Does Parental Separation lower Genetic Influences on Children's School-Related Skills?

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Abstract

The Scarr-Rowe hypothesis, which states that the relative importance of genes on cognitive ability is higher for advantaged compared to disadvantaged children, has recently been expanded to school-related skills. However, advantage/disadvantage is conceptualized as parental socioeconomic status and neglects other important factors. This study expands upon the literature to include household composition as an indicator for (dis-)advantage. Specifically, we investigate whether genetic influences for cognitive ability, school grades, and academic self-concept differ in one- compared to two-parent families. We use novel data from TwinLife, a population-register based sample of twin-families in Germany. We find that the heritability of school-related skills is higher for children in single- compared to two-parent families. Adjusting these models for parental income and education retrieve substantively similar results. Our findings therefore show that the quality of the family environment that is important for the realization of children's genetic potential is not just shaped by socioeconomic status, but also family structure.

Keywords: Cognitive Ability; Education; Academic Self-Concept; Parental Separation; Gene-Environment Interaction; Twins

INTRODUCTION

A prominent theme in sociology revolves around the extent that family background affects children's educational attainment. One important question is how differences in the resources available to families across social strata affect child development, especially those that are important predictors for children's educational outcomes. However, school-related skills are not only shaped by parents' resources but also by children's genes (e.g., Kovas et al. 2015; de Zeeuw, de Geus, and Boomsma 2015). In addition, research on cognitive skills shows that the relative importance of genetic influences differs by the social position of the family (e.g., Bates, Lewis and Weiss, 2013; Guo and Wang 2002; Turkheimer et al. 2003; Gottschling et al. 2019). This is known as the Scarr-Rowe hypothesis, which states that genes relevant for cognitive ability are more important among advantaged children compared to disadvantaged children (Scarr-Salapatek 1971; Rowe, Jacobson, and Van den Oord 1999).

Recently, this line of research has been extended to measures of educational success (Baier and Lang 2019; Conley et al. 2015; Domingue et al. 2015). To date, children's advantage and disadvantage has almost exclusively been measured in terms of parental socioeconomic status, such as parental education, income, occupation, or summative indices (e.g., Guo and Wang 2002; Turkheimer et al. 2003; Diewald et al. 2017; Baier and Lang 2019; Conley et al. 2015). However, parental socioeconomic status alone may not adequately capture a key dimension of advantage and disadvantage during childhood: household composition (Mclanahan, 2004). In this study, we concentrate on single-parent households generated by parental separation.

We combine behavioral genetic approaches with established theories rooted in family demography and sociology to examine the genetic component, or heritability, of school-related skills in two-parent and single-parent households. In this brief report, we address two research questions: *First, does the heritability of children's school-related skills vary by household composition?* Specifically, we compare the relative importance of genetic influences on cognitive ability, school grades, and academic self-concept in two-parent and single-parent households. *Second, are the differences in the heritability of children's school-related skills attributable to differences in parental education and income?* This gives us leverage on whether differences in the relative importance of genes for cognitive ability, school grades, and academic self-concept between single-parent and two-parent households are attributable to socioeconomic selection into parental separation.

BACKGROUND

Genetic Influences on School-Related Skills across Social Strata

An established line of research documents that genetic influences account for individual differences in characteristics relevant to education, such as cognitive and non-cognitive skills (e.g., Kovas et al. 2015; de Zeeuw, de Geus, and Boomsma 2015). More recently, the focus shifted to the gene-environmental interplay, i.e. how environmental conditions shape children's chances for genetic expression. Previous research on the importance of genes for cognitive ability has concentrated on parents' socioeconomic standing. The Scarr-Rowe hypothesis posits that genetic effects on IQ are stronger in advantaged families (Scarr-Salapatek, 1971; Rowe, Jacobson and Van den Oord, 1999). It is argued that advantaged parents provide a rearing environment that enhances genetic expression, while environmental conditions provided by socioeconomically disadvantaged tend to suppress the realization of genetic potential.

Current findings for the Scarr-Rowe hypothesis on IQ remain inconclusive: Some US studies found a Scarr-Rowe interaction (e.g., Guo and Wang 2002; Turkheimer et al. 2003; Bates, Lewis, and Weiss 2013), while Figlio and collaborators (2017) did not. Empirical support was found in

Germany (Gottschling et al. 2019) and Sweden (Fischbein 1980), but an international meta-analysis contradicted the German and Swedish findings and showed only support in the US (Tucker-Drob and Bates 2016).

A shortcoming of this literature is the narrow focus on socioeconomic status as an indicator of children's advantage or disadvantage. Parental education and occupation are the most common indicators used for socioeconomic status. No research has concentrated on heritability differences by childhood household composition, although environments conducive to the development of school-related skills vary starkly by family structure. Parental separation is associated with lower levels of children's cognitive ability (e.g., Carlson and Corcoran 2001), academic self-concept (e.g., Smith 1990), and academic performance (e.g., Brand et al. 2019).

Family Structure & Genetic Influences on School-Related Skills

We argue that *genetic influence on school-related skills will be higher in two-parent households compared to single-parent households (H1)*, due to both direct and indirect links between parental separation and children's family environment (Amato, 2010). Socioeconomic selection into parental separation was shown to partially account for lower levels of children's cognitive ability (e.g., Carlson and Corcoran, 2001) and educational attainment (e.g., Brand et al. 2019). Therefore, the traditional Scarr-Rowe hypothesis should apply in its traditional formulation. The environments created by two-parent families will be beneficial for the expression of their children's genetic potential, while the genetic predispositions of children in single-parent households will be suppressed due resource deficiency.

Beyond socioeconomic selection into parental separation, numerous mechanisms may account for the association between family structure and children's outcomes, such as marital conflict, household instability, and social control (see Teachman, 2003 for an overview). Marital conflict is related to higher stress levels and behavioral problems among children and was shown to partially account for the negative association between parental separation and academic self-concept (Smith, 1990). Similarly, the negative association between parental separation and education has been attributed to family instability, generated through divorce and re-partnering (Brand et al. 2019). Alternatively, two-parent families may control and supervise the activities of their children more than single-parent families (Thomson, McLanahan, and Curtin 1992).

In sum, if the differential rearing environments created by two-parent and single-parent families are only due to socioeconomic selection into parental separation, then we expect that *the genetic influence on school-related skills will not be higher in two-parent households compared to single-parent households when adjusted for parental education and income (H2)*. However, mechanisms beyond selection generate different environments following parental separation, then *the genetic influence on cognitive ability will be higher in two-parent households compared to single-parent households even when adjusted for parental education and income (H3)*.

DATA & METHODS

TwinLife Sample

We used the first wave of the newly collected data from the TwinLife study (Diewald *et al.*, 2017). TwinLife started in 2014 and provides a population-register based sample of monozygotic (MZ), same-sex dizygotic (DZ) twins and their families residing in Germany. TwinLife applies a social and regional stratified probability-based sampling strategy which enables us to analyze twin families from a broad range of the social spectrum (Lang and Kottwitz, 2017). Our target population referred to twin pairs from the second birth cohort (2003/2004), aged 10 to 12.

Outcome Variables

We selected three different indicators for school-related skills: cognitive ability as the most important single input factors for education, math grade as an indicator for educational performance, and math academic self-concept as motivational measure. We measured children's cognitive ability with the Culture Fair Intelligence Test (CFT 20-R). The CFT is a widely used standard psychometric test to indicate non-verbal (fluid) intelligence (Weiß, 2008). Children's cognitive scores were based on age-corrected scores and estimated by means of structural equation modeling. Missingness was moderate (3.59%).

Math grades were retrieved from pictures of children's most recent report card. If the most recent certificate was not available, then grades were assed via self-reports. Grades ranged from 1(very good) to 6 (insufficient). Germany has a highly stratified schooling system and we controlled for the different school-types children are attending to account for differences by school type. The results did not substantially change when running the analysis without controlling for school-type. In addition, we excluded children that attended a Waldorfschule (0.12%), which have a different grading system, as well as children attending special needs schools (1.30%). Missingness for grades was roughly 15%.

Finally we used the following 3 items measured on a five point scale to operationalize children's math academic self-concept (Dickhäuser et al. 2002): 1) I am … in maths (1 "not talented" to 5 "talented") 5) I know … in maths (1 "just a little" to 5 "a lot") 6) In maths many things are… (1 "easy" to 5 "difficult"). We created children's scores for academic self-concept by means of structural equation modeling and deleted cases in which information on all three items were missing (less than 1%). We used the inverse hyperbolic sine to transform the highly left-skewed distribution of academic self-concept to a nearly normal distribution. We deleted cases with missing information on the dependent variables and created one sample for each outcome.

Independent Variables

To test whether family composition affects the relative importance of genetic influences on cognitive ability we distinguish between children who live in single-parent households and children's whose biological parents are both present. We excluded step-families (4.5%), same-sex couples (0.15%) as well as widowers (0.44%) to ensure that we are comparing married two-parent families to divorced single-parent households. For this birth-cohort there were no single fathers among single parents. Therefore, twins that live in single-mother households in our sample experienced a parental separation sometime between birth and the survey, i.e. between ages 0-12.

We used mothers' education and household income to approximate children's social background. We chose both indicators to explore the role of financial resources and transmission mechanisms that are more directly linked to the development of cognitive ability, such as stimulating home and learning environments, parenting practices and educational resources). Mothers' educational degrees are transformed into a linear measure of years of education. We mean-centered mothers' education in the adjusted models. Financial resources were quantified as log monthly net household incomes equivalized using the OECD scale. Summary statistics by zygosity for each sample are displayed in Table 1. Due to missing information for mothers education (4.31%) and household income (13.51%), we used multiple imputation based on chained equations and 20 datasets per each observation (Van Buuren et al. 2006).

Table 1: Descriptive Statistics

	One parent						Two parents					
	MZ twins			DZ twins			MZ twins			DZ twins		
	mean sd	min	max	mean sd	min	max	mean sd	min	max	mean sd	min	max
Sample 1: cognitive ability (CS)												
CS	95.8	55	148	94.1	60	148	99.2	55	148	99.7	55	99.7
	15.7			15.3			16.3			16.0		16.0
age	11.0	10	12	11.0	10	12	11.0	10	12	11.0	10	11.0
	0.30			0.29			0.38			0.29		0.29
girl	0.63	0	1	0.56	0	1	0.52	0	1	0.51	0	0.51
	0.48			0.50			0.50			0.50		0.50
Mothers education												
years	12.6	7	18	13.0	7	20	13.7	7	20	14.1	7	14.1
	2.83			3.09			3.03			3.03		3.03
Household income												
log	7.08	5	8.50	7.11	5	8	7.29	4.50	9.50	7.37	5	7.37
	0.61			0.57			0.71			0.70		0.70
N_{Pairs}	68			84			301			460		
Sample 2: math grade (MG)												
MG	2.73	1	5	2.78	1	5	2.53	1	5	2.43	1	6
grade	0.93			0.91			0.89			0.88		
age	11.0	10	12	11.0	11	12	11.0	10	12	11.0	10	12
	0.31			0.17			0.38			0.28		
girl	0.63	0	1	0.55	0	1	0.51	0	1	0.52	0	1
	0.49			0.50			0.50			0.50		
mothers education												
years	12.8	7	18	13.1	7	20	13.7	7	20	14.1	7	20
	3.09			3.04			3.00			2.95		
household income												
log.	7.10	5	8.50	7.13	5	8	7.31	5	9.50	7.39	5	9.50
	0.64			0.57			0.72			0.69		
N_{Pairs}	54			69			259			373		
Sample 3: math academic self-concept (ASC)												
ASC	-0.07	-1.75	1.06	-0.05	-1.80	1.06	0.02	-3.14	1.50	0.05	-2.96	1.50
	0.81			0.84			0.92			0.90		
age	11	10	12	11.0	10	12	11	10	12	11	10	12
	0.29			0.26			0.38			0.29		
girl	0.61	0	1	0.56	0	1	0.53	0	1	0.50	0	1
	0.49			0.50			0.50			0.50		
mothers education												
years	12.8	7	18	13.0	7	20	13.7	7	20	14.0	7	20
	2.90			3.03			3.03			3.01		
household income												
log.	7.11	5	8.50	7.11	5	8	7.28	4.50	9.50	7.37	5	10
	0.62			0.55			0.71			0.70		
N_{Pairs}	70			89			319			489		

Source: TwinLife wave 1.

The Classical Twin Design & ACE-Decompositions

We assessed the relative importance of genetic influences on school-related skills by household composition using the Classical Twin Design (CTD), which is used in behavioral genetics to estimate the relative importance of genetic and environmental influences. The CTD exploits the similarities and differences between and across monozygotic and dizygotic twin pairs to estimate the heritability traits. Dizygotic and monozygotic twins are born and raised at the same time. Monozygotic twins are additionally genetically alike, whilst dizygotic twins share on average about 50% of their DNA. The CTD builds upon these distinct features to decompose the total variance of an outcome into variance that can be attributed to additive, genetic influences (A), shared environmental influences (C), and non-shared influences including the measurement error of the decomposition (E). This method is labeled ACE-variance decomposition method.

We started our analyses by estimating ACE-models for children's cognitive skills, math grades, and math academic self-concept for the overall sample. We used the linear multilevel mixed-effects parameterization developed by (Rabe-Hesketh, Skrondal and Gjessing, 2008) and the newly developed acelong.ado (Lang, 2017). Second, we performed non-parametric gene-environmental interaction analyses (Guo and Wang 2002) to test our first hypothesis. Specifically, we estimated ACE models for each outcome separately for twins in one-parent and two-parent households. Finally, we extended this estimation strategy by controlling for mothers' education and household income, analogous to a linear regression approach, to test our second and third hypotheses.

RESULTS

Overall Results from ACE-Variance Decompositions

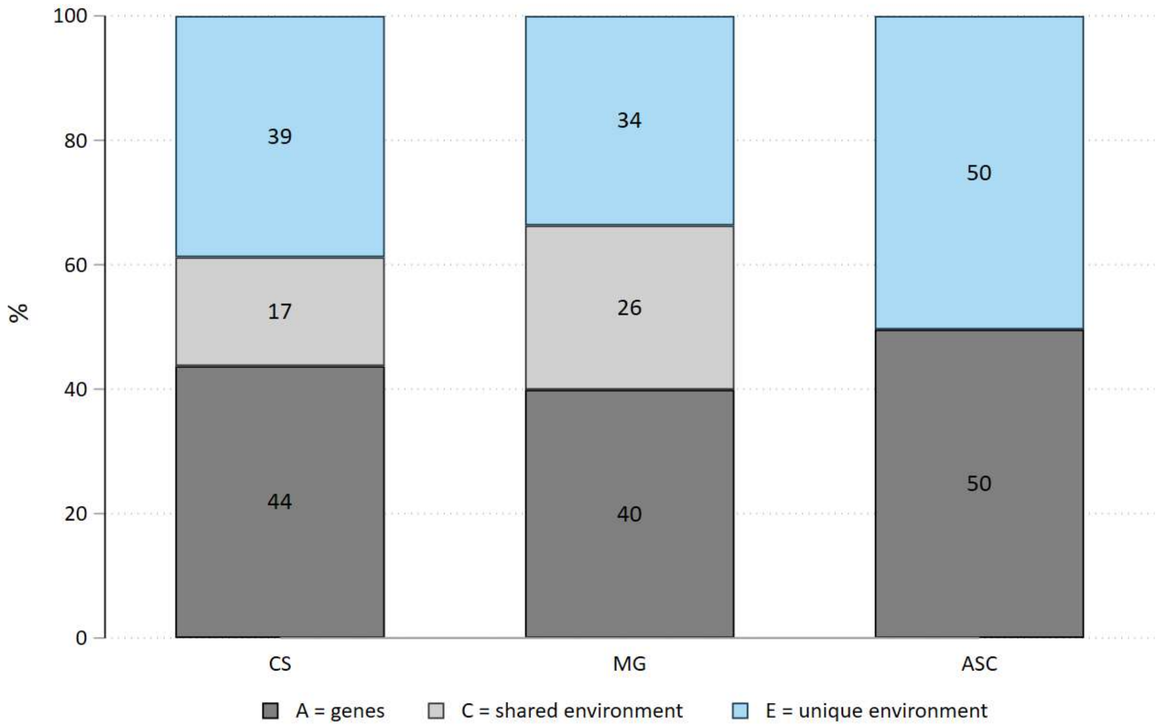
Table 1 displays the overall findings for the relative importance of genetic influences (A), shared environmental influences (C), and unique environmental influences (E) for cognitive skills (CS), math grade (MG) and math academic self-concept (ASC). Figure 1 visualizes the findings on the relative variance components in percent. In line with previous research, genetic influences mattered more than shared environmental influences for all three outcomes. Genetic influences were most important for math academic self-concept and accounted for roughly 50% of the total variance, followed by cognitive skills (44%), and math grades (40%). Shared environmental influences accounted for about a fourth of the total variation in math grades, about a fifth of the total variation in cognitive skills, and were absent for academic self-concept.

Table 2: ACE-Variance Decompositions for Twins Cognitive Skills (CS), Math Grade (MG), and Academic Self-Concept (ASC) – Overall Results

	b/var	c.s.e	z-value	95%-CI	
Cognitive skills (CS)					
Constant	98.78	0.46	215.51***	97.88	99.67
Total variance	260.05	9.84	26.43***	241.46	280.06
A in %	43.67	9.43	4.63***	33.67	54.21
C in %	17.48	7.87	2.22*	8.05	33.86
E in %	38.75	2.97	13.04***	35.25	42.37
N_{Pairs}	913				
Math Grade (MG)					
Constant	2.44	0.05	51.13***	2.34	2.53
Total variance	0.80	0.03	24.88***	0.74	0.87
A in %	39.39	10.40	3.79***	27.93	52.16
C in %	26.06	8.56	3.04***	15.62	40.15
E in %	33.26	3.46	9.61***	28.90	37.93
N_{Pairs}	755				
Math academic self-concept (ASC)					
Constant	0.02	0.02	1.06	-0.02	0.06
Total variance	0.59	0.01	40.27***	0.56	0.61
A in %	49.51	4.27	11.61***	45.31	53.73
C in %	---	---	---	---	---
E in %	50.34	3.90	12.90***	46.55	54.13
N_{Pairs}	967				

Notes: Clustered standard errors are calculated at the twin pair level. +: P(Z>|z|) < .10; *: P(Z>|z|) < .05; **: P(Z>|z|) < .01; ***: P(Z>|z|) < .001 (two-tailed tests). Source: TwinLife.

Figure 1: ACE-Variance Decompositions for Twins Cognitive Skills (CS), Math Grade (MG), and Academic Self-Concept (ASC) – Overall Results.



ACE-Variance Decompositions by Household Composition

Figure 2 shows how overall findings change if we differentiate between children living with one and two parents (base), and whether these results change once we adjust for mothers' education, and household income. The estimation results are displayed in table 3. In line previous research, we found that the mean values for all three outcomes are on average higher in two-parent families compared to one-parent families (see constant, table 3).

With regard to the relative importance of genetic and shared environmental influences, we found that genetic influences mattered more in two- compared to one-parent families. This finding held for all outcomes: cognitive skills, math grade, and math academic self-concept. Differences in the relative importance of genetic influences were most pronounced for cognitive ability and academic self-concept. Genes accounted for up to a third of the total variation (30% for cognitive skills and 34% for math academic self-concept) in one-parent families, but up to half of the total variation in in two parent families (47% and 50% respectively). For math grades, about a third of the total variation was attributable to genes in one-parent families and approximately 44% in two-parent families.

The reverse pattern was found for shared environmental influences. For cognitive ability, shared environmental influences were twice as large in one- compared to two-parent families (28% and 14% respectively). For academic self-concept, shared environmental influences only mattered in one-parent families (roughly 12%). Shared environmental influences on math grades differed only slightly by family composition (26% and 23% respectively). In sum, our results reveled a clear pattern corresponding with our first hypothesis: genetic influences on school-related skills were higher in two-parent families compared to one-parent families.

In the next step, we tested whether differences in the relative importance of genetic and shared environmental influences are driven by educational or financial differences. The results showed that mothers' education had a positive impact on children's cognitive ability and math grades in both one- and two-parent families (see associations table 3). However, mothers' education did not affect children's math academic self-concept. For cognitive ability and math grades, we also found that household income had a positive impact in one- and two-parent families, while household income was only positively associated with math academic self-concept in one-parent families.

For cognitive ability, we found that mothers' education explained about 12% of the total variance in one-parent families and only about 5% in two parent families (see explained variance by independent variables in figure 2, R^2 in %, table 3 respectively). In one parent families, both shared environmental and genetic influences decreased to some extent once adjusted for mothers' education. Genetic influences accounted for about a fifth of the total variation, and shared environmental influences for roughly 22%. In two parent families, the relative importance of genetic influences remained nearly the same and explained about 46% of the total variation, while shared environmental influences were lowered and accounted for about 10%. If differences in mothers education were attributable for differences in the heritability of cognitive skills between single- and two-parent households, then genetic influences would have increased and the proportion of explained variance would have been larger in two-parent families. However, genetic influences remained stable and educational differences did not seem to account for the differential heritability of cognitive skills.

Household income explained less of the total variation in cognitive ability than mothers' educational attainment. Slightly more than 1% of the variation in cognitive skills in one-parent families and 2% in two-parent families is attributable to genes. Consequently, we found no substantial changes in the relative importance of genetic and shared environmental influences compared to models without household income. In sum, adjusting for mothers' education and the financial situation of the household did not alter our base findings as substantial differences in the importance of genetic influences remained.

For math grades we found a similar pattern as for cognitive skills. Adjusting for mothers' education explained about 7% of the total variance in math grades in one parent families and 6% in two parent families. Again, household income explained less of the total variance (about 1% in one-parent and 3 % in two-parent families). Also for math grades we found that the adjustment for mothers' education and household income slightly changed the relative importance of shared environmental and genetic influences in one-parent families, but only the relative importance of shared environmental influences changed in two-parent families. Therefore, we find that differences in the heritability of math grades by household composition existed over and above differences in education and the financial situation of the household.

Results for math academic self-concept showed that shared environmental and genetic influences remained unaffected when adjusted for mothers' education and household income. The base results that showed substantial differences in genetic effects on math academic self-concept by family composition remained after adjusting for socio-economic selection. Taken together the findings showed that the impact of family composition on children's chances to realize their genetic potential existed net of differences in educational and economic resources. The analyses for all three outcomes support our third hypothesis that differences in the relative importance of genetic influences relevant for school-related skills by family structure are not driven by socio-economic selection.

Figure 2: ACE-Variance Decompositions for Twins Cognitive Skills (CS), Math Grade (MG), and Academic Self-Concept (ASC) – By Parental Separation and Conditioned on Mothers' Education and net Household Equivalent Income.

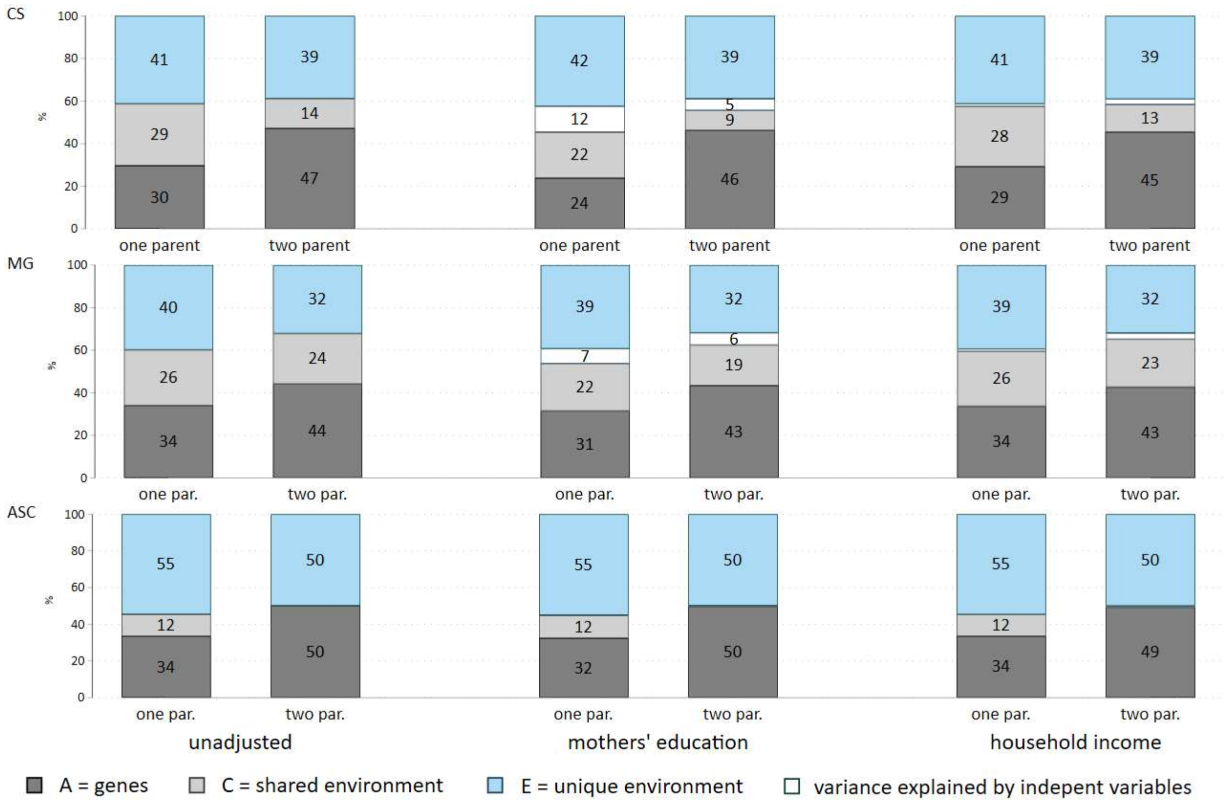


Table: ACE-Variance Decompositions for Twins Cognitive Skills (CS), Math Grade (MG), and Math Academic Self-Concept (ASC) – By Parental Separation and Conditioned on Mothers' Education and net Household Equivalent Income

	One Parent					Two Parents				
	b/var	c.s.e	z-value	95%-CI		b/var	c.s.e	z-value	95%-CI	
CS=cognitive skills										
constant	94.80	1.08	87.52***	92.68	96.92	99.57	0.50	199.08***	98.59	100.55
total variance	238.86	25.80	9.26***	193.29	295.18	260.59	10.61	24.55***	240.60	282.24
A in %	29.60	21.90	1.35	8.97	64.20	47.09	9.92	4.75***	37.07	57.36
C in %	28.99	17.02	1.70^{+}	11.44	56.34	14.01	8.38	1.67^{+}	4.80	34.46
E in %	41.24	7.44	5.54***	33.01	49.99	38.75	3.22	12.03***	34.96	42.67
N_{Pairs}	152					761				
mohers education										
constant	95.09	1.00	94.98***	93.13	97.06	98.43	0.51	194.89***	97.44	99.42
education	1.78	0.31	5.76***	1.18	2.39	1.21	0.15	7.74***	0.91	1.52
total variance	238.86	25.80	9.26***	193.29	295.18	260.59	10.61	24.55***	240.60	282.24
A in %	23.86	21.44	1.12	5.18	64.54	46.18	9.84	4.69***	36.11	56.58
C in %	21.55	15.17	1.42	6.49	52.20	9.44	8.13	1.16	1.89	36.05
E in %	42.42	7.85	5.40***	33.88	51.43	38.92	3.24	12.01***	35.11	42.86
R^2 in %	12.07					5.46				
N_{Pairs}	152					761				

household income										
constant	78.37	17.09	4.59***	44.88	111.86	73.24	5.97	12.26***	61.53	84.95
hh-income	2.31	2.40	0.96	-2.39	7.02	3.59	0.81	4.44***	2.00	5.17
total variance	238.86	25.80	9.26***	193.29	295.18	260.49	9.98	25.55***	240.60	282.24
A in %	29.26	21.63	1.35	8.85	63.79	45.49	9.85	4.62***	35.32	56.06
C in %	28.17	16.48	1.71+	11.08	55.24	12.87	8.10	1.59	4.13	33.66
E in %	41.31	7.44	5.55***	33.08	50.05	39.04	3.26	11.96***	35.22	43.01
R^2 in %	1.26					2.60				
N_{Pairs}	152					761				
MG=math grade										
constant	2.85	0.18	15.43***	2.49	3.21	2.39	0.05	50.16***	2.29	2.48
total variance	0.84	0.07	11.64***	0.71	1.00	0.78	0.04	21.98***	0.72	0.86
A in %	33.70	26.67	1.26	9.73	70.56	43.48	11.43	3.80***	31.49	56.30
C in %	25.78	21.42	1.20	6.38	63.91	23.39	9.56	2.45*	12.05	40.49
E in %	39.39	8.61	4.58***	29.75	49.93	31.72	3.66	8.68***	27.04	36.80
N_{Pairs}	123					632				
mothers education										
constant	2.97	0.18	16.44***	2.61	3.32	2.50	0.05	47.29***	2.40	2.61
education	-0.08	0.02	-4.12***	-0.12	-0.04	-0.06	0.01	-6.04***	-0.08	-0.04
total variance	0.84	0.07	11.64***	0.71	1.00	0.78	0.04	21.98***	0.72	0.86
A in %	31.46	26.27	1.20	8.20	70.22	43.44	11.47	3.79***	31.41	56.31
C in %	22.34	20.51	1.09	4.54	63.50	19.02	9.59	1.98+	8.04	38.69
E in %	39.30	8.68	4.52***	29.57	49.96	31.78	3.66	8.68***	27.10	36.87
R^2 in %	6.90					5.93				
N_{Pairs}	123					632				
household income										
constant	2.87	1.11	2.59*	0.70	5.05	3.54	0.35	10.18***	2.86	4.22
hh-income	0.00	0.15	-0.02	-0.29	0.28	-0.15	0.05	-3.33***	-0.24	-0.06
total variance	0.84	0.07	11.64***	0.71	1.00	0.78	0.04	21.98***	0.72	0.86
A in %	33.69	26.73	1.26	9.69	70.64	42.68	11.42	3.74***	30.60	55.71
C in %	25.70	21.46	1.20	6.30	64.00	22.50	9.52	2.36*	11.25	39.95
E in %	39.39	8.61	4.58***	29.75	49.93	31.92	3.68	8.68***	27.22	37.01
R^2 in %	1.22					2.90				
N_{Pairs}	123					632				
ASC= Academic self-concept										
constant	-0.06	0.05	-1.08	-0.16	0.05	0.04	0.02	1.71+	-0.01	0.08
total variance	0.68	0.04	16.02***	0.60	0.77	0.57	0.02	37.56***	0.54	0.60
A in %	33.63	31.92	1.05	7.31	76.50	50.01	4.61	10.86***	45.51	54.51
C in %	11.85	24.48	0.48	0.23	88.51	---	---	---	---	---
E in %	54.68	11.96	4.57***	44.00	64.95	49.85	4.17	11.97***	45.77	53.94
N_{Pairs}	159					808				
mothers education										
constant	-0.06	0.05	-1.06	-0.16	0.05	0.03	0.02	1.24	-0.02	0.07

education	0.02	0.02	0.99	-0.02	0.05	0.01	0.01	1.35	0.00	0.02
total variance	0.68	0.04	16.02^{***}	0.60	0.77	0.57	0.02	37.56^{***}	0.54	0.59
A in %	32.47	31.98	1.02	6.52	76.81	49.86	4.60	10.83^{***}	45.35	54.37
C in %	12.37	24.39	0.51	0.30	87.05	---	---	---	---	---
E in %	54.94	12.07	4.55^{***}	44.22	65.23	49.86	4.16	11.97^{***}	45.78	53.95
R^2 in %	0.22					0.28				
N_{Pairs}	159					808				
household (hh) income										
constant	0.06	0.68	0.09	-1.27	1.39	-0.54	0.22	-2.46^{*}	-0.97	-0.11
hh-income	-0.02	0.10	-0.17	-0.20	0.17	0.08	0.03	2.65^{*}	0.02	0.14
total variance	0.68	0.04	16.02^{***}	0.60	0.77	0.57	0.02	37.56^{***}	0.54	0.60
A in %	33.61	31.92	1.05	7.30	76.50	49.38	4.61	10.71^{***}	44.82	53.95
C in %	11.71	24.46	0.48	0.22	88.84	---	---	---	---	---
E in %	54.69	11.97	4.57^{***}	44.01	64.95	49.95	4.17	11.97^{***}	45.87	54.04
R^2 in %	0.00					0.67			0.67	
N_{Pairs}	159						808			

Notes: Clustered standard errors are calculated at the twin pair level. +: P(Z>|z|) < .10, *: P(Z>|z|) < .05; **: P(Z>|z|) < .01; ***: P(Z>|z|) < .001 (two-tailed tests). Source: TwinLife.

CONCLUSION

In this study, we sought to ascertain 1) whether parental separation lowers children’s chances to realize genetic dispositions relevant for school-related skills and 2) whether differences in heritability are driven by socio-economic selection into parental separation. We studied genetic effects on three different school-related skills – cognitive skills, math grades, and math academic self-respect – that are important predictors for children’s educational attainment. Drawing on previous findings that show that parental separation can have a negative impact on children’s educational performance and attainment, we expected genetic influence on school-related skills to be higher in two-parent compared to single-parent families (H1). In the case of socio-economic selection into divorce, we expected that genetic influences on school-related skills would be similar in one- parent- -and two-parent families once adjusted for mothers’ education and household income (H2). However, if differences by family structure emerge due to distinct processes associated with parental separation, such as lack of parental involvement and control and increased levels of social emotional stress and instability, then genetic influences on school-related skills would be higher in two-parent families compared to one-parent families even when adjusted for parental education and household income (H3).

Our results provided a clear pattern across all three outcomes. Genetic influences accounted for substantially more variance in children's school related skills in two-parent families compared to one-parent families. Further and in line with our third hypothesis, the higher genetic influence on school-related skills in two-parent families compared to one-parent families is not attributable to educational or income related differences between families. Our findings therefore support the notion that family environments and family dynamics induced by parental separation are detrimental for the expression of their children's genetic potential by means other than socioeconomic resources. Other mechanisms beyond socioeconomic selection into separation, such as differential parental involvement, social control, and socio-emotional stress, likely create rearing environments that hinder genetic expression in one-parent families. Future studies should investigate the mechanisms that generate the differences between single-parent and two-parent families. Longitudinal, genetically sensitive studies that comprise direct measures on parenting behaviors and children's perceived levels of stress could be one avenue for future research to identify the features of the rearing environment that suppress genetic expression.

Due to data limitations, we do not know when parents separated and were unable to study whether the timing of parental separation moderates the differential heritability between single- and two-parent families. However, the impact of divorce on children likely differs by children's age at divorce, but also children's vulnerability for negative life events may vary over their childhood. Children rely almost exclusively on familial resources during early childhood, whereas more proximal contexts, such as schools, teachers or peers, become more influential as children grow older. Furthermore, the impact of parental separation across children's early lives may also vary depending on the outcome of interest. While our results showed a stable pattern for differences in the heritability of school-related skills, we found that differences were more pronounced for cognitive skills and math academic self-concept than for math grades. Our overall findings for math grade showed that shared environmental influences, i.e. non-genetic influences that make siblings more alike, were more important for math grades than for cognitive skills and academic self-concept. This indicates first, that shared environmental influences affect school-related skills in distinct ways and second, that parents' efforts can affect children's grades more directly than their children's motivation or cognitive skills. In sum, to gain a better understanding on the link of parental separation and genetic expression, future research needs to study different outcomes while accounting for the timing of parental separation as well as the duration of exposure to marital conflict.

It is important to keep in mind that we studied differences in genetic effects among single- and two parent families, and excluded step-parent families. However, step-families and other complex family arrangements are becoming more common. Future research is needed to examine to what extent the presence of a step-parent changes the quality of the family environment. An additional adult in the household may be able to help facilitate a rearing environment tailored to the needs of children and thereby help children express their genetic potential. In contrast, stress and conflict associated with remarriage and merging two households may further suppress the realization of children's innate abilities.

Finally, our findings refer to Germany, often considered an ideal typical conservative welfare state that provides a relatively high level of social security. However, German labor market and family policy also actively incentivizes a male-breadwinner female-homemaker division of labor with low coverage of all-day childcare and schooling. Differences in the realization of children's genetic potential by household composition may be larger in liberal societies, such as the United States, where women are at a considerably higher risk of poverty following divorce. Compared to social democratic states where social systems secure divorced women's socioeconomic wellbeing and facilitate labor market participation, such as Sweden, heritability differences may be lower. Future research should estimate the heritability of school-related skills by household composition in other contexts to gain insight on the extent that institutional arrangements ameliorate or exacerbate the effects of parental separation.

Our study has for the first time shown that genetic effects on school-related skills differ considerably in single- and two-parent families and indicates that parental separation is associated with processes that affect the realization of children's genetic potential. A shift from traditional structural characteristics to family composition is needed to enhance our current understanding on the mechanisms behind the gene-environment interplay leading to the reproduction of educational inequality across generations.

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