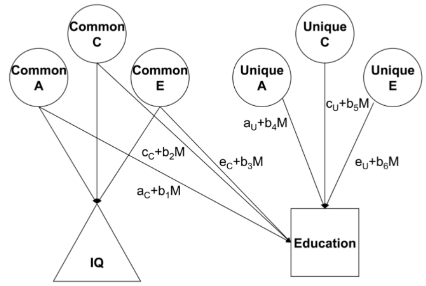

Fig. 1.

Diagrammatic model of genetic and environmental influences linking intelligence and educational attainment. In our study we tested genetic (*a*), shared environmental (*c*), and nonshared environmental (*e*) influences. The equations for the paths in the model allow level of intelligence (*M*) to moderate the genetic or environmental influences on educational attainment. “C” refers to influences common to intelligence and education, and “U” refers to influences unique to education.

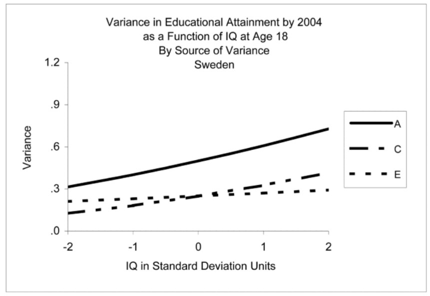

Fig. 2.

Variance in educational attainment in Sweden by 2004, as a function of IQ (in standard deviation units) measured at 18 years of age. Results are shown for three sources of variance: genetic (*A*), shared environmental (*C*), and nonshared environmental (*E*) influences.

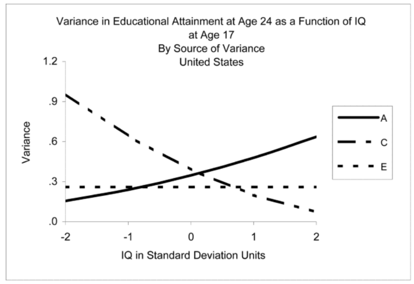

Fig. 3.

Variance in educational attainment in Minnesota by 24 years of age as a function of IQ (in standard deviation units) measured at 17 years of age. Results are shown for three sources of variance: genetic (*A*), shared environmental (*C*), and nonshared environmental (*E*) influences. We observed less genetic variance in educational attainment across the intelligence range in the MTFS population than in the Swedish population. For example, Table 3 shows that at the mean level of intelligence, genetic variance was .35 in the MTFS group, but .50 in the Swedish group. Genetic variance in educational attainment increased across the range of intelligence in both samples. The increase was steeper in the MTFS population than in the Sweden population: It quadrupled from .16 to .64 across the 4-standard-deviation range of intelligence in the MTFS population, but slightly more than doubled in the Swedish population.

Table 1

Twin Correlations of Study Variables in the Swedish and Minnesotan Populations

Population and variable	Monozygotic twins	Dizygotic twins
Swedish twins		
General intelligence at age 18	.83	.55
Education attained by 2004	.74	.47
Minnesota twins		
Wechsler Adult	.81	.51
Intelligence Scale IQ at age 17		
Education attained by 24 years of age	.63	.29

Note: For the Swedish twin pairs, general intelligence was measured using factor scores from the general factor based on the four ability tests administered by the Swedish National Service Administration. The Swedish sample consisted of males only and included 3,740 monozygotic and 4,422 dizygotic twin pairs. The Minnesotan sample consisted of male and female same-sex pairs and included 411 monozygotic and 430 dizygotic twin pairs.

Table 2

Fit Statistics From the Models of Variance Components Allowing for Gene-Environment Interaction and Correlation

Model	$-2LL$	*df*	χ^2	Δdf	*p*	Akaike information criterion	Bayesian information criterion
All parameters free	32,703.7	20752	—	—	—	32,737.7	32,960.2
Fix unique *c* and common *e* moderation paths[a]	32,708.4	20754	4.7	2	n.s.	32,734.4	32,904.5
Fix all moderation paths	32,826.1	20758	117.7	4	$< .001$	32,848.1	32,992.0

Note: Common and unique moderation paths were possible for each of the following: (*a*) genetic influences, (*c*) shared environmental influences, and (*e*) nonshared environmental influences. Fixed moderation paths were constrained to 0, which means that those sources of influence were present but did not vary across the levels of the moderators. Thus, moderation on *a* remained free in the final model. LL = log-likelihood; Δdf = difference in degrees of freedom between the model with all parameters free and the model under consideration, on which the statistical test is based.

[a]This was the best-fitting model.

Table 3

Estimates of Genetic and Environmental Variance Components in General Intelligence and Educational Attainment at Three Levels of General Intelligence in Sweden and Minnesota

Variance component	Sweden			Minnesota		
	−2 *SD*	0 *SD*	2 *SD*	−2 *SD*	0 *SD*	2 *SD*
General intelligence						
Genetic	same	0.58 (0.53, 0.64)	same	same	0.73 (0.58, 0.85)	same
Shared environmental	same	0.26 (0.20, 0.32)	same	same	0.07 (0.00, 0.22)	same
Nonshared environmental	same	0.16 (0.15, 0.18)	same	same	0.20 (0.17, 0.22)	same
Educational attainment						
Genetic	0.31 (0.17, 0.50)	0.50 (0.42, 0.58)	0.73 (0.50, 1.002)	0.16 (0.09, 0.26)	0.35 (0.13, 0.61)	0.64 (0.09, 1.57)
Shared environmental	0.13 (0.03, 0.55)	0.25 (0.19, 0.34)	0.42 (0.22, 0.68)	0.96 (0.79, 1.13)	0.39 (0.14, 0.61)	0.07 (0.00, 0.68)
Nonshared environmental	0.21 (0.16, 0.23)	0.25 (0.23, 0.27)	0.29 (0.23, 0.35)	Same	0.26 (0.22, 0.31)	same

Note: The table presents estimates of the variance in general intelligence and educational attainment explained by genetic, shared environmental, and nonshared environmental influences. Estimates are presented for three levels of general intelligence: the mean, 2 standard deviations below the mean, and 2 standards above the mean; “same” indicates that there is no difference from the variance at the mean level. The variance components are raw and do not necessarily add up to 1.00. Numbers in parentheses are 95% confidence intervals. The Swedish data included only male pairs. The Minnesotan data included both male and female same-sex pairs. In Sweden, general intelligence was measured by *g* factor score at age 18, and educational attainment was assessed through 2004. In Minnesota, intelligence was measured by IQ score at age 17, and educational attainment was assessed at age 24.

Table 4

Correlations Between Influences on Intelligence and Education at Three Levels of General Intelligence in Sweden and Minnesota

Variance component	Sweden			Minnesota		
	−2 *SD*	0 *SD*	2 *SD*	−2 *SD*	0 *SD*	2 *SD*
Genetic	0.53 (0.44, 0.62)	0.55 (0.50, 0.59)	0.56 (0.47, 0.65)	0.57 (0.31, 0.86)	0.38 (0.12, 0.67)	0.28 (0.02, 0.57)
Shared environmental	1.00 (0.87,1.00)	1.00 (0.94,1.00)	1.00 (0.87,1.00)	1.00 (0, 1.00)	1.00 (0, 1.00)	1.00 (0, 1.00)
Nonshared environmental	0.16 (0.11, 0.22)	0.15 (0.10, 0.20)	0.14 (0.09, 0.20)	0 (−0.13, 0.13)	0(−.13, 0.13)	0 (−0.13, 0.13)

Note: The table presents correlations at three levels of general intelligence: the mean, 2 standard deviations below the mean, and 2 standards above the mean. Numbers in parentheses are 95% confidence intervals. The Swedish data included only male pairs. The Minnesotan data included both male and female same-sex pairs.