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Socioeconomic background and the gene-environment interplay in social stratification across the early life course in Finland

Jani Erola[1], Hannu Lehti[1], Tina Baier[2] & Aleksi Karhula[1]
1) University of Turku
2) Leibniz Institute for Educational Trajectories

Aims of the study

The association between parents' and children's socioeconomic status is well-established in the literature, but there is little research on how parents' resources are related to the genetic effects on offsprings' status related attainment. In this study we ask 1) to what extent parents' socioeconomic characteristics shape genetic effects on children's' education, occupational standing and income; 2) does this vary over children's early life course; and 3) are there differences across the social strata?

To elaborate how parents' socioeconomic resources shape genetic effects on offsprings' attainment over the life course we differentiate between gene-environmental correlations (rGE) and gene-environment interactions (GxE) (Scarr and McCartney, 1983; Shanahan and Hofer, 2005). Due to the *passive* and *evocative* gene-environment correlations we expect that parental characteristics shape genetic effects on children's attainments stronger in early than in later stages of offspring's life course.

In the case of *passive* rGE, parents have an impact on the strength of the genetic expression by providing or selecting the environmental influences enhancing children's skills and talents. During the early childhood children rely almost exclusively on the family as they provide the environmental conditions and stimuli under which children develop, whereas later during the life course this kind of impact should become much more limited. Because of this, the influence of parents' socio-economic resources on genetic expression should be overall stronger the younger children are. Passive gene-environmental correlations can also shape genetic effects in distinct ways that vary between outcomes. Since educational degrees are attained typically earlier in the life course than occupational maturity is being reached and because the individual income trajectory peaks later than both education and occupational attainment, we expect that parents' socio-economic characteristics have the strongest impact on children's education and the smallest for income.

In the case of the *evocative* rGE, parents choose the environments based on their reflections on children's genetic dispositions, be that needs, abilities, skills or deficiencies in any of them. The success in education should be a strong signal for such characteristics. Thus, parent's influence on genetic expressions should be the strongest around the ages when decisive educational choices for children are made.

Additionally, genetic effects can vary according to social conditions, referred to as gene-environment interactions (*GxE):* enriched rearing environments provided by advantaged parents tend to enhance genetic expression while the rearing environment provided in disadvantaged environments tends to suppress of genetic effects. Consequently, we expect that genetic effects are stronger in advantaged than in disadvantaged families.

The data and research methods

The literature on gene-environment correlations and interactions is well acknowledged in genetics, but hard to study in the context of intergenerational attainment mainly because of excessive data requirements: data should allow genetically sensitive designs, distinguish a wide range of parental resources, and cover life courses from the early childhood to adulthood. We study the gene-environment correlations and interactions in socioeconomic outcomes among young adults using high-quality data on twins born 1975-1986, acquired from Finnish administrative registers. The data cover full Finnish population and a wide range of socioeconomic and demographic characteristics

from years 1975, 1980, 1985 and 1987-2016. In Finland, the importance of family background has been found to be relatively low for different types of socioeconomic attainment, presumably because of the free of charge education and the strong support of the egalitarian welfare state (i.e. Erola et al., 2016), which makes it a particularly interesting institutional context to analyze the importance of genes for these types of outcomes.

We and use the classical twin design (CTD, Plomin et al., 2008) to estimate the relative importance of genes. Twins are born at the same time, while dizygotic twins share on average 50% of their DNA, monozygotic twins are genetically identical. These distinct features of twins allow to decompose the total variance of an outcome into a component associated with additive genetic influences (A), shared environmental influences (C), and unique environmental influences (E) including the error term of the variance decomposition (ACE variance decomposing method, for limitations, see Turkheimer et al., 2005). Typically to the register data sources, our data sources do not include information on zygosity. Instead, the population estimates on the importance of genes are retrieved by comparing same- and opposite-sex twins. Opposite-sex twins are dizygotic while same-sex twins can be both mono- and dizygotic. We adjust our estimations on the relative importance of genetic influences based on the assumption that approximately half of the same-sex twins are monozygotic (Figlio et al. 2017). In order to estimate the importance of the observed parental characteristics at the different stages of offspring's early life course, we fit ACE models to retrieve genetic influences on the chosen outcomes (Rabe-Hesketh et al., 2008).

Our *outcomes* of interest refer to twin's highest education (measured in years), highest occupation-based socioeconomic status (ISEI), and average log gross annual income at age 28-34. Our explanatory variables refer to parental social background characteristics indicated with parents' highest level of education, socioeconomic status and income. Each of these characteristics are observed at five stages of the offsprings' early life course, at age 0-5, 6-10, 11-15, 16-20 and 21-25.

Findings

Table 1 reports ACE variance decompositions for young adults' education, ISEI and income. For education, genetic influences (A) matter most, as they account for about 46 % of the total variance in education. In the case of income, genetic effects are least pronounced, roughly 29%. ISEI sets in between, genes accounting for 42% of the total variation. Shared environmental influences (C), by contrast, are absent for income, and account only for about 7 % of the total variance of ISEI, and for about 11 % in the case of education. Results for income are similar to the earlier results on life-time earnings of an older birth cohort using observational data on twins in Finland (Hyytinen et al. 2019). The overall results provide support for our expectation that gene-environmental correlations differ across socioeconomic outcomes: both genetic and shared environmental influences are stronger the earlier the maturity in an outcome in question has been reached.

To examine possible life course variation we study different life stages of twins life course separately (i.e. ages 0-5, 6-10, 11-15, 16-20, and 21-25) and control for parental education, ISEI and family income. We focus on twins' ISEI (full paper includes analyses for education and income as well). Because shared environmental influences (C) on ISEI were not substantial (7%, see Table 1), we estimate AE-models in the subsequent models instead. Table 2 shows that the proportion explained by parental characteristics does not substantially change across the early life course. In addition, we do not find that there is any substantial variation in the extent to which parental characteristics account for genetic influences on ISEI. The total variance explained ranges between 14-15%, while parents socioeconomic characteristics account for about 29-32% of the genetic component (age 11-15 and 16-20: 1-0,36/0,527 and age 0-5 and 21-25: 0,372/0,527). This finding is in line with the previous results for Finland estimating the total effect of origins using sibling correlations but not distinguishing the genetic effect (Erola et al., 2016). In sum, our results do not provide support for our expectation that parents' socioeconomic resources matter more for genetic effects on young adult ISEI in earlier stages of the life course, or that it would be stronger at ages when decisive educational choices for children are made.

Table 1. ACE-variance decompositions for twins' education, ISEI and income

	Education		ISEI		Income	
	b	c.s.e	b	c.s.e	b	c.s.e
A	0,47	0,05	0,36	0,05	0,3	0,02
C	0,12	0,04	0,06	0,04	<0,01	---
E	0,45	0,01	0,44	0,01	0,73	0,06
Total variance	1,04	0,01	1,03	0,01	1,02	0,06
A in %	45,5	5,22	42,27	5,24	28,96	2,41
C in %	11,12	4,24	7,24	4,28	<0,01	---
E in%	43,38	1,1	50,48	1,19	71,04	5,73
Twin pairs	6542		6542		6542	
Observations	13084		13084		13084	

Table 2. AE-variance decompositions for twins' ISEI adjusted for parental education, ISEI and family income according to twins' age.

	Null model		AGE: 0-5		AGE: 6-10		AGE: 11-15		AGE: 16-20		AGE: 21-25	
	b	c.s.e	b	c.s.e	b	c.s.e	b	c.s.e	b	c.s.e	b	c.s.e
Par. education (ref: Basic)												
Vocational secondary			0.129	0.027	0.086	0.028	0.084	0.028	0.064	0.028	0.051	0.029
General secondary			0.216	0.054	0.226	0.058	0.190	0.059	0.206	0.065	0.250	0.068
Postsecondary tertiary			0.403	0.033	0.370	0.034	0.324	0.033	0.298	0.034	0.328	0.034
Bachelor's degree			0.468	0.061	0.681	0.068	0.559	0.259	0.150	0.102	0.262	0.085
Master's degree			0.688	0.045	0.695	0.045	0.569	0.044	0.560	0.045	0.641	0.044
Parental ISEI			0.011	0.001	0.007	0.001	0.009	0.001	0.008	0.001	0.006	0.001
(log) Family income			-0.001	0.015	0.148	0.022	0.191	0.024	0.188	0.020	0.153	0.019
Constant	-0.004	0.010	-0.726	0.141	-2.064	0.206	-2.630	0.231	-2.582	0.194	-2.149	0.185
A	0,527	0,02	0,372	0,01	0,369	0,01	0,36	0,01	0,36	0,01	0,372	0,01
E	0,521	0,01	0,528	0,01	0,528	0,01	0,529	0,01	0,529	0,01	0,528	0,01
Total var.	1,048	0,01	0,901	0,01	0,897	0,01	0,889	0,01	0,889	0,01	0,9	0,01
A in %	50,3	1,53	41,3	1,6	41,1	1,6	40,6	1,6	40,5	1,61	41,3	1,6
E in %	49,7	1,14	58,7	1,31	58,8	1,31	59,5	1,33	59,5	1,33	58,7	1,31
R^2			14,03		14,41		15,17		15,17		14,12	
Twin pairs	6542		6542		6542		6542		6542		6542	
Observations	13084		13084		13084		13084		13084		13084	

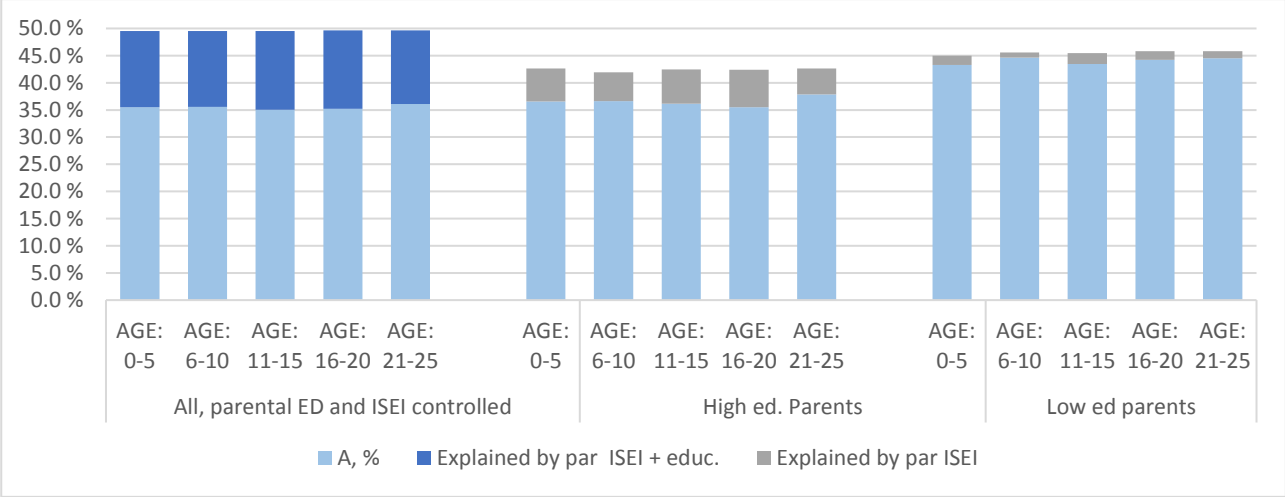
To test for differences across the social strata we split the analyses by parental education, (i.e. compulsory schooling or vocational secondary education at the maximum vs higher) and adjust the models for parental ISEI. The results are reported in Figure 1. Interestingly, we find that genetic influences on young adults' ISEI are slightly more pronounced among lower educated families. Observed parental characteristics explain only a small proportion of genetic effects among these families, (2.0/45.5=) 4,4 % at the maximum. For young adults from higher educated families the situation is different: the contribution of ISEI on the genetic variance is clearly bigger, reaching to (6.9/42.4=) 16,3 % of the genetic variation at age 16-20.

Conclusion

We studied how parental socioeconomic characteristics shape genetic effects on offsprings socioeconomic characteristics by accounting for differences across the early life-course. To explain

differences by age and socioeconomic outcomes we referred to the literature on gene-environment correlations (rGE) and gene-environmental interactions (GxE). Our preliminary results provide support for rGE: the strength of genetic and shared environmental effects depends on when the maturity in a socioeconomic outcome is reached. Both shared environmental and genetic influences matter more for the outcomes that peak earlier, for education first and strongest, for income last and weakest. Our expectation that the impact of parents' resources on genetic effects varies over the early life course, by contrast, was not supported. Additionally, we found evidence for GxE: the importance of parents' resources for genetic expression differs across the social strata. Among the highly educated families, parents' characteristics account for up to a sixth of genetic influences, while in less educated families parents' resources accounted for less than five percent of the genetic influences at the maximum. In the final version of the paper we compare the results across the different outcomes (education and income) and conduct comparisons across more distinguished subgroups (i.e. top/low income families), where we also expect the contrasts to be greater.

Figure 1. Genetic variance components (A) for twins ISEI and the variance explained by parental education and ISEI observed at different stages of children's life course.



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