A Genetically Informed Study of the Processes Underlying the Association Between Parental Marital Instability and Offspring Adjustment

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Abstract

Parental divorce is associated with problematic offspring adjustment, but the relation may be due to shared genetic or environmental factors. One way to test for these confounds is to study offspring of twins discordant for divorce. The current analyses used this design to separate the mechanisms responsible for the association between parental divorce, experienced either before or after the age of 16, and offspring well-being. The results were consistent with a causal role of divorce in earlier initiation of sexual intercourse and emotional difficulties, in addition to a greater probability of educational problems, depressed mood, and suicidal ideation. In contrast, the increased risk for cohabitation and earlier initiation of drug use was explained by selection factors, including genetic confounds.

Keywords

divorce; children of twins; education; substance use; cohabitation

Parental divorce is associated with negative outcomes and earlier life transitions as offspring enter young adulthood. Socioeconomic status, educational attainment, early sexual activity, non-marital childbirth, earlier marriage, and cohabitation are associated with the separation of one's parents (see reviews in Amato, 1999, 2000; Emery, 1999; Furstenberg & Teitler, 1994).[1] Furthermore, life course patterns during young adulthood appear to mediate the

association between parental divorce and adult psychopathology. Lower educational attainment, early childbearing, leaving home early (O'Connor, Thorpe, Dunn, Golding, & The ALSPAC Study Team, 1999), and early sexual activity (Cherlin et al., 1995) account for part of the statistical relation between parental divorce and adult difficulties. Therefore, any understanding of the mechanisms through which parental divorce influences adult offspring must consider developmental outcomes across a number of domains.

A meta-analysis found that effect sizes associated with divorce have increased over the past 20 years (Amato, 2001), and the effect sizes associated with parental divorce are larger in late adolescence and young adulthood than at earlier ages (Amato & Keith, 1991). In addition, longitudinal research has indicated that adult difficulties associated with parental divorce increase across the life span and cannot be explained by predivorce behavior problems (Cherlin, Chase-Lansdale, & McRae, 1998). These results suggest that outcomes associated with parental divorce are consequences of the separation, consistent with a causal hypothesis (see historical review in Rutter, 2000). Still, it is possible that the intergenerational association does not occur because divorce *causes* increased risk in offspring but because correlated factors, such as poverty, account for the intergenerational association. This hypothesis is referred to as the *selection hypothesis*—characteristics of families may lead to parental divorce and offspring adjustment problems (e.g., Amato, 2000; Emery, 1999; Emery, Waldron, Kitzmann, & Aaron, 1999). Research on divorce often controls statistically for many variables (e.g., family income, maternal personality characteristics, and ethnicity) that may confound the association between divorce and offspring outcomes (see reviews in Amato, 2000; Hetherington, Bridges, & Insabella, 1998; Simons & Associates, 1996). However, unmeasured variables, such as paternal characteristics, may still account for the statistical associations (D'Onofrio et al., 2003).

Furthermore, what appears to be an environmental family influence on children may actually be due to the genetic confounds. Behavior genetic analyses of divorce have indicated that genetic factors influence variation in what was originally believed to be a purely environmental measure (McGue & Lykken, 1992; Trumbetta & Gottesman, 1997). Researchers have been quick to point out that there are no genes that code for divorce; rather, genetic factors influence intermediate characteristics or endophenotypes (Gottesman & Gould, 2003) that influence the probability of getting divorced. Because parents both provide the environment and transmit their genes to their offspring, environmental and genetic factors are correlated. Genetic factors that influence the underlying liability to divorce can be passed to the offspring and subsequently influence the offspring's behavior, a phenomenon referred to as a passive gene–environment correlation (rGE; Eaves, Last, Martin, & Jinks, 1977; Plomin, DeFries, & Loehlin, 1977; Scarr & McCartney, 1983).[2] For example, genetic risk for neuroticism (Jockin, McGue, & Lykken, 1996), a characteristic associated with divorce (Karney & Bradbury, 1995), could be passed down to offspring and influence their adjustment. Developmental traits may also play a central role in understanding the genetic and environmental pathways between parental divorce and later adjustment—researchers have hypothesized that the rate at which individuals physically mature may be a genetic pathway that mediates the relation between family structure and adjustment problems in offspring (Caspi, 1998; Surbey, 1990).

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[1]The terms *divorce*, *parental separation*, and *marital instability* are used interchangeably throughout this article because the analyses combined parents that divorced; permanently separated married couples; and nonmarried, cohabiting parents that separated. The groups were collapsed because of the large number of married couples that separate without legally divorcing; recent research suggesting that separation of nonmarried, cohabiting parents is associated with similar problems as parental divorce; and the desire to be consistent with previous genetically informed studies of parental divorce (see review in D'Onofrio et al., 2005). Measures of offspring adjustment did not differ among the three groups.

[2]A full description of the processes through which differences at the DNA level influence complex behavior is beyond the scope of this article. See text for some possible mechanisms related to personality or developmental traits. It must be noted that genetic factors associated with divorce would not have to also increase the likelihood of marriage, given that an overwhelming majority of individuals currently marry (e.g., Casper & Bianchi, 2002).

However, it is important to note that the research illustrating genetic variation in divorce only suggests the possibility that shared genetic factors (passive rGE) may be responsible for divorce effects because the source of a risk variable is separate from the mode of risk mediation (Rutter, Silberg, & Simonoff, 1993). The processes that lead to exposure to a risk factor, such as parental divorce, are separate from the mechanisms through which the factor may influence an individual (see, e.g., Kendler & Karkowski-Shuman, 1997). Even though genetic factors contribute to variation in marital instability, the influence of parental divorce on offspring could still be environmentally mediated (i.e., the genetic influences on divorce may not influence the offspring's adjustment).

A number of genetically informed methods are available for explaining associations between family variables and offspring characteristics (Rutter, Pickles, Murray, & Eaves, 2001). Only one such study has been published on the relation between parental divorce and offspring life course outcomes (see D'Onofrio et al., 2005, for a review of behavior genetic studies exploring parental divorce and psychopathology in the offspring). O'Connor, Caspi, DeFries, and Plomin (2000) used 12-year-old participants in the Colorado Adoption Project to explore the genetic and environmental processes responsible for the association between parental divorce and offspring adjustment. Adoption studies separate the influence of environmental and genetic factors because adoptive parents are related only environmentally to their offspring, given the assumption of no selective placement in adoption. The results suggested that passive rGE accounted for the higher risk of difficulties in school achievement in children raised by divorced parents. In contrast, risk for behavioral problems and substance use associated with parental divorce appeared to be environmentally mediated. As the authors noted, there are a number of limitations and assumptions in adoption studies that may hinder the interpretation of the results.

The Children of Twins (CoT) design is an approach that has different methodological assumptions than other behavior genetic designs for exploring environmental risk factors that siblings in a family share (D'Onofrio et al., 2003). The CoT design can delineate the statistical association between an environmental risk factor and offspring adjustment into environmental processes specifically related to the risk factor, shared environmental factors, and shared genetic factors. The logic of the design is briefly described here (see D'Onofrio et al., 2003; D'Onofrio et al., 2005; Gottesman & Bertelsen, 1989; Heath, Kendler, Eaves, & Markell, 1985; and Rutter et al., 2001, for summaries of the rationale of the design). The strength of the CoT design stems from the use of different control groups for offspring in divorced families. Typical family studies of divorce use unrelated control groups (samples of nondivorced families), resulting in a phenotypic estimate of the influence of divorce that is confounded by all of the between-family factors associated with divorce.[3] The divorce effect is the difference between offspring in intact and divorced homes. Although statistical controls for measured variables can be used, the comparison of unrelated offspring includes the influence of all salient, unmeasured characteristics that differ between intact and divorced families.

However, comparing offspring of dizygotic (DZ) twins discordant for divorce (i.e., children from a divorced family are compared with their cousins in intact households) provides a within-twin-family estimate that is free from all confounds associated with divorce that vary between unrelated families. If environmental factors that make twins similar for divorce also account for higher rates of adjustment problems in the offspring, the divorce effect in the offspring of DZ twins discordant for divorce will be less than the phenotypic association. For example, if poverty was an environmental factor that influenced both twins and accounted for the relation between parental divorce and offspring adjustment, all of the cousins in a twin family (offspring of both twins) would experience the socioeconomic risk factors. As a result, the difference

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[3]We refer to estimates of the divorce effect using designs that are not genetically informative as phenotypic associations.

between the children of the divorced and nondivorced cotwins would be smaller than the divorce effect using unrelated comparisons.

Offspring of monozygotic (MZ) twins discordant for divorce provide a better comparison—differences between the offspring in the intact and divorced families are free from shared environmental *and* genetic confounds related to the twins. Similar to offspring of discordant DZ twins, the comparison of children of discordant MZ twins controls for environmental confounds that vary between unrelated families. Offspring of MZ twins also have the same genetic relationship with their parent and their parent's cotwin because the twins are genetically the same. Therefore, offspring of both of the MZ twins receive the same genetic risk associated with divorce from the twins, regardless of whether the children experienced the separation of their parents. If the divorce effect was due to shared genetic factors (passive rGE) passed down from parents to offspring (perhaps personality or developmental characteristics), offspring of both cotwins would receive the same underlying liability from the twins. The offspring of MZ twins discordant for divorce provides a comparison group with the highest degree of genetic and common environmental relatedness.

Overall, a comparison of the divorce effects using these different control groups helps to distinguish between the different processes responsible for the intergenerational association. Differences between offspring of MZ twins discordant for divorce are consistent with a causal hypothesis because unmeasured shared environmental and genetic factors related to the twins do not confound the association. However, if the divorce effect in discordant MZ twin families is lower than the phenotypic divorce effect, the intergenerational association with parental divorce is confounded by selection factors. A comparison of the divorce effects in MZ and DZ discordant families can help to highlight the nature of the selection factors. If the influence of parental divorce is lower in offspring of MZ discordant twins than in offspring of DZ twins, genetic confounds may account for part of the phenotypic relation. Shared environmental factors would be implicated if the divorce effects in MZ and DZ discordant twin families were similar to each other (and below the phenotypic estimate), because the confounds would not be related to genetic risk associated with divorce. In addition to the methodological controls in the CoT design, the approach can be combined with the use of statistical controls for covariates (see Discussion section for a review of the implications of the genetic and environmental influence of the twins' spouses on the offspring).

The goal of the current analyses was to examine whether selection factors, including genetic and shared environment confounds, account for the association between parental divorce (before and after the age of 16) and young-adult well-being.[4] Because of the importance of life course patterns and normative development associated with parental divorce, we focus primarily on academic achievement, sexual maturation and living arrangements, timing of substance use, presence of subclinical levels of depression, and onset of emotional difficulties. Analysis of the associations between parental divorce and lifetime risk of psychopathology is presented elsewhere (D'Onofrio et al., 2005). To the extent that the association between divorce and offspring adjustment is explained by selection, we can conclude that divorce does not play a causal role. On the other hand, the argument for causality is strengthened considerably if we can rule out at least some of these potential selection effects.

We used a number of approaches to explore the possibility that selection factors account for the phenotypic association between parental divorce and offspring outcomes. Because of the

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[4]Because the development literature suggests that age at parental separation may be an important moderator of divorce effects (e.g., Emery, 1999), we sought to explore differences between offspring who experienced earlier and later parental separation. Owing to assessment protocol, we were unable to specify the age at which every offspring from broken homes experienced parental divorce, but we were able to ascertain whether it was before or after the age of 16. Although the age of 16 may not be the best developmental cutoff, the ability to discriminate, albeit broadly, between early and late parental divorce outweighs the limitations in using 16 as the cutoff age.

number of analyses presented and the fact that the CoT design is not widely known, it is important to be clear about our methods and the logic behind them. First, the analyses explored whether parental separation was related to offspring adjustment problems across multiple domains of young-adult adjustment. Second, offspring who had never experienced a separation were compared with offspring who had never experienced a separation but whose parents had been divorced in a previous relationship. If offspring in the latter group were to exhibit more adjustment problems than those in the former group, selection factors would be implicated (e.g., Capaldi & Patterson, 1991). Third, offspring who experienced the separation of their parents before and after the age of 16 were compared with unrelated individuals who had never experienced a divorce. If parental divorce after the age of 16 were to predict onset of a behavior that occurred before the age of 16, then parental separation alone would not account for the increased difficulties. Rather, family processes that culminated in divorce or selection factors would account for the association between parental divorce and the outcomes. Fourth, life course and demographic outcomes that were associated with parental divorce before or after the age of 16 were explored using the CoT design. The association between parental divorce and each offspring outcome was estimated using unrelated control participants, offspring of DZ twins discordant for divorce, and offspring of MZ twins discordant for divorce. Each comparison was also estimated while controlling for measures of psychopathology, adjustment problems, and demographic characteristics of the adult twins. Therefore, the analyses controlled for unmeasured environmental and genetic confounds related to the twins and variability due to measured parental characteristics.

Method

Samples

Longitudinal Adult Twin Study—Adult twins were drawn from the Australian National Health and Medical Research Council Twin Registry. The twins in the cohort used in the current analyses were born between 1893 and 1965, with an overwhelming majority being born after 1939 (25th percentile = 1939). The twins participated in a longitudinal study consisting of three health and behavior surveys. The first assessment, referred to as the Canberra Study, was a mailed questionnaire during the early 1980s ($N = 8,183$ individual twins; 69% response rate; Jardine & Martin, 1984). A second mailed questionnaire, the Alcohol Cohort Follow-Up I Study (ALC1), was completed in 1988–1989 and was based on complete pairs from the Canberra Study ($N = 6,327$ individuals; 83% response rate; Heath & Martin, 1994). The third survey (referred to as the Semi-Structured Assessment for the Genetics of Alcoholism Study, Phase 1) was a telephone interview completed in 1992–1993 ($N = 5,889$ individual twins; 86% response rate; Heath et al., 1997). Tests for self-selection biases in the longitudinal sample, comparing participants who dropped out of the study and those who completed each assessment, have not found detectable differences in risk for abnormal behavior (Heath et al., 1997; Slutske et al., 1997).

Offspring of twins—The offspring for the current analyses were drawn from a study designed to explore the intergenerational transmission of psychopathology and problems associated with parental divorce. Therefore, data were collected from the offspring of adult twins in three at-risk subgroups and a control group. The three at-risk groups included (a) twins with a history of alcohol dependence and/or conduct disorder, (b) twins with a history of depression, and (c) twins with a history of divorce. If either twin had one of the disorders or divorce, offspring from both twins were recruited. Both twins were not required to have children. The control group of offspring was based on twin pairs in which neither cotwin met any of the at-risk criteria. The adult twins originally had to consent for the research team to contact their children. Once parental consent was given, the offspring were contacted. If the offspring consented to participate, they completed a telephone interview and were mailed a

questionnaire. In total, 1,409 adult twins completed the screening interview (85% response rate), and 2,554 offspring completed the telephone interview (82% response rate). Approximately a quarter (24%, $n = 601$) of the participating offspring were drawn from twin families in which neither twin reported a history of alcohol dependence, conduct disorder, depression, or divorce. A majority of the offspring (51%, $n = 1,296$) came from nuclear families in which the twin parent did not meet any of the criteria. Additional information regarding the sample, such as the proportion of offspring from the at-risk and control groups, can be found in D'Onofrio et al. (2005).

The average age of the offspring was 25.1 years (range: 14–39), and 50.6% were female. Of the 2,554 offspring in the study, 1,876 (73.5%) were from families in which the adult twin had no history of marital instability, 83 (3.3%) had not experienced the separation of their parents but the adult twin had separated from an earlier relationship, 442 (17.3%) had experienced the separation of their parents before the age of 16, and 153 (6.0%) had experienced the separation of their parents after the age of 16. The offspring also reported on their current marital status: 28.3% were married, 3.8% were divorced or separated, and 68.4% had never been married. A subsample ($n = 176$) completed the interview a second time to establish the reliability of the instrument. They were reinterviewed on average 1.08 years (range: 0.51–1.62) later.

Measures

Adult characteristics—On the basis of marital items in each adult assessment, including a detailed history of living arrangements in the ALC1 study, a lifetime history of divorce and marital separation was calculated for each participant. Marital separation included separation from a cohabiting relationship, defined as living with someone for more than 6 months. Approximately a quarter of the twins (23.7%) reported a lifetime history of marital separation. Previous analyses revealed that genetic factors contributed to variation in marital instability in the sample (see D'Onofrio et al., 2005). In summary, 15% (confidence interval [CI] = 5%–19%) of the variation in marital instability was due to additive genetic factors. The majority of variance (85%, CI = 81%–90%) was due to nonshared environmental factors, with a limited role of environmental factors that influenced both twins equally (0%, CI = 0%–7%).

Measures of the adult twins that could act as selection factors were assessed. Characteristics of the twins were also included in the analyses to help account for the sampling strategy for the offspring study. Parental age at birth of the first child was calculated from the children's date of birth. The respondents also reported their highest level of education on a 7-point Likert scale: (a) *less than 7 years' schooling* (1.0%); (b) *8–10 years' schooling* (32.1%); (c) *11–12 years' schooling* (21.7%); (d) *apprenticeship, diploma, and so forth* (16.2%); (e) *technical or teachers' college* (14.6%); (f) *university first degree* (8.5%); and (g) *university postgraduate training* (5.9%).

The Semi-Structured Assessment for the Genetics of Alcoholism (SSAGA; Bucholz et al., 1994) was given to the adult twins in the early 1990s. The SSAGA is based on validated research interviews and has demonstrated moderate to high reliability (Bucholz et al., 1994). The original SSAGA was adapted for use as a diagnostic telephone interview in Australia (e.g., Slutske et al., 1998). The number of lifetime symptoms of diagnoses for conduct disorder, alcohol abuse, and major depression, as outlined in the *Diagnostic and Statistical Manual of Mental Disorders* (3rd ed., rev; *DSM–III–R*; American Psychiatric Association, 1987), were calculated for each adult twin. The lifetime history of ever using an illegal drug (24.67%) was also included. Finally, the twin's history of suicidality was calculated on the basis of a 5-point Likert scale (1 = *no thoughts or plans of suicide*, 2 = *transitory thoughts of plan or attempt*, 3 = *persistent thoughts about suicide*, 4 = *plan for suicide or minor attempt*, 5 = s*erious suicide attempt;* Statham et al., 1998).

Zygosity was based on two self-report items given to both of the twins, an approach that has at least 95% agreement with assignment based on genotyping (Eaves, Eysenck, & Martin, 1989).

Offspring of twins—The offspring were also assessed with the SSAGA. All items analyzed in this article were drawn from the interview segment of the protocol. With respect to educational outcomes, the offspring reported their years of education and whether they had ever failed a grade in school. Female offspring were asked to report their age when they had their first menstrual period. All respondents were asked whether they had ever had sexual intercourse. If so, they reported how old they were when they first had sexual intercourse with their consent. Each offspring was also asked whether he or she had ever lived with someone as though they were married for a period of 6 months or longer. The respondents were instructed not to count anyone who they later married. Therefore, the variable assesses the tendency to form cohabiting relationships that do not lead to marriage. Each participant was also asked whether he or she had ever consumed alcohol, been drunk ("couldn't talk clearly or it was hard to keep your balance"), smoked cigarettes, and tried marijuana. If respondents answered in the affirmative, they indicated when they had first experienced the event. The SSAGA also included sections on depression and suicidality. The offspring were asked whether there had (a) ever been 2 weeks or more when they were depressed or down most of the day, nearly every day or (b) ever been 2 weeks or more when they were a lot less interested in most things or unable to enjoy the things they used to enjoy, most of the day, nearly every day. A positive endorsement for either was coded as depressed mood. Although the symptoms are important criteria for the diagnosis of major depression as described in the fourth edition of the *DSM* (*DSM–IV*; American Psychiatric Association, 1994), the variable represents depressed mood, rather than a diagnosis, because the episodes did not have to meet all of the *DSM–IV* criteria. The respondents reported the age of onset for the first depressed mood. The SSAGA also assessed lifetime prevalence and age of first suicidal ideation.

Table 1 presents the means, standard errors, and reliability of the outcome variables in the entire sample. Most of the variables had adequate test–retest reliability. A few of the items, such as lifetime history of intercourse, cohabitation, and intoxication, had lower reliability over time. However, this does not reflect inaccuracies in measurement; rather, the low reliability reflects the chronological development of many of the participants in the study. Most of the discrepant reporting or "unreliability" in lifetime history of intercourse (92%), cohabitation (98%), and intoxication (86%) was due to participants who originally denied these experiences but then participated in them during the period of time between the two measurements.

Analyses

Comparison of separation groups—The means and prevalences of the offspring variables were calculated separately for the four separation groups: offspring whose parents never separated (*never separated*), offspring whose parents had separated from a previous relationship (*previous separation*), offspring who experienced their parents' separation before the age of 16 (*before age 16*), and offspring who experienced the separation of their parents after the age of 16 (*after age 16*). All means are presented after controlling for age, age squared, and gender of the offspring. Comparisons among the groups were conducted with mixed-model analyses of covariance (ANCOVA) to account for the nested nature of the data. The continuously distributed variables were conducted with SAS Proc Mixed (Littell, Milliken, Stroup, & Wolfinger, 1996) and controlled for the age, age squared, and gender of the offspring. For the age-of-onset variables, offspring were included only if they had ever endorsed the outcome (e.g., ever tried smoking or consuming alcohol).[5] Multilevel binomial models, based on each offspring's age, were used with the dichotomous outcomes as implemented in the Hierarchical Linear Modeling (HLM) software program (Raudenbush, Bryk, Cheong, &

Congdon, 2001). The approach controlled for variable exposure to the risk for the outcomes based on the age of the offspring. Because the dichotomous variables were analyzed contingent on the age of the offspring, age and age squared were not included as predictors, but the comparisons controlled for the gender of the offspring.

Omnibus comparisons were initially conducted for each outcome variable. For offspring variables that were related to the separation groups, the previous separation, before age 16, and after age 16 groups were each compared with the never separated group.

CoT analyses using HLM—HLM estimated the influence of divorce, using the multiple comparison groups discussed above (unrelated offspring, children of DZ twins discordant for divorce, and offspring of discordant MZ twins). The goal of the analyses was to calculate the divorce effect using comparison groups that differed in genetic and environmental risk associated with parental divorce. HLM was used because the approach can analyze regression-type problems in which the observations are not independent (e.g., multiple offspring per family) and can include measured covariates at different levels of analysis (see review in Raudenbush & Bryk, 2002). The CoT design includes three, nested levels of analysis: the offspring, nuclear-family, and twin-family levels (see D'Onofrio et al., 2005, for a graphical representation). The offspring level includes characteristics unique to each individual, such as age. The nuclear-family level represents factors that all siblings share, such as parental psychopathology. The twin-family level incorporates factors that all cousins share (e.g., zygosity status of the twins). A series of three-level hierarchical linear models were fit in which the residual variance components, or random effects, at each of the three levels were estimated.

There were a small number of families with variation in divorce at the offspring level. Only nine nuclear families had offspring for whom one had experienced a separation and another hadn't (i.e., one child wasn't born yet), and only 32 nuclear families contained siblings who differed in the age at parental separation. No definitive conclusions could be drawn from the comparison of individuals within nuclear families.[6] As a consequence, nuclear-family-level divorce variables (early or late parental divorce) were created on the basis of the average number of offspring within a nuclear family who had experienced the separation of their parents either before or after the age of 16.

Four hierarchical linear models were fit for each measure of offspring adjustment. Model 1 compared offspring who had experienced the separation of their parents either before or after 16 with offspring in unrelated families who had never experienced a separation (a phenotypic relation). The model included parental divorce as a second-level (nuclear-family-level) variable. Gender of the offspring was included in each model. For continuously distributed outcome variables, age and age squared of the offspring were included to control for any nonlinear associations with age. Multilevel models contingent on the age of the offspring were conducted for dichotomous outcome variables, because not all offspring had gone through the "risk period" for each outcome (Raudenbush et al., 2001). As a result, age and age squared were not included as predictors for the dichotomous variables.

Model 2 made the same comparison as Model 1 but also included statistical controls for characteristics of the twin parent that could act as selection factors. The analyses controlled for parental age at the birth of first children; parental level of education; and lifetime history of parental conduct disorder symptoms, alcohol abuse symptoms, alcohol dependence

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[5]The continuous variables were also analyzed with multilevel models, based on the age of the offspring, but the results did not differ. Because of the complexity of the analyses the results for the standard HLM are presented.
[6]Complete results are presented in the Supplementary Appendix, which is shown on the Web at http://dx.doi.org/10.1037/0012-1649.42.3.486.supp

symptoms, cigarette smoking, illicit drug use, and suicidality. Model 2 thus provides an example of the standard divorce analysis that uses measured covariates to control for possible confounds.

Model 3 used the CoT design to provide comparisons of offspring with their cousins in MZ and DZ families. Table 2 presents the sample sizes for the entire data set and for the MZ and DZ twin families by age of parental separation and the divorce status of the parent's cotwin. The design allows the influence of parental divorce to be separated into the effects of divorce within (second-level) and between (third-level) twin families. Two within-twin-family estimates were made for each of the divorce variables, because the design includes MZ and DZ twin families. The first within-twin-family parameter compared the offspring of MZ twins discordant for divorce (i.e., comparing cousins), providing an estimate of the relation between parental divorce and the offspring variable free from genetic and shared environmental confounds related to the twins. As discussed above, the magnitude of the within-MZ estimate tests whether the intergenerational relation is due to environmental risk factors related to divorce (consistent with a causal hypothesis) or unmeasured genetic and environmental confounds related to the twins (the selection hypothesis). The second within-twin-family parameter estimated the difference in magnitude between the within-MZ- and within-DZ-family estimates ($b = DZ - MZ$). Therefore, the second within-twin-family parameter provides a formal statistical test of the difference between the divorce effects in MZ and DZ families. A higher within-twin-family estimate in DZ twins would suggest that genetic factors confound the intergenerational association. Owing to the small sample sizes in some of the comparisons, interpretation of the parameters did not rely solely on significance testing; effect sizes were also used in the interpretation. The HLM also included an approximation of the between-twin-family estimate of divorce (see D'Onofrio et al., 2005, for more details).

Model 4 included all of the parameters from Model 3 but also included the statistical controls for parental confounds (see list of variables above). Model 4 represents an approach that uses both methodological and statistical controls. If the phenotypic association between parental divorce after the age of 16 and the offspring outcome were to be small, the phenotypic association was not subsequently decomposed into separate MZ and DZ estimates. Because the major focus of this article is on parental separation, the unstandardized parameter estimates, standard errors, and significance levels for the divorce variables are provided in the text. Unstandardized estimates were used because appropriate comparisons of parameter estimates cannot be made with standardized coefficients (e.g., Kim & Mueller, 1976). The continuously distributed variables are also expressed in meaningful units (e.g., years). The parameter estimates for all of the variables in the models and the standardized divorce estimates (distributed as effect sizes and odds ratios) are presented in the Supplementary Appendix, which is shown on the Web at http://dx.doi.org/10.1037/0012-1649.42.3.486.supp. Algebraic representations of the models can be found elsewhere (D'Onofrio et al., 2005).

Results

Comparison of Separation Groups

Table 3 presents the means and crude prevalence rates for the offspring variables by the separation groups, with the overall significance levels. The offspring in the four groups differed in years of education and failing a grade. Parental separation was not related to age of menarche or lifetime history of intercourse, but the groups differed on age at first intercourse, lifetime history of cohabitation, and having a baby before the age of 20. The separation groups did not differ on prevalence of ever drinking, being intoxicated, or trying cigarettes. However, the offspring in the four groups differed in the age of first drinking, age of first intoxication, and age of first cigarette use, marijuana use, and age of first marijuana use. Depressed mood, age of first depressed mood, and suicidal ideation also differed across the separation groups.

For the variables that were associated with marital instability, three comparisons were made. The first comparison contrasted the two groups of offspring who had never experienced their parents' separation: the never separated and the previous separation groups. There were no significant differences for any outcomes (see footnote 6). For all of the outcomes associated with the overall separation groups, offspring who had experienced a separation before the age of 16 differed from those whose parents had never separated. The offspring who experienced their parents' divorce after the age of 17 also differed from the never separated group for years of education, age at first intercourse, cohabitation, and becoming a parent before the age of 20.

CoT Analyses Using HLM

Of the 2,554 offspring in the study, 47 were not included in the HLM because of missing data. The majority of the missing observations were due to incomplete information regarding the marital status of the offspring's aunt or uncle. However, the offspring with incomplete data did not differ from those included in the analyses for any life course outcome (see footnote 6). Because there were no differences between the previous separation and never separated groups for any of the offspring variables, the two groups were collapsed in the HLM. The prevalence and means for each life course outcome were calculated for the never separated, separation before age 16, and separation after 16 groups separately for MZ and DZ twins, conditional on the divorce status of their parent's cotwin (referred to as the avuncular relationship; see footnote 6).

Education—The unstandardized divorce parameters and standard errors from the HLM are presented in Table 4. Years of education were associated with parental divorce before the age of 16 ($b = -0.48$ years in Model 1). Statistical controls for parental characteristics slightly reduced the magnitude of the association ($b = -0.31$ years in Model 2). Estimates of the association using offspring of MZ twins discordant for divorce, both without ($b = -0.32$ years in Model 3) and with statistical controls for measured covariates ($b = -0.26$ years in Model 4), suggest that the size of the intergeneration relation is half the original phenotypic estimate. The differences between the within-MZ and within-DZ estimates ($b = 0.31$ years in Model 3 and $b = 0.37$ years in Model 4) were in the opposite direction of what would be expected by genetic confounds for early divorce. Therefore, the findings suggest no presence of rGE (i.e., the genetic variation in divorce is not associated with the offspring characteristic). The phenotypic, within-DZ-, and within-MZ-family divorce estimates for the age of onset variables are also presented in Figure 1. The figure illustrates how the phenotypic association between divorce and years of education was reduced when statistical and methodological controls for confounds were used.

The results for the relation between parental divorce after the age of 16 and years of education also suggest that approximately half of the intergenerational association is due to selection factors. The phenotypic association in Model 1 ($b = -0.45$ years) was reduced when statistical controls were used in Model 2 ($b = -0.34$ years). The comparison of the offspring of MZ twins in Models 3 ($b = -0.26$ years) and 4 ($b = -0.17$ years) also resulted in reduced estimates of the divorce effect. There was little difference in the divorce estimates among MZ and DZ discordant twin families ($b = -0.03$ years for Models 3 and 4), suggesting that genetic confounds were not responsible for the lower divorce effects. A similar pattern was seen for the association between failing a grade and early parental divorce. The original phenotypic estimate ($b = 0.39$ logits) in Model 1 associated with early divorce was ultimately reduced by approximately 50% when statistical and methodological controls were used in Model 4 ($b = 0.21$ logits), but there was little evidence for genetic confounds in Models 3 and 4 because the differences between the MZ and DZ divorce effects were minimal ($b = 0.10$ and $b = 0.01$ logits, respectively). Figure 2 presents the parameters for the dichotomous outcomes, presented as odds ratios.

Sexual development, living arrangements, and early parenting—Age at first intercourse had a sizable association with early parental divorce in Model 1 ($b = -1.01$ years). Statistical controls in Model 2 slightly reduced the magnitude of the divorce effect. The within-MZ-family estimates suggest that the relation may be half of the original estimate, as early parental divorce was still associated with an onset 0.53 years earlier in Model 4. Furthermore, the associations with early parental divorce appear to be larger in DZ families (DZ estimate – MZ estimate = −0.44 years in Model 3), suggesting that genetic factors may account for part of the original phenotypic association. Parental divorce after the age of 16 was also associated with age at first sexual intercourse in Model 1 ($b = -0.56$ years), but the association was substantially reduced when the CoT design was used. Later parental divorce was associated with a decrease of only 0.16 years in age at first intercourse when offspring of discordant MZ twins were compared and statistical covariates were included in Model 4.

The results for cohabitation are some of the most striking findings. Although early parental divorce had a large phenotypic association with cohabitation in Model 1 and the estimate remained robust when statistical controls were used in Model 2, there was no association when offspring of MZ twins discordant for divorce were compared in Models 3 and 4. The within-DZ estimate appeared to be larger than the MZ estimate in Model 3 ($b = 1.09$ logits, $p = .09$), suggesting that passive rGE accounted for all of the phenotypic relation. The association between late divorce and cohabitation showed a slightly different pattern. The use of the CoT design also substantially reduced the estimates of the association (0.90 logits in Model 1 vs. 0.16 logits in Model 4), indicating that the relation may not be causal. Yet there was little evidence of the role of genetic confounds, because the within-DZ-family estimates were not larger than the within-MZ-family estimates (DZ estimate – MZ estimate = −0.11 years in Model 3 and −0.20 years in Model 4). Rather, the pattern of divorce estimates implies that shared environmental confounds account for the relation between parental divorce after the age of 16 and risk of cohabitation.

Because of the low prevalence of endorsement for becoming a parent before the age of 20, the effects of divorce could not be calculated in the genetically informed analyses.

Alcohol, cigarette, and drug use—Early parental divorce was associated with age initiating drinking in Model 1 ($b = -0.41$ years), but the magnitude of the relation was greatly reduced when statistical and methodological controls were used ($b = -0.13$ years in Model 4). The difference between the within-MZ and within-DZ estimates in Model 3 suggests that passive rGE may partly confound the associations, but the limited statistical precision makes a definitive conclusion difficult. Similar to initiation of alcohol use, early parental divorce was associated with age of first intoxication ($b = -0.50$ years in Model 1). The association was reduced by approximately 50% in Model 4, but the results did not suggest any genetic confounds because the difference between the divorce effects in discordant MZ and DZ families was minimal in Model 3. The same overall results were obtained when exploring the relations between parental divorce before the age of 16 and initiation of cigarette smoking. The phenotypic association in Model 1 ($b = -0.63$ years) was greatly reduced in Model 4 ($b = -0.33$ years), and there was little difference in the MZ and DZ divorce effects in Model 3 or 4.

Lifetime history of marijuana use was associated with early parental divorce in Model 1, and the results of the model fitting suggest that genetic and shared environmental confounds do not mediate any of the relation. The divorce estimates using statistical controls in Model 2 and comparing offspring of discordant twins in Models 3 and 4 were consistent with the original phenotypic relations, indicating that environmental risk factors specifically associated with divorce account for higher rates of marijuana use in children in separated households. However, the results for age of initiating marijuana use suggest a different underlying mechanism. Early parental divorce was associated with an earlier age of onset in Model 1 and when statistical

controls for parental characteristics were used in Model 2. Yet there was no association in offspring of discordant MZ twins in Models 3 and 4. The findings discount a causal association. The larger within-DZ- than within-MZ-family estimates in Models 3 and 4 suggest that genetic factors may account for the association.

Emotional problems—There was a phenotypic association between early parental divorce and risk for depressed mood in Model 1, and the use of statistical and methodological controls for possible confounds did not reduce the estimate in the subsequent models. Parental divorce before the age of 16 was also associated with an earlier onset of depressed mood ($b = -1.77$ years in Model 1). The use of the CoT design slightly reduced the magnitude of the association ($b = -1.52$ years and $b = -1.32$ years in Models 3 and 4, respectively). The difference between the within-MZ and within-DZ estimates ($b = -0.78$ years in Model 3 and $b = -0.72$ years in Model 4) is also suggestive of a slight role of passive rGE. However, the results suggest that environmental risks that specifically covary with divorce account for a majority of the intergenerational association, with the possibility of a small genetic confound.

Finally, parental divorce before the age of 16 was associated with the risk of experiencing suicidal ideation in Model 1. Although statistical controls for parental characteristics slightly reduced the magnitude of the estimate in Model 2, the within-MZ-family parameters in Models 3 and 4 were consistent with the phenotypic association, which is consistent with a causal theory. Furthermore, the differences between the within-MZ and within-DZ parameters in the last two models are in the opposite direction of what would be expected by passive rGE.

Discussion

Summary of Results

The current analyses used a longitudinal study and genetically informed method, the CoT design, to account for possible confounds in the putative effects of parental divorce on offspring adjustment. The results therefore provide a more fully informed test of the common view that parental divorce causes the well-being of offspring to decline. The findings support a few general conclusions toward that end. First, and consistent with a large body of research, parental divorce, especially when experienced before the age of 16, is associated with a number of measures of adjustment and life course outcomes, including lower educational attainment, earlier initiation of sexual activity, higher rates of cohabitation, earlier age of onset of alcohol and drug use, and earlier emotional problems. Second, children who had not experienced a divorce but whose parents had separated from a previous relationship did not differ from offspring whose parents had never been separated. Third, in most of the analyses, the estimates from the HLM that controlled for shared environmental and genetic factors related to the adult twins were smaller than the original phenotypic associations and the estimates that used only statistical controls. Fourth, the relative contributions of genetic selection, selection due to shared environmental factors, and the effects of parental divorce differed across outcomes. Some putative effects of divorce appear to be due to genetic and/or environmental selection. Other apparent divorce effects seem to be partially due to selection, and still other effects appear to be true effects of divorce, at least inasmuch as we could account for the processes using the CoT design, an approach that offers a major advantage over other methods of studying parental divorce. Below, we consider how these general patterns differ across various domains.

Education—The phenotypic associations between parental divorce and educational outcomes, such as years of education and risk of failing a grade, are consistent with previous research (e.g., McLanahan & Sandefur, 1994). However, the phenotypic associations were reduced substantially when both statistical and methodological controls were used. The findings suggest that the association between parental divorce and educational attainment and

repeating a grade are consistent with a causal relation, but the size of the associations was approximately half of the initial estimates. The results do not replicate previous findings for the role of passive rGE in academic achievement (O'Connor et al., 2000), but the disparity may reflect the differences in the educational variables used in the studies.

Sexual development, living arrangements, and early parenting—Although some research has found associations between parental divorce and age of menarche (e.g., Hetherington, 1993), no relation was found in the current analyses. Yet the null findings are consistent with epidemiological studies in Britain that support the notion that age of menarche does not contribute to the differences between women of divorced and intact families on measures of sexual activity, partner formation, or childbearing (Kiernan & Hobcraft, 1997). These results do not support the possibility that sexual maturation is a genetically mediated process that accounts for higher levels of adjustment problems in divorced families (Caspi, 1998; Surbey, 1990). However, the association between other family risk factors, such as stepfather presence, and sexual maturation may be the result of genetic confounds. A CoT analysis of stepfather presence and age of menarche suggests that the association is not due to causal processes; rather, familial confounds account for the association (Mendle et al., 2006).

Findings from the current sample are also consistent with previous research exploring age of first intercourse (Cherlin, Kiernan, & Chase-Lansdale, 1995; Kiernan & Hobcraft, 1997). Parental divorce, especially parental separation before the age of 16, was associated with an earlier initiation of sexual activity. Although genetic factors may account for part of the association, the results suggest that parental marital dissolution may have a sizable impact on offspring's sexual activity. Because of the negative health outcomes associated with early sexual activity, the results suggest that prevention efforts targeted at children from broken households may be especially beneficial.

The relationship between parental divorce and offspring cohabitation provides an example of the complexity of studying the impact of marital dissolution. Early parental divorce is associated with an increased probability of forming a cohabiting relationship, but the use of the CoT design suggests that genetic factors completely account for the relation. The association between parental divorce after the age of 16 and cohabitation also appears to be mostly due to selection factors, but the results do not support the role of passive rGE. Rather, environmental factors that twins (and siblings) share appear to account for the statistical relation. The use of the CoT design suggests that the processes responsible for the likelihood of forming a cohabiting relationship may differ depending on the age of parental divorce; however, studies of sensitive periods are difficult to conduct with just one time point (see the limitations discussed below). Overall, the results imply that statistical associations between parental divorce and cohabitation in other studies (e.g., Cherlin et al., 1995; Furstenberg & Teitler, 1994; Kiernan, 1992) may not represent causal relations.

Although having a child before the age of 20 was related to parental divorce, consistent with other studies (Amato, 1999), the low prevalence of the outcome made it impossible to explore within the current genetically informative context.

Alcohol, cigarette, and drug use—Parental divorce was not associated with offspring reports of ever using alcohol, being intoxicated, or trying a cigarette, but experiencing the separation of one's parents before the age of 16 was related to the age at which individuals first use alcohol, become intoxicated, and smoke cigarettes. In each case, controlling for parental characteristics and nonmeasured confounds via the CoT design reduced the magnitude of the association. Again, early parental divorce may have a small causal influence on these developmental outcomes, but the magnitude of the effect was reduced, suggesting that divorce may not have as large of an impact as originally expected.

Early parental divorce was associated with the risk of ever using marijuana in the entire sample, and the magnitude of the association was not reduced with statistical or methodological controls for confounds. These findings suggest a relation between early parental divorce and offspring marijuana use that is consistent with the causal hypothesis. However, the sizable association with age at first marijuana use in the entire sample appears to be entirely due to confounds, because there was no association in the offspring of discordant MZ twins. Furthermore, the within-family estimate in DZ families appears to be larger than the within-family MZ estimate, a pattern that suggests genetic mediation.

Emotional problems—Parental divorce before the age of 16 was associated with depressed mood, and the magnitude was not reduced in the HLM, consistent with a causal association. The magnitude of the finding is commensurate with previous research on internalizing problems (e.g., Amato & Keith, 1991). Furthermore, early parental divorce was associated with a much earlier age of onset of emotional problems, one of the largest phenotypic associations in the current study. The magnitude was somewhat lower in the offspring of discordant MZ twins, compared with discordant DZ twins, implying both a large causal association and some role of rGE. Lifetime history of suicidal ideation was related to early parental divorce, and similar to depressed mood, the magnitude was not reduced by the statistical and methodological controls. The findings for emotional problems are consistent with the literature that illustrates that parental divorce is a traumatic experience for many young children (e.g., Emery, 1999). Furthermore, the findings highlight the need for researchers to explore measures of pathology *and* subclinical distress, because parental divorce may have a greater impact on the latter (Laumann-Billings & Emery, 2000).

Limitations

A number of limitations of the current research need to be addressed. First, a statistical association between parental divorce and offspring life course outcomes, even with the statistical and methodological controls used in the current analyses, does not prove causation (D'Onofrio et al., 2003). Environmental risk factors associated with divorce within a twin family (i.e., those factors that affect only one twin and his or her children) may actually be responsible for the outcomes. For example, the analyses were unable to control for income before and after the parental separation. However, the relation between family instability and some life course patterns, such as premarital childbirth, are independent of low income, unstable income, or changes in income after parental separation (Wu, 1996). Furthermore, the analyses presented here, consistent with most research on divorce (e.g., Capaldi & Patterson, 1991; Emery et al., 1999; Simons & Associates, 1996), statistically controlled for measures of only one of the two parents' characteristics. Therefore, the associations reported here may be confounded by the environmental or genetic contributions of the spouses of the twins. It must be noted that the CoT design by itself does not account for the spouses of the twins. However, CoT analyses that included measured covariates of both parents did not appreciably change the results for the variables presented in the current article (D'Onofrio, 2005). The analyses also assumed that reciprocal influences were negligible, such that offspring adjustment problems and life course patterns did not influence the probability that the parents would separate.

Second, it is unclear whether the results of the current study will generalize to other samples. Although research suggests that findings from Australia are consistent with studies in other Western countries (Pryor & Rogers, 2001; Rogers, 1996), the findings may not apply to populations in the United States or Britain. Furthermore, the sample was selected, in part, on the basis of psychopathology and divorce in the twin parents (and a control group). Statistical controls were used to help account for the parental psychopathology, but it is unclear whether unmeasured characteristics of the families could account for findings. The magnitude of the

phenotypic divorce effects are consistent with previous research, but replications of the CoT results will be extremely important, especially to determine whether the same conclusions are found in samples in the United States and in other cultures.

Third, although the comparison of offspring from MZ twins discordant for divorce provides an excellent control group, the CoT design requires large samples to delineate between shared environmental and genetic confounds (Heath et al., 1985). As a result, the analyses presented here that suggest genetic mediation, compared with the role of shared environmental factors, should be considered cautiously. Furthermore, the statistical power in the current project to precisely estimate all of the divorce parameters, especially when separating the effects of early and later parental divorce, was limited (i.e., the standard errors around some of the estimates are large). Therefore, the interpretation of the results relied primarily on the magnitude of the parameter estimates instead of exclusively focusing on significance testing, because we did not want to confuse statistical precision with the importance of parameter estimates. The limited statistical power is most prominent for the outcomes associated with later divorce because of the smaller number of parents in the sample who separated after their children reached the age of 16.

Fourth, it is impossible to determine whether differences in estimates for early and later parental divorce represent fundamental differences in the underlying mechanisms, because an offspring's age at the time of the divorce is perfectly correlated with the time since the divorce and the measurement of the outcome (see Emery, 1999, for a detailed description). Fifth, all of the offspring items in the current analyses were based on the children's self-report, gathered retrospectively.

Finally, the analyses in this article focused on documenting the genetic and environmental processes underlying the association between parental divorce and developmental outcomes in young adulthood. The analyses did not seek to detail the environmental mechanisms that are responsible for the deleterious outcomes specifically associated with parental divorce. The divorce literature has suggested a number of processes related to parental divorce, especially early parental separation: loss of attachment figures, cognitive difficulties in understanding parental divorce, changes in schemas related to intimate relationships, loss of social capital, deleterious parenting practices, socioeconomic factors, and family conflict (see review in Emery, 1999). Likewise, the specific genetic processes that mediate the relation between parental divorce and cohabitation were not explicitly explored. Research must also examine how parental divorce interacts with genetic predispositions to influence offspring adjustment (e.g., O'Connor, Caspi, DeFries, & Plomin, 2003). Finally, future studies must explore how developmental milestones in young adulthood may mediate the association between parental divorce and later difficulties (e.g., Cherlin et al., 1995).

Conclusions

The consequences of parental divorce for society at large continue to be debated in the social science literature (see review in Thompson & Wyatt, 1999). All discourse about the consequences of divorce for offspring is predicated on a proper understanding of the causal pathways linking marital separation and offspring characteristics. If the increased rates of adjustment problems are due to selection factors, interventions to reduce the prevalence of divorce will be misguided. Likewise, studies that are consistent with causal associations provide further evidence that a reduction in the prevalence of divorce or an amelioration of the environmental risk factors associated with parental separation will result in offspring with fewer difficulties.

The findings of the current analyses provide further support for a causal association between experiencing parental divorce before the age of 16 and (a) educational attainment, failing a

grade, marijuana use, depressed mood, and suicidal ideation and (b) earlier onset of sexual intercourse and age of first period of depressive symptoms. These findings, in conjunction with other studies of divorce using the CoT design (D'Onofrio et al., 2005) and intervention programs for divorced families (e.g., Wolchik et al., 2002), support the causal hypothesis of the consequence of divorce. In contrast, offspring cohabitation and age of first use of marijuana do not appear to be consequences of divorce; rather, factors that increase the risk for parental divorce also lead to these offspring outcomes.

Genetically informed studies of environmental variables are beginning to highlight the importance of specific environmental risk factors. Whereas some researchers have used behavior genetic results to claim that the parental behaviors (within certain limits) are not important influences on children's development or adjustment (e.g., Harris, 1998; Rowe, 1994), behavior genetic studies using the CoT design (e.g., D'Onofrio et al., 2005; Jacob et al., 2003) and other behavior genetic approaches (e.g., Caspi et al., 2004) have illustrated that many family risk factors influence children and young adults. However, the findings from the current study and others (e.g., Gottesman & Bertelsen, 1989; Mendle et al., 2006) also illustrate that a more nuanced approach is necessary, because the mechanisms through which genetic and environmental factors act depend on the specific environmental risk factor and developmental outcome being explored.

Acknowledgments

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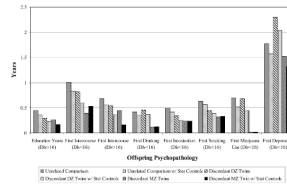
Figure 1.
Age of onset associated with parental divorce using methodological and statistical controls. The estimates represent the difference in age of offspring from intact and divorced families (years intact minus years divorced). Div = divorce; DZ = dizygotic; MZ = monozygotic; stat = statistical.

Figure 2.
Risk for life course patterns with parental divorce using methodological and statistical controls.
Div = divorce; DZ = dizygotic; MZ = monozygotic; stat = statistical.

Table 1

Demographic Information and Reliability Estimates for Offspring Characteristics

Variable	*M*/Prevalence	*N*	Reliability[a]
Age	25.06 (0.11)	2,554	
Education			
Years of education	13.48 (0.04)	2,553	.89
Failed grade	9.52%	2,553	.85
Sexual development, living arrangements, and early parenting			
Age of menarche	13.01 (0.04)	1,284	.86
Intercourse	85.88%	2,543	.60
Age first intercourse	17.43 (0.05)	2,168	.95
Cohabited	5.17%	2,553	.20
Baby before 20	1.41%	2,554	.80
Alcohol, cigarette, and drug use			
Drank alcohol	97.96%	2,554	1.00
Age first drink	15.21 (0.04)	2,502	.80
Intoxicated	86.18%	2,554	.61
Age first drunk	16.53 (0.05)	2,201	.85
Tried cigarette	75.37%	2,554	.88
Age first cigarette	14.58 (0.07)	1,924	.82
Tried marijuana	66.12%	2,550	.82
Age first use marijuana	17.39 (0.07)	1,681	.89
Emotional problems			
Depressed mood	51.16%	2,549	.67
Age first depressed mood	19.05 (0.15)	1,303	.85
Suicidal ideation	28.70%	2,547	.69
Age first ideation	17.72 (0.17)	726	.82

Note. Standard errors are in parentheses.

[a]Test–retest correlations are presented for continuous variables, and kappas are presented for dichotomous variables (*N* = 176).

Table 2

Sample Size of Offspring by Family Structure and Age of Parental Divorce

	Parental separation		
Avuncular divorce	**None**	**Before 16**	**After 16**
Entire sample			
No	1,418	313	92
Yes	492	141	51
DZ twins			
No	692	152	38
Yes	255	70	29
MZ twins			
No	726	161	54
Yes	237	71	22

Note. Owing to incomplete data, 47 offspring were not included in the analyses. DZ = dizygotic; MZ = monozygotic.

Table 3

Percentages and Means of Life Course Outcomes According to Separation Groups

| | Timing of separation | | | | | | | | Overall significance level[b,c] |
| Variable | No separation | | Previous[a] | | Before age 16 | | After age 16 | | |
	M/%	N	M/%	N	M/%	N	M/%	N	
Age of offspring	24.71 (0.20)	1,876	22.15 (0.56)	83	24.26 (0.29)	442	27.15 (0.43)	153	$F(3, 203) = 25.04$
Education									
Years of education	13.57 (0.05)	1,875	13.67 (0.23)	83	13.16 (0.10)*	442	13.04 (0.17)*	153	$F(3, 203) = 8.21$
Failed grade	8.80%	1,875	6.02%	83	11.54%*	442	11.38%	153	$\chi^2(3) = 7.48$
Sexual development, living arrangements, and early parenting									
Age of menarche	13.03 (0.05)	946	13.14 (0.24)	42	12.88 (0.10)	232	12.90 (0.19)	64	$F(3, 88) = 0.86$
Intercourse	85.07%	1,869	81.39%	83	86.76%	438	95.42%	153	$\chi^2(3) = 0.89$
Age first intercourse	17.65 (0.07)	1,577	17.73 (0.30)	68	16.66 (0.13)*	377	16.96 (0.21)*	146	$F(3, 178) = 17.88$
Cohabited	4.11%	1,875	2.41%	83	8.14%*	442	11.11%*	153	$\chi^2(3) = 22.56$
Baby before 20	1.07%	1,876	0.00%	83	2.04%*	442	4.48%*	153	$\chi^2(2) = 15.25^d$
Alcohol, cigarette, and drug use									
Drank alcohol	98.19%	1,876	95.18%	83	97.06%	442	99.35%	153	$\chi^2(3) = 2.24$
Age first drink	15.29 (0.06)	1,842	15.50 (0.25)	79	14.82 (0.11)*	429	15.19 (0.18)	152	$F(3, 198) = 5.02$
Intoxicated	85.29%	1,876	84.34%	83	88.01%	442	92.81%	153	$\chi^2(3) = 1.69$
Age first intoxication	16.64 (0.06)	1,600	16.63 (0.28)	70	16.10 (0.12)*	389	16.57 (0.19)	142	$F(3, 173) = 5.11$
Tried cigarette	74.15%	1,876	66.27%	83	79.86%	442	82.35%	153	$\chi^2(3) = 3.12$
Age first cigarette	14.74 (0.09)	1,390	15.16 (0.42)	55	14.01 (0.16)*	353	14.80 (0.27)	126	$F(3, 152) = 5.64$
Marijuana use	63.18%	1,874	66.27%	83	74.55%*	440	77.78%	153	$\chi^2(3) = 9.87$
Age first use marijuana	17.57 (0.09)	1,180	17.44 (0.38)	55	16.83 (0.16)*	327	17.52 (0.29)	119	$F(3, 138) = 5.30$
Emotional problems									
Depressed mood	48.91%	1,875	39.76%	83	60.73%*	438	57.52%	153	$\chi^2(3) = 11.57$
Age first depression	19.37 (0.16)	916	18.96 (0.82)	33	17.63 (0.29)*	266	18.99 (0.51)	88	$F(3, 100) = 9.16$

Variable	Timing of separation								
	No separation		Previous[a]		Before age 16		After age 16		Overall significance level[b,c]
	M/%	*N*	*M*/%	*N*	*M*/%	*N*	*M*/%	*N*	
Suicidal ideation	26.73%	1,874	25.30%	83	35.24%*	437	35.95%	153	$\chi^2(3) = \mathbf{11.37}$
Age first ideation	17.87 (0.20)	496	18.33 (0.95)	21	17.16 (0.35)	154	17.01 (0.58)	55	$F(3, 42) = 1.64$

Note. The means were calculated controlling for gender, age, and age squared of the offspring. Standard errors are in parentheses.

[a] Twin parent had been separated before having offspring.

[b] Values in bold are significant at $p < .05$.

[c] The tests of significance for categorical outcomes controlled for variable exposure based on the age of the offspring.

[d] Because of empty cells, only the offspring in the last two groups were compared with the no-separation group.

*
Offspring outcomes differ compared with no-separation group ($p < .05$).

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Table 4

Parameters for Parental Divorce for Offspring Life Course Outcomes From Hierarchical Linear Models

| | Divorce before age 16 models | | | | | | Divorce after age 16 Models | | | | | |
| | | | **3** | | **4** | | | | **3** | | **4** | |
Variable	1 (Phen)	2 (Phen)	MZ	DZ–MZ	MZ	DZ–MZ	1 (Phen)	2 (Phen)	MZ	DZ–MZ	MZ	DZ–MZ
Years of education	**−.48**	**−.31**	−.32	.31	−.26	.37	**−.45**	−.34	−.26	−.03	−.17	−.03
	(.11)	(.11)	(.30)	(.43)	(.29)	(.41)	(.19)	(.18)	(.38)	(.53)	(.37)	(.50)
Failed grade	**.39**	**.29**	.26	.10	.21	.01	−.10	.01	—	—	—	—
	(.13)	(.13)	(.31)	(.41)	(.31)	(.42)	(.21)	(.22)	—	—	—	—
Age at first intercourse	**−1.01**	**−.83**	−.39	−.44	−.53	−.08	**−.68**	**−.56**	−.44	.11	−.16	−.20
	(.14)	(.15)	(.38)	(.46)	(.37)	(.54)	(.24)	(.23)	(.31)	(.67)	(.45)	(.65)
Cohabited	**.65**	**.40**	−.16	1.09	−.15	.98	**.90**	**.70**	.55	.11	.16	−.20
	(.17)	(.17)	(.48)	(.64)	(.49)	(.63)	(.22)	(.22)	(.53)	(.67)	(.45)	(.65)
Age at first drink	**−.41**	**−.35**	−.12	−.33	−.13	−.24	−.11	.06	—	—	—	—
	(.11)	(.12)	(.21)	(.30)	(.21)	(.30)	(.20)	(.20)	—	—	—	—
Age at first intoxication	**−.50**	**−.42**	−.24	−.10	−.25	.00	−.23	−.16	—	—	—	—
	(.13)	**(.14)**	(.26)	(.35)	(.26)	(.35)	(.21)	(.45)	—	—	—	—
Age at first cigarette	−.63	−.57	−.32	−.12	−.33	−.06	−.11	−.07	—	—	—	—
	(.19)	**(.19)**	(.37)	(.51)	(.37)	(.51)	(.30)	(.31)	—	—	—	—
Marijuana use	**.18**	**.18**	**.16**	−.07	**.18**	−.11	.06	.06	—	—	—	—
	(.04)	(.04)	(.07)	(.10)	(.07)	(.10)	(.06)	(.07)	—	—	—	—
Age at first marijuana use	**−.70**	**−.53**	.02	.66	−.02	.43	−.05	.00	—	—	—	—
	(.18)	(.18)	(.33)	(.48)	(.33)	(.48)	(.29)	(.29)	—	—	—	—
Depressed mood	**.24**	**.22**	**.23**	.02	**.22**	−.02	.02	.00	—	—	—	—
	(.05)	(.05)	(.10)	(.14)	(.10)	(.14)	(.10)	(.05)	—	—	—	—
Age at first depression	**−1.77**	**−1.57**	**−1.52**	−.78	**−1.32**	−.72	−.10	.13	—	—	—	—
	(.33)	(.34)	(.65)	(.90)	(.66)	(.42)	(.57)	(.57)	—	—	—	—
Suicidal ideation	**.29**	**.18**	.26	−.16	.25	−.17	.14	.08	—	—	—	—
	(.08)	(.09)	(.17)	(.23)	(.18)	(.23)	(.13)	(.14)	—	—	—	—

Note. Standard errors are in parentheses. Values in bold are significant at *p* < .05. Phen = phenotypic associations that are comparisons of unrelated individuals. MZ = differences among offspring of monozygotic twins discordant for divorce. DZ–MZ = difference between the within-dizygotic and -monozygotic family estimates. Parameter estimates are distributed as years for the continuously distributed outcomes and

logits for the dichotomous variables. See text for a complete description of the models and statistical controls used in Models 2 and 4. Dashes indicate that outcomes not associated with parental divorce after the age of 16 were not included in the children-of-twins analyses.