Research Article

Psychological Science
1–9

DOI: 10.1177/0956797617734864
www.psychologicalscience.org/PS

Genetics, the Rearing Environment, and the Intergenerational Transmission of Divorce: A Swedish National Adoption Study

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Abstract

We used classical and extended adoption designs in Swedish registries to disentangle genetic and rearing-environment influences on the intergenerational transmission of divorce. In classical adoption analyses, adoptees (n = 19,715) resembled their biological parents, rather than their adoptive parents, in their history of divorce. In extended adoption analyses, offspring (n = 82,698) resembled their not-lived-with fathers and their lived-with mothers. There was stronger resemblance to lived-with mothers, providing indirect evidence of rearing-environment influences on the intergenerational transmission of divorce. The heritability of divorce assessed across generations was 0.13. We attempted to replicate our findings using within-generation data from adoptive and biological siblings (ns = 8,523–53,097). Adoptees resembled their biological, not adoptive, siblings in their history of divorce. Thus, there was consistent evidence that genetic factors contributed to the intergenerational transmission of divorce but weaker evidence for a rearing-environment effect of divorce. Within-generation data from siblings supported these conclusions.

Keywords

divorce, intergenerational transmission, adoption study, extended adoption study, sibling study

Received 2/23/17; Revision accepted 9/11/17

Divorce is an increasingly common life event worldwide (United Nations, 2014). Despite its growing prevalence and social acceptance (Gallup News Service, 2016), the dissolution of low-conflict marriages continues to be associated with a number of poor behavioral, emotional, and financial outcomes for divorcing partners and their children (Amato, 2000; Amato & Hohmann-Marriott, 2007). Compared with offspring of continuously married parents, the adult children of divorced parents are at increased risk to have their own marriages end in divorce (Wolfinger, 2005), with odds ratios (ORs) ranging from 1.26 to 3.62 in cross-national data (Dronkers & Harkonen, 2008). Yet questions remain about what contributes to this intergenerational transmission.

Efforts to identify the factors that contribute to the intergenerational transmission of divorce have largely focused on (a) demographic–socioeconomic, (b) attitudinal, and (c) interpersonal behavior mediators (Amato, 1996). Tests of these mediators using nationally representative data from the United States supported the latter two pathways, suggesting that parental divorce weakens individuals' commitment to marriage and undermines

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the interpersonal skills needed for marriage (Amato, 1996). Further examination of these two pathways found greater evidence for the lack-of-commitment pathway compared with the interpersonal-skills pathway (Amato & DeBoer, 2001). The conclusion from this work is that there is a rearing-environment effect on divorce whereby parental divorce socializes offspring to be less committed to marriage (Wolfinger, 2005).

Another plausible explanation is that divorcing parents and their offspring share genetic factors predisposing them toward divorce (D'Onofrio et al., 2007; Scarr & McCartney, 1983). Estimates from Australian, Swedish, and American twin samples suggest that genetic factors account for 15% to 53% of the variation in divorce (D'Onofrio et al., 2005; Jerskey et al., 2010; McGue & Lykken, 1992; Salvatore et al., 2017), with unique environmental factors (i.e., environmental exposures that make siblings different from one another) accounting for the remaining variation. The range of heritability estimates likely reflects differences in the social contexts of divorce across these countries, which may moderate genetic influences.

Twin studies, which examine resemblance within a generation, are important in suggesting that genetic factors may influence the intergenerational transmission of an outcome. However, other study designs that incorporate parents and their offspring are needed to evaluate the role of genetic and rearing-environment factors in intergenerational transmission. This is because heritability estimates from twin studies do not directly address whether genetic factors account for transmission across generations and because the shared-environment estimate (*C*) from a within-generation twin model is not equivalent to vertical transmission of the environment between generations. In the one extant study of the intergenerational transmission of divorce that used a genetically informative Australian children-of-twins sample, D'Onofrio et al. (2007) found that the rearing-environment effect of divorce accounted for the majority (66%) of its intergenerational transmission, whereas genetic factors shared between parents and their offspring accounted for 34%.

Adoption designs provide another powerful natural experiment to examine the contributions of genetic and rearing-environment factors to the intergenerational transmission of divorce (D'Onofrio, Lahey, Turkheimer, & Lichtenstein, 2013). We considered three such designs using Swedish national registry data. In the first test, we used a classical adoption design to examine divorce resemblance between adoptees and their biological and adoptive parents. Such resemblance would provide direct evidence that genes and the rearing environment, respectively, influence the intergenerational transmission of divorce.

In the second test, we used an extended adoption design and examined divorce resemblance in not-lived-with (NLW) families (Kendler et al., 2015), where one parent provided genes but not a rearing environment (i.e., an NLW parent), and the other parent provided genes and rearing environment (i.e., a lived-with [LW] parent). As with the adoptee–biological parent relationship in an adoption design, divorce resemblance between offspring and an NLW parent would provide direct evidence that genes contribute to the intergenerational transmission of divorce. NLW families also provide an indirect test of the rearing environment. If resemblance between offspring and the LW parent was stronger than resemblance between offspring and the NLW parent, this would suggest that the rearing environment contributes to the intergenerational transmission of divorce above and beyond genetic influences. We included parental education, parental externalizing disorders (alcohol use disorder, drug abuse, and criminal behavior), and offspring year of birth as covariates to examine the robustness and specificity of intergenerational divorce resemblance to these potential confounders.

In a third test, we examined divorce resemblance between adoptees and their adoptive and biological siblings to test whether the intergenerational findings replicated within a generation. Divorce resemblance between adoptees and their biological and adoptive siblings would provide direct evidence that genes and the rearing environment, respectively, influence the familial transmission of divorce within the same generation. As a set, these designs provided three direct tests of genetic influences on divorce and two direct and one indirect tests of the rearing environment on divorce. Additionally, we used the tetrachoric correlations corresponding to each of these three tests to estimate the heritability of divorce.

Method

Swedish national registries

We linked the following nationwide Swedish registers through the unique 10-digit identification number assigned at birth or immigration to all Swedish residents (the identification number was replaced by a serial number to ensure anonymity):

1. The Swedish Multi-generation Register, which links children born after 1932 through 1973 to their biological and adoptive parents and contains individual data, such as sex, year of birth, and death
2. The Total Population Register, which includes annual data on marital status from 1968 to 2013 and on family from 1990
3. The National Census, which contains marital status and household data from 1960, 1965, 1970, 1975, 1980, 1985, and 1990; education data were available in 1960, 1970, and 1990

4. The Longitudinal Integration Database for Health Insurance and Labor Market Studies (LISA), which includes annual information on education from 1990 to 2012
5. The Swedish Hospital Discharge Register, which contains information on hospitalizations from 1964 to 2012
6. The Swedish Outpatient Register, which contains information from outpatient care visits from 2000 to 2012
7. The Swedish Crime Register, which covers national data an all convictions in lower court from 1973 to 2012
8. The Suspicion Register, which lists individuals strongly suspected of a crime from 1995 to 2012
9. The Prescribed Drug Register, which covers all prescriptions that were picked up from July 2005 to March 2014

We examined two study groups: (a) adoptees and (b) offspring not living with one parent (the father). For the adoptee sample, we included those adopted before 10 years of age to two adoptive parents (who were required to be married by Swedish adoption law) where we had information on at least one biological and both adoptive parents. We verified that none of the adoptive parents were close biological relatives. If biological siblings were adopted together, they were excluded. For the NLW family sample, we identified children who grew up only with the mother, at least until the age of 15 years, and were never registered in the same household as their biological father. There were too few NLW mothers for analysis; hence, we focused only on NLW fathers. All statistical analyses were based on the subgroup of offspring and NLW fathers who were ever married (to anyone), because marriage is a condition of divorce.

As with all behavior-genetic studies, the broader social context of the behavior under investigation is important. We note that over the study period, marriage rates fluctuated and legal barriers to divorce decreased in Sweden. For example, the crude marriage rate decreased from 6.7 to 4.5 marriages per 1,000 inhabitants per year between 1960 and 2000 but increased thereafter to 5.5 in 2014 (Eurostat, 2017). Divorce laws were liberalized in the early 20th century and then again in 1974 (Simonsson & Sandstrom, 2011). The crude divorce rate was 1.2 in 1960 and stabilized at approximately 2.5 in 1970 and thereafter (Eurostat, 2017).

Measures

We defined marital status in 1960 and 1965 from the Swedish Census and from 1968 and onward from the Total Population Register. Parental divorce was defined as at least one parent who had been divorced, and individuals could be defined as divorced only if they had ever been married. Biological full siblings, half siblings, and adoptive siblings were defined from the Swedish Multi-generation Register. For siblings, we categorized the predictor as at least one divorced sibling, which was independent of whether any sibling was ever married. For the intergenerational analyses, we examined parental education, parental externalizing disorders, and offspring year of birth as covariates. Education was included to examine the possibility that any observed intergenerational effects could be attributed to broad socioeconomic circumstances rather than parental divorce specifically. Likewise, we included parental alcohol use disorder, drug abuse, and criminal behavior as covariates to examine the specificity of the intergenerational transmission of divorce. We selected these externalizing-disorder covariates in view of previous findings that divorce and alcohol use disorder are phenotypically and genetically correlated in the Swedish population (Salvatore et al., 2017), as well as the broader literature suggesting that alcohol use disorder, drug abuse, and criminal behavior are all part of a spectrum of externalizing disorders (Kendler, Prescott, Myers, & Neale, 2003; Krueger et al., 2002). Parental education was defined as *high* (studies at the university level) or *low–mid* (no university studies, including missing data) using information from the National Census and LISA registers. Our definitions of alcohol use disorder, drug abuse, and criminal behavior in parents came from medical, legal, and prescription registers. Information concerning the International Classification of Disease codes and legal convictions for each behavior are detailed in Kendler et al. (2016). Offspring year of birth was included to account for secular trends in rates of divorce, which could influence divorce resemblance between parents and children.

Data analysis

First, for the adoption analyses, we investigated the simple univariable associations between adoptees' divorce and each predictor variable using logistic regression, followed by a multivariable logistic regression that included all significant predictors ($p < .05$) from the simple models. Second, for the NLW family analyses, we investigated the association between divorce in the offspring and their biological parents, starting with divorce in the NLW fathers and LW mothers in univariable logistic regressions and then in a second step adding all significant predictors into a multivariable model, as described above. Third, we analyzed the association between the adoptees and their

biological full, half, and adoptive siblings, using a multivariable logistic regression in which the variables for biological and adoptive sibling divorce were entered simultaneously.

Finally, we calculated the heritability of divorce across and within generations. Heritability in the adoption and extended-adoption designs was estimated by examining the resemblance (using tetrachoric correlations) between adoptees and biological parents and between offspring and NLW fathers, assuming that their resemblance equaled $0.5a^2$, with a^2 defined as the proportion of population variance in risk of divorce attributable to additive genetic effects (commonly called *heritability*). We accounted for the correlation between biological parents' divorce, and to avoid problems with handling missingness in tests of the homogeneity of these estimates, we limited these analyses to include only adoptees with two married biological parents and offspring of married NLW fathers. All adoptees and offspring had to be married at least once, as well. Heritability in the sibling analyses was estimated by examining the resemblance between adoptees and their biological full and half siblings, assuming that their resemblance equaled $0.5a^2$ and $0.25a^2$, respectively. The analyses were conducted using SAS software, Version 9.3, and Mplus (Muthén & Muthén, 2015).

Results

Divorce resemblance between adoptees and their biological and adoptive parents

For the adoption analyses, we identified 19,715 adoptees (52.6% male). Characteristics of the adoptees and their biological and adoptive parents are shown in Table 1. Biological parents had higher rates of divorce, alcohol use disorder, drug abuse, criminal behavior, and lower rates of higher education than adoptive parents. The effect sizes (represented as ORs) corresponding to the differences in the covariates were as follows—alcohol use disorder: OR = 5.07, 95% confidence interval (CI) = [4.70, 5.47]; drug abuse: OR = 4.49, 95% CI = [3.84, 5.25]; criminal behavior: OR = 5.79, 95% CI = [5.37, 6.24]; and education: OR = 0.60, 95% CI = [0.57, 0.63]. The tetrachoric correlation for divorce between adoptive and biological parents was −0.01, 95% CI = [−0.05, 0.03].

We ran the analyses to examine divorce resemblance between adoptees and their biological and adoptive parents in two stages. In the univariable analyses (Table 2), adoptees significantly resembled their biological parents in their history of divorce but not their adoptive parents. Adoptees' divorce resemblance with biological

Table 1. Characteristics of the Biological and Adoptive Parents, Biological and Adoptive Siblings, and Adoptees

	Parents		Siblings			
Characteristic	Biological	Adoptive	Full biological	Half biological	Adoptive	Adoptees
Number of adopted children with at least one of this type of relative	19,715	19,715	3,884	16,213	10,200	19,715
Number of relatives with available data	29,574	39,430	8,523	53,097	13,606	19,715
Number of males						10,368 (52.6%)
Birth year (*SD*)						1959.4 (6.0)
Fathers (*SD*)	1932.0 (9.7)	1923.1 (9.0)				
Mothers (*SD*)	1935.6 (8.6)	1925.8 (8.7)				
Number ever married	25,278 (85.5%)	39,430 (100%)	3,050 (78.5%)	13,525 (83.4%)	7,526 (73.8%)	13,455 (68.2%)
Number divorced (% of married)	14,323 (56.7%)	4,229 (10.7%)	1,968 (50.7%)	8,567 (52.8%)	3,342 (32.8%)	6,124 (45.5%)
Number with alcohol use disorder	3,799 (19.3%)	887 (4.5%)				
Number with drug abuse	842 (4.3%)	194 (1.0%)				
Number with criminal behavior	4,236 (21.5%)	890 (4.5%)				
Number with higher education	3,122 (15.8%)	4,735 (24.0%)				

Note: Percentages reflect participants with available information in the sample. For criminal behavior, drug abuse, alcohol use disorder, and higher education, the counts and percentages reflect participants with at least one parent who had the characteristic.

Table 2. Odds Ratios for Predictors of Divorce in Adoptees From Their Adoptive and Biological Parents

Parent type and predictor	Univariable analyses	Multivariable analysis
Adoptive		
Divorce	0.96 [0.86, 1.07]	
Education (low–mid vs. high)	1.04 [0.96, 1.13]	
Alcohol use disorder	1.06 [0.89, 1.27]	
Drug abuse	0.97 [0.68, 1.38]	
Criminal behavior	1.16 [0.98, 1.37]	
Biological		
Divorce	1.22 [1.13, 1.31]*	1.24 [1.14, 1.35]*
Education (low–mid vs. high)	1.06 [0.97, 1.17]	
Alcohol use disorder	1.13 [1.03, 1.23]*	1.12 [1.01, 1.23]*
Drug abuse	1.03 [0.89, 1.22]	
Criminal behavior	1.11 [1.02, 1.21]*	1.12 [1.01, 1.23]*
Birth year	0.97 [0.97, 0.98]*	0.97 [0.96, 0.98]*

Note: The multivariable analysis included all parameters that were significant ($p < .05$) in the univariable analyses. Values in brackets are 95% confidence intervals.
*$p < .05$.

and adoptive parents could not be equated, $\chi^2(1, N = 11{,}989) = 12.44$, $p < .01$, indicating that divorce resemblance was significantly greater between adoptees and their biological than between adoptees and their adoptive parents. Of the covariates, alcohol use disorder and criminal behavior among biological parents were also associated with a higher likelihood of divorce in adoptees. Adoptees' year of birth was also associated with their divorce history. Adoptees born later had lower risk of divorce, which may reflect their relatively younger age at the end of follow-up compared with adoptees born earlier or cross-cohort differences in factors (e.g., commitment or traditionalism) associated with deciding to marry. In the second-stage multivariable analysis (Table 2), we continued to observe divorce resemblance between adoptees and their biological parents even after controlling for the significant effects of the biological parent alcohol use disorder, criminal behavior, and adoptee birth year covariates.

Divorce resemblance between offspring and their NLW fathers and LW mothers

We identified 82,698 offspring of NLW fathers. Table 3 summarizes the characteristics of the NLW fathers and LW mothers. The tetrachoric correlation for divorce between NLW fathers and LW mothers was 0.47, 95% CI = [0.37, 0.57].

We ran the NLW family analyses to examine divorce resemblance between offspring and their NLW fathers and their LW mothers in two stages. In the first-stage univariable analyses (Table 4), offspring resembled their NLW fathers and their LW mothers in their history of divorce. Of the covariates, NLW fathers' and LW mothers' alcohol use disorder, criminal behavior, and low education were associated with higher likelihood of offspring divorce. Offspring's year of birth was also associated with their divorce history. Offspring born later had lower risk of divorce, which again may reflect their relatively younger age at the end of follow-up or cohort differences in the factors associated with deciding to get married, compared with those born earlier. In the second stage multivariable analyses (Table 4), offspring continued to resemble their NLW fathers and their LW mothers in their history of divorce after we controlled for alcohol use disorder, criminal behavior, and low education. In the indirect test of the rearing environment, we found that LW mothers' divorce was a stronger predictor of offspring divorce compared with NLW fathers' divorce, as indicated by a significant difference in the corresponding odds ratios—NLW father: OR = 1.07, 95% CI = [1.03, 1.12]; LW mother: OR = 1.26, 95% CI = [1.21, 1.31]; $\chi^2(1, N = 45{,}920) = 23.05$, $p < .05$.

Divorce resemblance between adoptees and their biological and adoptive siblings

The number of adoptive and biological siblings included in the study and their marriage and divorce characteristics are shown in Table 1. By definition, these analyses could include only the adoptees with siblings. Preliminary descriptive analyses indicated that the rates of marriage and divorce were similar for adoptees with and

Table 3. Characteristics of the Not-Lived-With Fathers and Lived-With Mothers in the Extended Adoption Analyses

Characteristic	Not-lived-with fathers	Lived-with mothers
Number with marital-status information	80,921[a]	82,698
Mean birth year (*SD*)	1938.7 (9.0)	1942.1 (7.8)
Number who had ever married	66,934 (82.7%)	67,769 (81.9%)
Number who had divorced, if married	45,405 (67.8%)	44,821 (66.1%)
Number with higher education[b]	23,816 (32.5%)	20,454 (24.8%)
Number with alcohol use disorder	17,084 (20.7%)	4,756 (5.8%)
Number with drug abuse	3,000 (3.6%)	1,879 (2.3%)
Number with criminal behavior	21,479 (26.0%)	6,239 (7.5%)

[a]Some fathers died before the marital-status registration started. [b]No education information was available for 9,388 fathers and 294 mothers.

without siblings, suggesting that the subsample of adoptees with siblings was not biased with respect to base rates of marriage or risk of divorce. In a multivariable model in which we examined divorce resemblance among adoptees and their biological and adoptive siblings, having a divorced adoptive sibling was not associated with adoptees' divorce, OR = 1.03, 95% CI = [0.94, 1.13], but having a divorced biological full or half sibling (who was raised in a different family) was associated with increased risk of divorce for adoptees—biological full sibling: OR = 1.20, 95% CI = [1.07, 1.34]; biological half sibling: OR = 1.28, 95% CI = [1.20, 1.38]. In formal tests that compared the strength of divorce resemblance across sibling types, we found no difference in divorce resemblance between adoptees and their full and half biological siblings, $\chi^2(1, N = 13{,}455) = 1.14$, $p = .28$. However, divorce resemblance between adoptees and their biological siblings was significantly higher than divorce resemblance between adoptees and their adoptive siblings, $\chi^2(2, N = 13{,}455) = 14.71$, $p < .01$.

Heritability of divorce across and within generations

The tetrachoric correlations for divorce between adoptees and their biological mothers and fathers were 0.08, 95% CI = [0.04, 0.12], and 0.06, 95% CI = [0.02, 0.10], respectively. The tetrachoric correlation for divorce between offspring and their NLW fathers was 0.06, 95% CI = [0.05, 0.08]. A test of homogeneity indicated no difference between these three estimates, $\chi^2(2, N = 44{,}472) = 0.93$, $p = .63$. The combined tetrachoric correlation estimate equaled 0.063 (*SE* = 0.008). This divorce resemblance across generations, an estimate of

Table 4. Odds Ratios for Predictors of Divorce in Offspring From Their Not-Lived-With Fathers and Lived-With Mothers

Parent type and predictor	Univariable analyses	Multivariable analysis
Not-lived-with father		
Divorced, if married	1.17 [1.13, 1.22]*	1.07 [1.03, 1.12]*
Education (low–mid vs. high)	1.16 [1.10, 1.21]*	1.08 [1.02, 1.13]*
Alcohol use disorder	1.14 [1.09, 1.19]*	1.06 [1.01, 1.11]*
Drug abuse	1.01 [0.92, 1.12]	
Criminal behavior	1.14 [1.09, 1.19]*	1.18 [1.13, 1.24]*
Lived-with mother		
Divorced, if married	1.33 [1.28, 1.38]*	1.26 [1.21, 1.31]*
Education (low–mid vs. high)	1.23 [1.17, 1.29]*	1.11 [1.06, 1.17]*
Alcohol use disorder	1.38 [1.28, 1.49]*	1.27 [1.17, 1.38]*
Drug abuse	1.07 [0.94, 1.22]	
Criminal behavior	1.28 [1.19, 1.37]*	1.26 [1.17, 1.36]*
Offspring birth year (by year)	0.95 [0.94, 0.95]*	0.94 [0.94, 0.94]*

Note: The multivariable analysis includes all parameters that were significant ($p < .05$) in the univariable analyses. Values in brackets are 95% confidence intervals.
*$p < .05$.

$0.5a^2$, resulted in a heritability estimate of 0.13, 95% CI = [0.09, 0.16].

The tetrachoric correlations for divorce between adoptees and their biological full and half siblings were 0.11, 95% CI = [0.04, 0.18], and 0.09, 95% CI = [0.05, 0.12], respectively. The divorce resemblance between full siblings, corresponding to $0.5a^2$, resulted in a heritability estimate of 0.22, 95% CI = [0.16, 0.29]. The divorce resemblance between half siblings, represented by $0.25a^2$, resulted in a higher heritability estimate of 0.35, 95% CI = [0.32, 0.39]. We tested whether the full- and half-sibling estimates could be combined into a single estimate of within-generation heritability. However, the corresponding heritability estimates were significantly different, −0.13, 95% CI = [−0.25, −0.01], and for this reason we report them separately.

Discussion

We examined the influence of genes and the rearing environment on the intergenerational transmission of divorce using Swedish national registries. First, in a classical adoption design, we found that risk of divorce in adoptees was related to biological parents' divorce but not to adoptive parents' divorce. This finding suggests that genetic factors primarily accounted for the intergenerational transmission of divorce. Second, in an extended adoption design, we found that offspring resembled their NLW fathers and their LW mothers in their history of divorce, with stronger resemblance observed with LW mothers. Divorce resemblance between offspring and their NLW fathers provided direct evidence that genetic factors contributed to the intergenerational transmission of divorce. The stronger resemblance observed between offspring and their LW mothers (compared with their NLW fathers) also provided indirect evidence that the rearing environment contributed to the intergenerational transmission of divorce above and beyond significant genetic influences. Finally, in a third test that used data from siblings to examine whether the intergenerational findings replicated in a within-generation design, we found that adoptees significantly resembled their biological siblings, but not their adoptive siblings, in their history of divorce. This finding suggests that genetic factors, but not the rearing environment, explained divorce resemblance within a generation.

As a set, findings across these three tests of the Swedish registry data provided consistent evidence that genetic factors contributed to the familial aggregation of divorce. The heritability estimate (a^2) of divorce across generations was 0.13, whereas the heritability estimate of divorce within a generation was higher and differed when estimated from full and half biological siblings, a^2 = 0.22 and 0.35, respectively. Heritability calculated from an intergenerational study is likely to represent a lower-bound estimate, given that secular changes in marital behavior can alter how a genetic predisposition is expressed across generations (i.e., gene-by-age or gene-by-cohort interaction). Nevertheless, the results are robust in that all provide evidence for genetic influences on divorce, which is consistent with prior twin studies (D'Onofrio et al., 2005; Jerskey et al., 2010; McGue & Lykken, 1992; Salvatore et al., 2017). It is important to note that the findings from our adoption and extended adoption designs expand on these twin studies by providing direct evidence that genetic factors contribute to the intergenerational transmission of divorce. Thus, using entirely different methods, our results mirror those of D'Onofrio et al.'s (2007) initial report that genetic factors contribute to the intergenerational transmission of divorce. Such findings highlight the need for genetically informed designs to better understand the circumstances under which divorce is a pathogenic environment (Kendler & Baker, 2007).

Although there are not genes for divorce (Turkheimer, 1998), divorce is genetically correlated with a personality composite that indexes high levels of negative emotionality, high levels of positive emotionality, and low levels of constraint (Jockin, McGue, & Lykken, 1996), all of which are correlated to marital problems and instability (Cramer, 1993; Karney & Bradbury, 1995; South, Krueger, & Iacono, 2011). A genetic predisposition for divorce may also have an effect through other genetically influenced traits related to marital instability, such as early age at menarche (Belsky, Steinberg, & Draper, 1991). In short, a genetic predisposition for divorce may index a range of individual differences that contribute to marital instability.

In contrast to previous reports (Amato, 1996; D'Onofrio et al., 2007; Wolfinger, 2005), the three tests of the Swedish data provided inconsistent evidence for the role of the rearing environment in divorce transmission across and within generations. In the classical adoption analyses, we found no divorce resemblance between adoptees and their adoptive parents. Likewise, in the sibling analyses, we found no divorce resemblance between adoptees and their adoptive siblings. Thus, in these two direct tests, we found no evidence that the rearing environment contributed to divorce. However, in the test using the NLW families, we observed stronger divorce resemblance between offspring and their LW mothers than between offspring and their NLW fathers. LW mothers contribute both genes and rearing environment, whereas NLW fathers contribute genes but not a rearing environment. Thus, the stronger association observed for LW mothers provided some indirect

evidence that the rearing environment contributed to the intergenerational transmission of divorce above and beyond the contribution of genetics alone. This finding highlights that a genetic predisposition for divorce is not fate. Furthermore, the stronger association observed for LW mothers suggests a role for passive gene–environment correlation, whereby divorced LW mothers provide both this genetic predisposition and rearing environment for their offspring.

These results should be interpreted in view of the study's limitations. First, whether the same pattern of findings would hold for nonmarital relationship stability or in other populations is unknown. Second, selective placement of adoptees can bias adoption studies; however, lack of association between adoptive and biological parents' divorce reduces this concern. Third, divorce resemblance was stronger with biological half siblings than with biological full siblings. This finding was unexpected in view of the lower genetic similarity between biological half siblings than biological full siblings. This may be a chance effect, and we note that divorce resemblance with biological full and half siblings did not differ significantly (see Supplementary Material 1 in the Supplemental Material available online). Fourth, there was a lower rate of divorce among adoptive parents compared with biological parents, which is likely a result of screening adoptive parents for their ability to provide a stable home and financial environment for the child (Björklund, Lindahl, & Plug, 2006). This may have limited the ability to detect rearing-environment effects. Fifth, parental education is an imperfect proxy for socioeconomic status, particularly given increased access to higher education in the late 20th century (Swedish Higher Education Authority, 2013).

Sixth, bias can arise when adoptees and their biological parents have contact prior to adoption. During the study period, adoptees were typically removed from the biological mother shortly after birth for placement in nurseries and then a foster or prospective adoptive family on a trial basis (Bjorklund et al., 2006; Bohman, 1970). Supplementary tests of contact bias indicated only negligible effects, and when we reanalyzed our classical adoption and sibling data restricting our sample to those whom we knew were living in the adoptive home by the age of 5 years, the results were nearly identical to those found in the entire cohort (see Supplementary Material 1 and 2).

Summary

In all three tests, we found direct evidence of genetic influences on divorce across and within generations. In contrast, of the three tests of the rearing environment on divorce, only the indirect test from the NLW families was significant. The two direct tests of the rearing environment on divorce from the adoption and sibling analyses were null. Thus, our findings suggest a role for both mechanisms—but more consistent evidence for genetic effects. This study provides some of the strongest evidence to date that genetic factors contribute to the intergenerational transmission of divorce.

Action Editor

Ayelet Fishbach served as action editor for this article.

Author Contributions

J. E. Salvatore and K. S. Kendler developed the study concept and design. S. Larsson Lönn analyzed the data. J. E. Salvatore drafted the manuscript, and S. Larsson Lönn, J. Sundquist, K. Sundquist, and K. S. Kendler provided critical revisions. All authors approved the final version of the manuscript for submission. K. Sundquist and K. S. Kendler share last authorship of this article.

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Declaration of Conflicting Interests

The author(s) declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

Funding

This project was supported by the U.S. National Institutes of Health Grants AA0235341, DA030005, and K01AA024152; the Swedish Research Council (2014-2517); the Swedish Research Council for Health, Working Life and Welfare (in Swedish: FORTE; Reg. Nos. 2013-1836 and 2014-0804); the Swedish Research Council (2012-2378 and 2014-10134); and a clinical research grant provided by the county of Scania, Sweden.

Supplemental Material

Additional supporting information can be found at http://journals.sagepub.com/doi/suppl/10.1177/0956797617734864

References

Amato, P. R. (1996). Explaining the intergenerational transmission of divorce. *Journal of Marriage and Family*, *58*, 628–640. doi:10.2307/353723

Amato, P. R. (2000). The consequences of divorce for adults and children. *Journal of Marriage and Family*, *62*, 1269–1287. doi:10.5559/di.23.1.01

Amato, P. R., & DeBoer, D. D. (2001). The transmission of marital instability across generations: Relationship skills or commitment to marriage? *Journal of Marriage and Family*, *63*, 1038–1051. doi:10.1111/j.1741-3737.2001.01038.x

Amato, P. R., & Hohmann-Marriott, B. (2007). A comparison of high- and low-distress marriages that end in

divorce. *Journal of Marriage and Family*, *69*, 621–638. doi:10.1111/j.1741-3737.2007.00396.x

Belsky, J., Steinberg, L., & Draper, P. (1991). Child experience, interpersonal development, and reproductive strategy: An evolutionary theory of socialization. *Child Development*, *62*, 647–670. doi:10.2307/1131166

Björklund, A., Lindahl, M., & Plug, E. (2006). The origins of intergenerational associations: Lessons from Swedish adoption data. *The Quarterly Journal of Economics*, *121*, 999–1028. doi:10.1162/qjec.121.3.999

Bohman, M. (1970). *Adopted children and their families: A follow-up study of adopted children, their background, environment and adjustment*. Stockholm, Sweden: Proprius.

Cramer, D. (1993). Personality and marital dissolution. *Personality and Individual Differences*, *14*, 605–607. doi:10.1016/0191-8869(93)90155-V

D'Onofrio, B. M., Lahey, B. B., Turkheimer, E., & Lichtenstein, P. (2013). Critical need for family-based, quasi-experimental designs in integrating genetic and social science research. *American Journal of Public Health*, *103*, 46–55. doi:10.2105/ajph.2013.301252

D'Onofrio, B. M., Turkheimer, E., Emery, R. E., Harden, K. P., Slutske, W. S., Heath, A. C., . . . Martin, N. G. (2007). A genetically informed study of the intergenerational transmission of marital instability. *Journal of Marriage and Family*, *69*, 793–809. doi:10.1111/j.1741-3737.2007.00406.x

D'Onofrio, B. M., Turkheimer, E., Emery, R. E., Slutske, W. S., Heath, A. C., Madden, P. A., & Martin, N. G. (2005). A genetically informed study of marital instability and its association with offspring psychopathology. *Journal of Abnormal Psychology*, *114*, 570–586. doi:10.1037/0021-843x.114.4.570

Dronkers, J., & Harkonen, J. (2008). The intergenerational transmission of divorce in cross-national perspective: Results from the Fertility and Family Surveys. *Population Studies*, *62*, 273–288. doi:10.1080/00324720802320475

Eurostat. (2017). *Marriage and divorce statistics*. Retrieved from http://ec.europa.eu/eurostat/statistics-explained/index.php/Marriage_and_divorce_statistics

Gallup News Service. (2016). *Gallup poll social series: Values and beliefs*. Retrieved from http://www.gallup.com/file/poll/191909/160526MoralAcceptability.pdf

Jerskey, B. A., Panizzon, M. S., Jacobson, K. C., Neale, M. C., Grant, M. D., Schultz, M., . . . Lyons, M. J. (2010). Marriage and divorce: A genetic perspective. *Personality and Individual Differences*, *49*, 473–478. doi:10.1016/j.paid.2010.05.007

Jockin, V., McGue, M., & Lykken, D. T. (1996). Personality and divorce: A genetic analysis. *Journal of Personality and Social Psychology*, *71*, 288–299. doi:10.1037//0022-3514.71.2.288

Karney, B. R., & Bradbury, T. (1995). The longitudinal course of marital quality and stability: A review of theory, methods, and research. *Psychological Bulletin*, *118*, 3–34. doi:10.1037/0033-2909.118.1.3

Kendler, K. S., & Baker, J. H. (2007). Genetic influences on measures of the environment: A systematic review. *Psychological Medicine*, *37*, 615–626. doi:10.1017/s0033291706009524

Kendler, K. S., Ji, J., Edwards, A. C., Ohlsson, H., Sundquist, J., & Sundquist, K. (2015). An extended Swedish national adoption study of alcohol use disorder. *JAMA Psychiatry*, *72*, 211–218. doi:10.1001/jamapsychiatry.2014.2138

Kendler, K. S., Lonn, S. L., Maes, H. H., Lichtenstein, P., Sundquist, J., & Sundquist, K. (2016). A Swedish population-based multivariate twin study of externalizing disorders. *Behavior Genetics*, *46*, 183–192. doi:10.1007/s10519-015-9741-7

Kendler, K. S., Prescott, C. A., Myers, J., & Neale, M. C. (2003). The structure of genetic and environmental risk factors for common psychiatric and substance use disorders in men and women. *Archives of General Psychiatry*, *60*, 929–937. doi:10.1001/archpsyc.60.9.929

Krueger, R. F., Hicks, B. M., Patrick, C. J., Carlson, S. R., Iacono, W. G., & McGue, M. (2002). Etiologic connections among substance dependence, antisocial behavior, and personality: Modeling the externalizing spectrum. *Journal of Abnormal Psychology*, *111*, 411–424. doi:10.1037/0021-843X.111.3.411

McGue, M., & Lykken, D. T. (1992). Genetic influence on risk of divorce. *Psychological Science*, *3*, 368–373. doi:10.1111/j.1467-9280.1992.tb00049.x

Muthén, L. K., & Muthén, B. O. (2015). *Mplus user's guide* (7th ed.). Los Angeles, CA: Author.

Salvatore, J. E., Larsson Lönn, S., Sundquist, J., Lichtenstein, P., Sundquist, K., & Kendler, K. (2017). Alcohol use disorder and divorce: Evidence for a genetic correlation in a population-based Swedish sample. *Addiction*, *112*, 586–593. doi:10.1111/add.13719

Scarr, S., & McCartney, K. (1983). How people make their own environments: A theory of genotype greater than environment effects. *Child Development*, *54*, 424–435. doi:10.2307/1129703

Simonsson, P., & Sandstrom, G. (2011). Ready, willing, and able to divorce: An economic and cultural history of divorce in twentieth-century Sweden. *Journal of Family History*, *36*, 210–229. doi:10.1177/0363199010395853

South, S. C., Krueger, R. F., & Iacono, W. G. (2011). Understanding general and specific connections between psychopathology and marital distress: A model based approach. *Journal of Abnormal Psychology*, *120*, 935–946. doi:10.1037/a0025417

Swedish Higher Education Authority. (2013). *Higher education in Sweden: 2013 status report*. Retrieved from http://english.uka.se/download/18.5d85793915901d205f911834/1487932593308/status-report-statistics-higher-education-sweden-2013.pdf

Turkheimer, E. (1998). Heritability and biological explanation. *Psychological Review*, *105*, 782–791. doi:10.1037//0033-295x.105.4.782-791

United Nations. (2014). *Demographic yearbook*. New York, NY: Author.

Wolfinger, N. H. (2005). *Understanding the divorce cycle: The children of divorce and their own marriages*. New York, NY: Cambridge University Press.