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Parental Divorce and Adolescent Delinquency: Ruling out the Impact of Common Genes

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Abstract

Although the well-documented association between parental divorce and adolescent delinquency is generally assumed to be environmental (i.e., causal) in origin, genetic mediation is also possible. Namely, the behavior problems often found in children of divorce could derive from similar pathology in the parents, pathology that is both heritable and increases the risk that the parent will experience divorce. To test these alternative hypotheses, we made use of a novel design that incorporated timing of divorce in a sample of 610 adoptive and biological families. We reasoned that if genes common to parent and child mediate this association, non-adopted youth should manifest increased delinquency in the presence of parental divorce *even if the divorce preceded their birth* (i.e., was from a prior parental relationship). However, should the association be environmental in origin, adolescents should manifest increased delinquency only in response to divorce exposure, and this association should not vary by adoption status. Results firmly supported the latter, suggesting that it is the experience of parental divorce, and not common genes, that drives the association between divorce and adolescent delinquency.

Keywords

shared environment; delinquency; divorce; adoption design; passive gene-environment correlation

Parental divorce is a consistent (if modest) predictor of delinquency and other externalizing behaviors during childhood and adolescence (Amato & Keith, 1991; Fergusson, Horwood, & Lynskey, 1992; Hetherington, Bridges, & Insabella, 1998). For example, in his updated meta-analysis on the impact of divorce, Amato (2001) concluded that the mean Cohen's *d* effect size for conduct problems was .33, suggesting a modest association between youth delinquency and parental divorce. Similarly, Amato & Keith (1991) reported a Cohen's *d* effect size of .23. Despite the increased social acceptability and prevalence of divorce in recent decades (and thus the sheer number of exposed children) (Thornton & Young-DeMarco, 2001), the differences in delinquency between youth from intact and divorced families have not decreased (and indeed, appear to have increased) (Amato, 2001; D'Onofrio et al., 2005).

In spite of the robust nature of this association however, relatively little is known regarding its etiology. That is, though generally assumed to be environmental in origin (i.e., causal), such that the experience of parental divorce acts to disrupt the child's behavior, genetic mediation is also possible (McGue & Lykken, 1992). Namely, the behavior problems often found in children of divorce could derive from similar pathology in their biological parents, pathology that is both heritable (Rhee & Waldman, 2002) and increases the risk that the parent will

experience, among other things, divorce (Harden et al., 2007). In other words, parents may provide genes to their biological offspring that increase both the risk of delinquency and the corresponding risk of divorce exposure. The latter possibility represents a core theory within the field of developmental behavioral genetics, and is referred to as a passive gene-environment correlation (i.e., passive rGE) (Plomin, DeFries, & Loehlin, 1977),

Though descriptive, identification of the origins of this association as genetic or environmental represents a key public health goal within developmental psychology, as each hypothesized mechanism has distinct ramifications for clinical care and future developmental research. Should the association reflect a passive rGE "in disguise", future researchers would target the mechanisms through which genetic influences on delinquency influence divorce risk. For example, they could ask whether the association stems from a common genetic association with negative emotionality, which in addition to being genetically influenced itself (Bouchard & Loehlin, 2001), predicts both antisocial behavior (R. F. Krueger, 1999) and divorce (McGue & Lykken, 1992). Alternately, they could ask whether the association is a function of assortative mating for antisocial behavior (R. F. Krueger, Moffitt, Caspi, Bleske, & Silva, 1998; Taylor, McGue, & Iacono, 2000), such that those with these predilections select spouses like themselves, and thus indirectly select for probable marital discord and divorce. For their part, clinicians might re-conceptualize parental divorce in the same way that many now consider family history of psychopathology; that is, as an indicator of liability to, rather than as a cause of, antisocial behavior. Put differently, clinicians would not anticipate a decrease in antisocial behavior upon therapeutic resolution of the divorce, as the divorce would simply be an indicator of genetic liability to delinquency. By contrast, should the association reflect a "causal" one, in which divorce increases delinquency via environmental mechanisms, researchers would instead focus on understanding the environmental mechanisms through which divorce increases risk for delinquency, already an important area of research in developmental psychology (Hetherington et al., 1998)). Such research would likely directly inform intervention efforts, as divorce would be conceptualized as an experience necessitating interventions specifically designed to reduce the subsequent risk of delinquency.

Given these varying trajectories for future research and clinical care, and the clear need to distinguish between them, several genetically-informed studies have already sought to delineate the origins of the association between divorce and delinquency. Most recently, a series of Children-of-Twins studies by D'Onofrio and colleagues (D'Onofrio et al., 2007; D'Onofrio et al., 2005, 2006) explored whether genetic or environmental factors related to the twin parent accounted for the association between parental divorce and offspring psychopathology. Results consistently supported an environmentally-mediated effect of divorce on offspring externalizing psychopathology/behavior problems. Similarly, O'Connor et al. (2000) examined 398 adoptive and biological families of 12 year-olds in a prospective longitudinal study, comparing mean externalizing behavior problems across divorced and intact adoptive and biological families (O'Connor, Caspi, DeFries, & Plomin, 2000). They found that the associations between parental divorce and child behavior problems were not consistently stronger in biological than in adoptive families, results that again suggest environmental mediation.

Although such findings are collectively consistent with an environmental influence of divorce on child behavior problems, additional research is needed to confirm this conclusion. First, only studies of non-biologically related family members can completely exclude passive rGE (Burt, McGue, Krueger, & Iacono, 2007). Because adoptive parents do not share genes with their adopted children, passive rGE is fully eliminated, thereby providing a direct estimate of family-level or "shared" environmental influences. Additional adoption studies are thus needed to more definitively clarify the origin of the association between divorce and delinquency.

Second, prior studies have relied exclusively on standard behavioral genetic techniques (i.e., comparisons of the association between divorce and delinquency across family members with different degrees of genetic relatedness). Though these designs do allow researchers to generally disambiguate genetic from environmental mediation (though as noted, unless samples include non-biologically related family members, passive rGE cannot be fully resolved), constructive replication using other sorts of "natural experiments" would most certainly serve to strengthen these conclusions. In particular, we could evaluate the association between divorce and delinquency by timing of divorce, comparing parental divorces that preceded the birth/adoption of the adolescents (i.e., those from prior romantic relationships) to parental divorces that occurred during the adolescents' lifetime (i.e., the divorce of the rearing parents). Should genes common to parent and child mediate the association, we would expect non-adopted youth to manifest higher rates of delinquency in the presence of parental divorce, even if the divorce preceded their birth (i.e., was from a prior parental relationship). Moreover, this pattern would not extend to adopted youth. By contrast, environmental mediation would be indicated if delinquency in non-adopted youth is associated only with divorces during the adolescent's lifetime, and this association is equivalent to that in adopted youth.

Though the latter design would help to further delineate the roles of passive rGE and the environment in the association between parental divorce and adolescent delinquency, it has never before been used (to our knowledge). The current study sought to do just this, thereby serving to more fully clarify the origin of the association between parental divorce and adolescent delinquency.

METHODS

Participants were from the Sibling Interaction and Behavior Study (SIBS), a population-based study of adoptive and biological adolescent siblings and their parents. Adoptive families living in the Twin Cities greater metropolitan area were contacted based on records for the three largest adoption agencies in Minnesota (averaging between 600 and 700 placements a year), and were selected to have 1) an adopted adolescent placed as an infant and first assessed between the ages of 11 and 19 years, and 2) a second non-biologically related adolescent sibling falling within the same approximate age range. Adopted adolescents had a mean age of placement of 4.8 months (SD = 4.7 months). Although biological siblings were selected to have gender and age composition similar to that of the adopted siblings, biological and adoptive families were otherwise not matched so as to obtain representative samples of both family-types (Stoolmiller, 1998). Other eligibility requirements (for both adoptive and biological families) included living within driving distance of our Minneapolis-based laboratory, participating siblings no more than 5 years apart in age, and the absence of cognitive or physical handicaps that would preclude completion of our daylong assessment.

As they typically no longer lived at home, participants aged 19 or 20 (n=23) were excluded from the present sample. The current sample thus consisted of the remaining 406 biologically-unrelated and 204 biologically-related families where at least one of the two adolescents was younger than 19 (n=1,199 adolescent siblings, 604 mothers, and 541 fathers from 610 families). Of the adoptive families, some (n=124) also contained a non-adopted child, who was biologically related to his or her parents, but not to the target adoptee. Roughly 38% of the sample consisted of opposite-sex sibling pairs.

SAMPLE CHARACTERISTICS

Among eligible families, 63% of adoptive and 57% of biological families participated. Importantly, there were no significant differences between participating and non-participating adoptive families in parental education, occupational status, and marital dissolution (McGue

et al., 2007). Moreover, there were no significant differences between participating and non-participating biological parents in terms of paternal education, paternal and maternal occupational status, or rate of divorce, although participating mothers were significantly more likely to have a college degree (44%) than non-participating mothers (29%). Among participating families, adoptive parents were less likely than non-adoptive parents to be diagnosed with lifetime Drug Abuse or Dependence, but there were no significant differences in the rates of major depressive disorder, nicotine dependence, antisocial personality disorder, or alcohol dependence (see McGue et al., 2007). However, as compared to non-adoptive parents, adoptive parents typically had a higher occupational status (3.2 versus 2.5, respectively; occupational status was coded on the 6-point Hollingshead scale with 1 reflecting professional/managerial classes) and were more likely to have a college education (44% versus 64%, respectively).

The adolescent participants ranged in age from 10 to 18 years (average 14). A little over half of the sample was female (55%). Mothers ranged in age from 32 to 60 years (average 46), and fathers ranged in age from 35 to 64 years (average 48). The adoptive and biological parents (and therefore, the biological adolescents) were broadly representative of the ethnic composition of the Minnesota population at the time they were born; approximately 95% were Caucasian. However, due to predominantly international adoptions in Minnesota, the adopted adolescents were 67% Asian-American, 21% Caucasian, 2% African-American, 2% East Indian, 3% Hispanic/Latino, 1% South or Central American Indian, 4% mixed race, and 0.1% other ethnicities. English was the primary language spoken in the home.

MEASURES

Adolescent delinquency—We made use of two self-report indices of adolescent delinquency: the Delinquent Behavior Index (DBI) and a DSM-IV Conduct Disorder (CD) symptom count. The DBI (Burt & Donnellan, 2008; Burt, McGue et al., 2007; Farrington & West, 1971; Gibson, 1967) is a 36-item inventory of minor (e.g., skipping school) and more serious (e.g., using a weapon in a fight) delinquent behaviors (available on 1,181 adolescents). Participants were asked whether they had engaged in each behavior in their lifetime (0=no; 1=yes). Items were summed such that higher scores reflect endorsement of more delinquent behaviors. If fewer than four items were missing, items were prorated and added to the scale score. The scale demonstrated good internal consistency reliability across the sample, with alphas of .84, .88, and .91, respectively, for participants aged 10–12, 13–15, and 16–18.

We also made use of a lifetime self-reported DSM-IV “symptom count” variable corresponding to the sum of endorsed or partially-endorsed criterion A symptoms of CD (available on 1,193 adolescents). All participants were assessed in-person by trained bachelor and masters-level interviewers for DSM-IV mental disorders. Siblings were interviewed by separate interviewers. Prior to age 16, CD was assessed using the Diagnostic Interview for Children and Adolescents-Revised (DICA-R) (Reich, 2000; Welner, Reich, Herjanic, Jung, & Amado, 1987). For older youth, CD was assessed (as part of the Antisocial Personality Disorder interview) via the Structured Clinical Interview for personality disorders (SCID-II) (Spitzer, Williams, Gibbon, & First, 1987). Supplementary probes and questions were added to both interviews to ensure complete coverage of each symptom and to ensure CD symptom assessments were comparable across interviews. Of the 13 possible symptoms of CD, only symptom 9 (“has forced someone into sexual activity with him or her”) was not assessed.

Following the interview, a clinical case conference was held in which the evidence for every symptom was discussed by at least two advanced clinical psychology doctoral students. As necessary, audio tapes from the interview were replayed or the participant was re-contacted for clarification. As actual diagnoses were not used in the current study, duration rules were excluded. Symptoms judged to be definitely present (i.e., they were clinically significant in

both severity and frequency) were counted as one full symptom. Symptoms judged to be probably present (i.e., they were clinically significant in either severity or frequency, but not both) were counted as half of a symptom. The reliability of the consensus process was good, with a kappa of 0.79 for diagnoses of CD.

Symptom counts, rather than diagnoses, were used primarily to increase statistical power, as diagnostic prevalence rates in community-based sample are lower than in clinically-referred samples. Also, available data indicate that patterns of genetic and environmental influence are similar for categorical and dimensional models of psychopathology (Eaves et al., 1997; O'Conner, McGuire, Reiss, Hetherington, & Plomin, 1998; Sherman, McGue, & Iacono, 1997; Silberg et al., 1996; Slutske et al., 1997).

In order to better capture both clinically-significant (e.g., physical assault, setting fires) and less clinically-significant, but still problematic (e.g., driving a car without a license, carrying a weapon in a public place, etc.) delinquent behaviors, we also created a composite of the DBI and the CD symptom count variables. This composite is advantageous in that it allows us to more completely assess the full range of delinquent acts, thereby increasing both our statistical power and (arguably) the applicability of our results. The CD/DBI composite was created by standardizing and then averaging these scores so as to ensure that, despite their different scoring metrics, each scale was weighted equally.

Importantly, levels of delinquency in these participants are comparable to those in other samples. We compared DBI data from the current sample to that in two other samples: a large epidemiological sample of twins (Burt, McGue, & Iacono, in preparation) and a sample of male college students at a large Midwestern university (Burt & Donnellan, 2008; note that DBI was analyzed on a 1–3 scale in that publication, but was converted to 0–2 here to maintain consistency with the present study). The mean DBI score in late-adolescent male college students (ages 17–21, averaged 19 years-old, n = 148) was 8.09 (SD = 4.9), whereas the mean DBI score in similarly-aged male participants in our sample (ages 16–18, n = 93) was 8.24 (SD = 6.8), a trivial difference (Cohen's d = .02). Similarly, the mean DBI score in mid-adolescent twins (ages 13–16 years-old, n = 1,328) was 4.81 (SD = 5.2), whereas the mean DBI score in mid-adolescent participants in our sample was 4.31 (SD = 4.6). As before, this difference is quite small (Cohen's d = -.10). Such results thus strongly suggest that our delinquency data are comparable to those in other adolescent samples.

Parental marital history—Parental marital history was assessed via a parental life events questionnaire (Billig, Hershberger, Iacono, & McGue, 1996), which included questions on number of divorces, parental age during divorces, and whether the divorce took place during the children's lifetimes. As these are single item measures, reliability and validity are difficult to assess. However, among divorced rearing parents, father and mother reports of years since divorce were correlated .88, suggesting that such measures may be reliable. Parental divorce history data was missing for 16 adolescents.

The lifetime rate of divorce in these data was slightly lower than that reported in other studies of predominantly Caucasian samples (D'Onofrio et al., 2007). Namely, 15.4% of mothers and 14.4% of fathers had been divorced during their lifetimes, for a total of 20% of participating families with at least one parent with a history of divorce. This somewhat low divorce rate is likely a function of the study's requirement that siblings share both parents (i.e., are full biological siblings, or "full" adoptive siblings). In particular, requiring that parents remain together long enough to have at least two children together inadvertently selects for marital stability. As noted, however, participating families were as likely to be divorced as eligible but non-participating families. Moreover, unlike prior adoption studies (O'Connor et al., 2000), there were no significant differences in lifetime rates of parental divorce between adoptive and

non-adoptive families (20.1% of adoptive families and 19.9% of biological families, p = .91), nor in mean parental age at first divorce (31.4 years for adoptive parents and 33.0 years for biological parents, p=.20).

Dividing the sample by timing of divorce yielded the following participant groups. Of non-adopted youth with complete data, 37 had parent(s) who had divorced in a prior relationship, 60 had parents who had divorced during the adolescents' lifetimes, and 419 had never divorced parents. Of adopted youth with complete data, 95 had parent(s) who had divorced in a prior relationship, 43 had parents who had divorced during the adolescents' lifetimes, and 523 had never divorced parents. In those few families (n=10; 60% adoptive) where a parent had divorced both a previous spouse (i.e., before the child) and the other rearing parent (i.e., during the child's lifetime), adolescents were assigned to the latter group. Of parents divorced during their children's lifetime, child age at divorce ranged from infancy to late adolescence (average age = 7.5 years, SD = 4 years). Further, the SIBS assessment took place an average of 6.5 years after the divorce.

STATISTICAL ANALYSES

The association between the delinquency of non-adopted youth (i.e., BIO) and their parents' divorce(s) is a function of the 50% of additive genetic influences shared between them as well as any family-level environmental effects (i.e., those environmental influences that increase similarity among family members). By contrast, because adopted youth (i.e., ADOP) do not share genes with their parents, the association between the delinquency of adopted youth and their parents' divorce functions as a "direct estimate" of environmental mediation.

Making use of both these distinctions and timing of divorce, we examined the origins of the association between divorce and delinquency. We tested two alternative hypotheses. Should genes common to parent and child mediate the association between divorce and delinquency, we would expect non-adopted youth to manifest higher rates of delinquency in the presence of parental divorce, *even if the divorce preceded the birth of the adolescent* (i.e., was from a prior parental relationship). Moreover, this association should not extend to adopted youth, as they do not share genes with their parents. By contrast, an environmental influence of divorce on delinquency would be implicated if delinquency in non-adopted youth is associated only with *divorces during the adolescents' lifetimes*, and this association is similar to that in adopted youth. Importantly, though well-suited to clarify the respective roles of passive rGE and environmental influences on the association between parental divorce and child outcomes, the current study is the first to make use of this design.

We tested these hypotheses via two interrelated sets of analyses. We first computed phenotypic correlations between adolescent self-reported delinquency and parent-reported divorce. These correlations were then compared across adoption status to offer an indication of both passive rGE (i.e., the association is a function of genes common to parent and child) and environmental contributions. As in most adoption studies, a significant correlation for adopted youth is indicative of family-level or shared environmental influences, while a larger correlation for non-adopted than adopted youth is suggestive of a passive rGE. However, the current study allowed for an additional test of environmental mediation versus passive rGE by also evaluating correlations by timing of divorce. Significant correlations with divorce during the adolescent's lifetime, but not with divorces preceding the adolescent's life, are further indicative of environmental influences, whereas significant BIO correlations with divorces preceding the adolescent's life are further suggestive of passive rGE.

We next evaluated the association between divorce and mean levels of delinquency by timing of divorce and adoption status. To do so, we made use of a 2 × 3 analysis of variance design, thereby allowing us to evaluate the main effects of adoption status (i.e., ADOP, BIO) and timing

of divorce (i.e., never divorced, at least one rearing parent was divorced in a prior marriage (before child's lifetime), rearing parents divorced during child's lifetime) on delinquency, as well as the interaction between the two. This final term is particularly important as it allows us to explicitly examine whether the association between timing of divorce and delinquency varies by adoption status. Of note, when using Type III sum of squares (as done here), this model acts as a direct extension of the DeFries-Fulker twin analyses (DeFries & Fulker, 1985). Namely, the interaction between the predictor (in this case, timing of divorce) and degree of genetic relatedness (in this case, adoption status) is thought to estimate passive rGE, whereas the main effect of timing of divorce is thought to estimate family-level or shared environmental mediation. These conclusions were then augmented using the interpretive framework specified above. An environmental influence of divorce on delinquency is further suggested if increases in delinquency are associated only with divorces during the adolescents' lifetimes, and this association is similar across ADOP and BIO youth. By contrast, should the association between divorce and delinquency reflect a passive rGE, we would expect not only a significant interaction between adoption status and timing of divorce, but we would also expect BIO youth to manifest higher rates of delinquency in the presence of parental divorce, even if the divorce preceded the birth of the adolescent.

Analyses were conducted using Hierarchical Linear Modeling (HLM) in SPSS 15.0 (Norušis, 2007) to account for the non-independence of observations within families while maximizing statistical power. In particular, because siblings are nested within families, our data have a two-level structure with the adolescent as the lower-level unit and the family as the upper-level unit. Predictor variables can occur at either the child-level (e.g., adoption status) or the family-level (e.g., divorce).

RESULTS

DESCRIPTIVES

Of parents experiencing divorce, roughly 44% had been divorced during the siblings' lifetime, though this proportion varied significantly across biological (61%) and adoptive (35%) families ($p<.01$). Though it is unclear what may account for this difference, it does not appear to stem from differences in parental externalizing disorders (as assessed via aggregated symptom counts of DSM-IV Antisocial Personality Disorder, Alcohol Abuse, and Alcohol Dependence in each parent). Namely, parents who divorced in a prior relationship (one preceding the birth/adoption of their children; n=67 families) did not significantly differ from parents who divorced each other during their children's lifetime (n=52 families) on externalizing symptom counts (all $p>.15$). Furthermore, among parents who had divorced in a prior relationship, there were no differences in the number of externalizing symptoms between those couples where only one parent had divorced (n=53) and those where both parents had divorced (n=14) (all $p>.50$). Such results collectively suggest that externalizing psychopathology in the parents does not vary by timing of divorce, supporting the utility of our design.

Independent-samples t-tests indicated that mean levels of delinquency were largely equivalent across adopted and non-adopted youth on both the DBI (ADOP mean = 4.0, SD = 4.3, range 0–24; BIO mean = 3.9, SD = 4.7, range 0–32; $p = .74$) and the CD symptom count (ADOP mean = .50, SD = .95, range 0–7 symptoms; BIO mean = .60, SD = 1.25, range 0–9 symptoms; $p = .13$). To adjust for positive skew, delinquency data were log-transformed prior to analysis (standard skewness coefficient following transformation: DBI = .11; CD = 1.60). Age was positively associated with both delinquency ($r = .38$ and .19 for the DBI and CD, respectively, both $p<.01$) and divorce ($r = .07$, $p<.05$). Male youth reported higher levels of delinquent behaviors than did female youth ($r = -.23$ for the DBI and $-.25$ for CD, both $p<.01$), but did not experience more divorce ($r = .03$, ns). One-way ANOVA's were used to compute the

strength of the relationship between delinquency and ethnicity. No association was observed ($p>.20$).

Given these findings, all analyses were conducted on age- and sex-residualized scores (although the results were essentially identical when analyses are conducted on the raw data). Further, each delinquency variable was standardized to have a mean of zero and a standard deviation of 1.0 to facilitate interpretation of any mean differences in delinquency by timing of divorce. The residualized DBI and CD symptom counts were correlated .49 ($p<.001$).

CORRELATIONS BY TIMING OF DIVORCE

Correlations between delinquency and divorce were calculated separately by adoption status. As a reminder, a significant correlation for adopted youth is indicative of environmental mediation of the association, while a larger correlation for non-adopted than adopted youth is suggestive of passive rGE. As seen in Table 1, we examined the associations of delinquency with divorces during the adolescent's lifetime and divorces prior to the birth of the adolescent. We adjusted for the non-independence of the observations within families by using the number of families, rather than the number of individuals, to calculate p-values.

Results revealed that the association between divorce and delinquency is largely exclusive to divorces during the adolescent's lifetime. Indeed, divorces during the adolescent's lifetime were associated with increased delinquency in both ADOP and BIO youth (with the exception of CD in ADOP youth, though this association did approach significance at $p<.10$), while divorces preceding the birth of the adolescent (i.e., those from prior parental relationships) were not. Moreover, associations between delinquency and divorce were uniformly equivalent across BIO and ADOP youth (all $p > .30$). Such results argue against passive genotype-environment correlations and in favor of environmental origins to the association between divorce and delinquency.

MEAN LEVELS OF DELINQUENCY BY TIMING OF DIVORCE

We next compared mean levels of delinquency across adoption status and timing of divorce using a 2×3 HLM design with families (rather than individual adolescents) as the unit of analysis. As noted, when using Type III sum of squares, the main effect of divorce timing estimates family-level environmental mediation, while the interaction with adoption status estimates passive rGE (according to the DeFries-Fulker method). In particular, because passive rGE can exist only in biological families, the failure to find a significant interaction with adoption status effectively rules out passive rGE. As seen in Table 2, timing of divorce was found to be a highly significant predictor of delinquency (all $p<.01$). Adoption status, by contrast, did not predict mean levels of CD, the DBI, or the CD/DBI composite. Moreover, as indicated by the non-significant interaction between adoption status and timing of divorce (all $p>.50$), the association between timing of divorce and delinquency did not appear to vary across adoption status. Such findings extend our correlational results by further suggesting that the association between divorce and delinquency is predominantly environmental in origin.

We then augmented these analyses via pairwise comparisons of estimated marginal means of delinquency across timing of divorce (presented in Figure 1; note that estimated marginal means, rather than Cohen's *d* effect sizes, are presented because these comparisons were conducted using HLM, so as to statistically adjust for the non-independence of the data across siblings). As a reminder, each delinquency variable was standardized to have a mean of zero and a standard deviation of 1.0 prior to analysis to facilitate interpretation. Given that there was no observable interaction between adoption status and timing of divorce in the prediction of delinquency, statistical comparisons are presented without regard to adoption status (however, mean levels of delinquency are presented separately across adoption status in

Appendix 1; as seen there, delinquency appears to be associated only with divorces of the rearing parents in both ADOP and BIO youth).

Youth from never divorced families reported significantly less delinquent behavior than youth whose rearing parents had divorced during their lifetime (marginal mean differences of .40 for the DBI (95% confidence interval (CI) = .17, .63), .35 for CD (CI = .13, .57), and .44 for the CD/DBI composite (CI = .21, .67), respectively; $p \leq .002$ across all indices of delinquency). By contrast, there were no differences in delinquency between youth from never divorced families and those whose parent(s) had been divorced prior to the birth of the child[1] (marginal mean differences of .07 for the DBI (CI = −.30, .15; $p = .52$), .09 for CD (CI = −.31, .12; $p = .40$), and .11 for the CD/DBI composite (CI = −.33, .12; $p = .35$), respectively). Finally, youth whose rearing parents had divorced reported higher levels of delinquency than those whose parent(s) had been divorced in a prior relationship, though only significantly so for the DBI and the CD/DBI composite (marginal mean differences of .32 for the DBI (CI = .02, .63; $p = .037$), .26 for CD (CI = −.04, .55; $p = .086$), and .34 for the CD/DBI composite (CI = .03, .64; $p = .030$), respectively). Our finding of increased delinquency only in adolescents whose parents had divorced during their lifetime is notably consistent with the pattern expected under the environmental mediation hypothesis, particularly when combined with prior results indicating that this association did not vary by adoption status. Such findings collectively suggest that it is the actual experience of parental divorce that is associated with adolescent delinquency, and that this association does not reflect a passive gene-environment correlation in disguise.

POST-HOC ANALYSES EXPLORING DIVORCES DURING CHILD'S LIFETIME

Since our primary analyses suggest that the association between divorce and delinquency is environmental in origin, we conducted some exploratory, post-hoc analyses on families divorced during the adolescent's lifetime to better understand this effect. We focused on adolescent age at parental divorce, recency of divorce (i.e., did the divorce occur in the last five years?), and remarriage, as these variables have previously been found to moderate the impact of divorce on children (Hetherington et al., 1998). Of note, these analyses should be considered preliminary, since our sample of families divorced during the adolescent's lifetime is relatively small (i.e., 52 families containing 103 adolescents). Analyses again adjusted for the non-independence of the data across siblings.

Among adolescents whose parents had divorced during their lifetime, results revealed little to no association between delinquency and adolescent age at parental divorce (as noted, ages ranged from infancy to 16 years-old; correlations ranged between -.05 and -.09 across all indices of delinquency, $p \geq .50$). Similarly, the recency of parental divorce appeared to have little impact, as there was no difference in mean levels of delinquency between families that had divorced in the last 5 years and those that had divorced prior to that (all $p \geq .50$). By contrast, remarriage did appear to moderate the impact of divorce on delinquency (note also that remarriage was equally likely in adoptive and non-adoptive parents, p=.49). In particular, adolescents in families where neither parent had remarried reported slightly more CD than those in families where at least one parent had remarried (estimated marginal means were .48 for CD (p=.08), .19 for DBI (p=.44), and .39 for CD/DBI (p=.14)). Moreover, this association generally persisted when our divorced sample was further restricted to include only adopted

[1]We further evaluated adolescent delinquency in those families where parental divorce preceded the birth of the adolescents, comparing delinquency in those families where both parents had previously divorced (n=14) to those where only the mother or only the father had previously divorced (n=21 and 32, respectively). If the association between delinquency and divorce were a function of passive rGE, we would expect increased levels of delinquency in adolescents from families where both parents had divorced (given their higher genetic "loading" for divorce) as compared to those from families where only one parent had divorced. No significant differences in adolescent delinquency were observed (all p>.30), offering additional evidence against passive rGE.

adolescents (estimated marginal means were .62 for CD (p=.09), .20 for DBI (p=.51), and .48 for CD/DBI (p=.14)), implying that, like divorce, the impact of remarriage on delinquency is also environmental in origin.

DISCUSSION

The aim of the present study was to clarify the respective etiological roles of passive gene-environment correlation and the shared environment in the association between parental divorce and adolescent delinquency. To do so, we made use of a simple but novel design incorporating both adoption status and timing of parental divorce. Analyses uniformly supported environmental mediation, and did so across multiple indices of delinquency. Namely, the association between delinquency and parental divorce was specific to divorces that had occurred during the adolescents' lifetimes (i.e., divorces of the rearing parents) and was not observed for divorces that preceded the adolescents' births (i.e., divorces that occurred in a prior marriage), results that persisted across adopted and non-adopted youth. Such findings both argue for environmental mediation of this association and argue against a passive gene-environment correlation. Moreover, the environmental impact of divorce on delinquency appeared to be attenuated by subsequent remarriage, an association that also appears to be environmental in origin. Such findings thus constructively replicate and extend prior findings of environmental mediation (D'Onofrio et al., 2007; D'Onofrio et al., 2005; O'Connor et al., 2000), collectively suggesting that it is the actual experience of parental divorce (and remarriage), and not common genes, that drives the association between divorce and adolescent delinquency.

There are several limitations to bear in mind when interpreting the results of this study. First, the current results apply only to adolescence and not to other developmental periods, as it has recently been suggested that the heritability of antisocial behavior may vary by age/age-of-onset. In particular, genetic influences may be stronger (and shared environmental influences correspondingly weaker) in antisocial behavior with a childhood-onset versus that with an adolescent-onset (Moffitt, 2003). It thus remains unclear whether these findings would generalize to earlier or later developmental stages. Second, the association between adolescent delinquency and recent divorce is rather small (e.g., r = .12 across the full sample; Cohen's *d* = .25), indicating that divorce accounts for just over 1% of the variance in adolescent delinquency. Though modest, this effect size is consistent with that found in other studies (Cohen's *d* = .23 – .33) (Amato, 2001; Amato & Keith, 1991).

Third, although divorce does appear to be associated with delinquency via environmental mechanisms, it remains unclear whether this association extends to other forms of behavior problems, such as Attention Deficit Hyperactivity Disorder or Oppositional Defiant Disorder. However, other work suggests that the association is generally comparable (Blazei, 2007). Next, our observed effects appeared somewhat weaker for CD than for the CD/DBI composite or, to a lesser extent, the DBI. Though it remains unclear what may account for this small difference in effects, it may reflect the reduced statistical power inherent in restricting the outcome to clinically-significant symptoms in a community-based sample such as this one. By contrast, effects were robust for the full range of delinquent acts captured by our CD/DBI composite.

Next, because our indicator of marital separation (i.e., have you ever separated from a spouse because you weren't getting along?) was both imprecise and less amenable to comparisons by timing of divorce (i.e., "separations" in prior relationships -- those preceding the birth of the children -- always resulted in divorce, whereas those during the child's lifetime may not have), our divorce variable was operationalized to include only actual divorces per se. Future adoption studies should explore the unique contributions of separation to adolescent delinquency.

Furthermore, the insignificant influence of child's age at divorce on delinquency, a somewhat unusual finding, could represent problems with either statistical power or restricted range. Importantly, however, child age at parental divorce ranged from infancy to age 16, with an average age of 7.5 (SD = 4 years), arguing against range restriction on child age at divorce. Moreover, there was no evidence of range restriction for delinquency in these data (as discussed previously). By contrast, the sub-sample of families divorced during the adolescent's lifetime was rather small for stand-alone analyses (i.e., 52 families containing 103 adolescents), and we thus suspect that reduced power may indeed have impacted our post-hoc analyses exploring divorces during the adolescent's lifetime.

Finally, although divorce is a robust predictor of child and adolescent delinquency, it is important to note that it may not directly elicit offspring misbehavior. For example, we found preliminary evidence that remarriage moderates the impact of divorce on delinquency. Another possibility is that marital conflict, which typically precedes and accompanies divorce, mediates some of the association between divorce and child delinquency (Hetherington et al., 1998). If true, current study results would imply that marital conflict may exert an environmentally-mediated influence on adolescent delinquency. However, this conclusion is not consistent with the findings of a recent Children-of-Twins study conducted by Harden and colleagues (2007), which found that this association was genetically-mediated. Accordingly, more research is needed to specifically address this question.

All that said, the results of the current study have two important implications. First, divorce was associated with adolescent delinquency via family-level or shared environmental mechanisms, a finding that stands in stark contrast to the oft-cited conclusion that the family environment impacts children at a child-specific rather than family-wide level (Plomin & Daniels, 1987). Importantly, however, more recent work during childhood and adolescence has indicated both a stronger role for the shared environment (Burt, McGue et al., 2007) and a weaker role for the non-shared environment (Burt, Carter, McGue, & Iacono, 2007; Burt, McGue, Iacono, & Krueger, 2006; Turkheimer & Waldron, 2000) in psychological and behavioral outcomes. The current results dovetail nicely with this more recent conceptualization of environmental influences, offering further support for the notion that the shared environment may have been dismissed too soon, at least with regard to adolescent delinquency.

Next, and most importantly, our findings suggest that parental divorce (and possibly remarriage) is associated with adolescent delinquency via shared environmental mechanisms, and that this association is not a misidentified passive gene-environment correlation in disguise. Such results are consistent with a "causal" connection between parental divorce and adolescent delinquency. This conclusion is striking in that it offers genetically-informed support for the prevailing view of divorce as a shared environmental risk factor for delinquency (Hetherington et al., 1998). It is perhaps ironic that behavioral genetics, the field which has long argued against assuming that psychosocial risk factors like divorce have solely environmentally-mediated influences on offspring (Plomin, 1995), may now be supporting this position (at least in regards to the association between divorce and adolescent delinquency). However, we would argue that, by allowing researchers to attend to issues of possible genetic confounding, behavioral genetics offers a particularly promising and rich framework for developmental studies of environmental effects.

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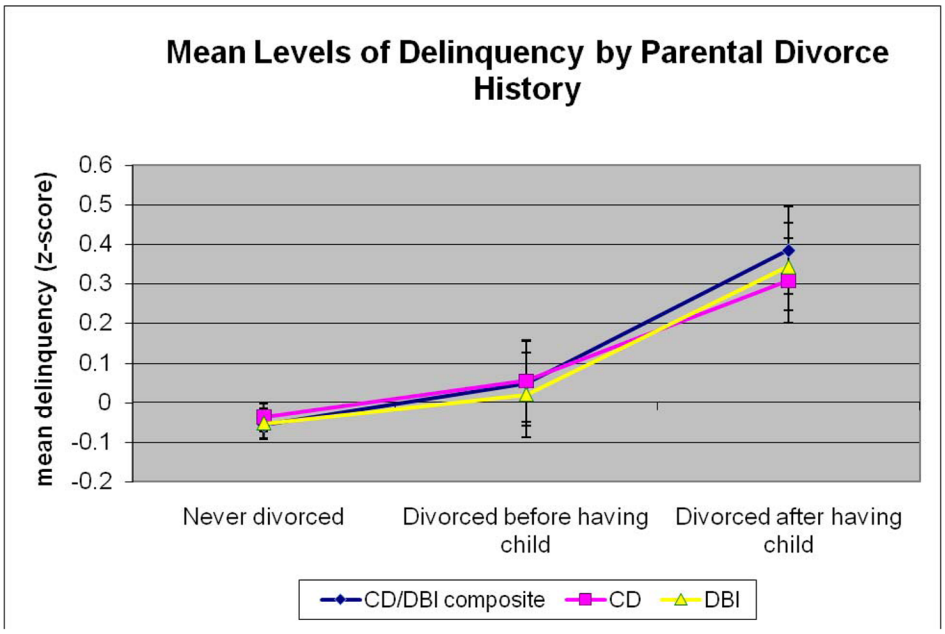

Figure 1.

Note. Figure presents estimated marginal means (and standard errors) for adolescent delinquency by parental divorce history (as estimated in HLM): never divorced, divorced before having child (at least one rearing parent was divorced in a marriage preceding the birth/adoption of the adolescents), and divorced after having child (divorce of rearing parents occurred following birth/adoption of the adolescents). Prior to HLM analyses, each scale was standardized to have a mean of zero and a standard deviation of 1.0 to facilitate interpretation. Because the interaction between divorce and adoption status was not significant (i.e., the association between divorce and delinquency does not appear to vary across adopted and non-adopted youth), results are presented for the full sample.

Table 1

Associations between divorce and adolescent delinquency by adoption status and timing of divorce

	Correlations between divorce and adolescent delinquency	
	Parents divorced after having child	**Parents divorced before having child**
DBI questionnaire		
BIO	**.13*** (n=295)	**.01** (n=281)
ADOP	**.11*** (n=346)	**.03** (n=369)
CD symptom count		
BIO	**.11*** (n=297)	**.05** (n=283)
ADOP	**.09** (n=348)	−**.01** (n=371)
CD/DBI composite		
BIO	**.15*** (n=296)	**.04** (n=282)
ADOP	**.12*** (n=347)	**.02** (n=370)

Note. Phenotypic correlations are reported for adopted adolescents (ADOP; those who do not share genes with their parents) and non-adopted adolescents (BIO; those who do share genes with their parents). To adjust for the non-independence of the observations, number of families was used to determine significance (note that families with both an adopted and a biological child are therefore represented twice, whereas families with two adopted or two biological children are represented only once). We examined associations between delinquency and divorce, though the timing of the divorce varies across the two columns. In the first column, families where a divorce occurred during a prior marriage (or before the child was born) were excluded, while in the second column, families where a divorce occurred during the siblings' lives were excluded. Those correlations significantly greater than zero are indicated (* = p<.05).

Table 2

Testing for Family-Level Environmental Mediation and Passive Gene-Environment Correlation by Examining Effects of Adoption Status and Timing of Divorce on Adolescent Delinquency

	F (df)	p-value
DBI		
Adoption Status	0.81 (1, 963)	.37
Timing of Divorce	5.77 (2, 601)	.003
Adoption Status × Divorce	0.01 (2, 963)	.99
CD		
Adoption Status	0.66 (1, 911)	.42
Timing of Divorce	4.90 (2, 608)	.008
Adoption Status × Divorce	0.62 (2, 910)	.54
CD/DBI composite		
Adoption Status	0.003 (1, 956)	.96
Timing of Divorce	7.27 (2, 602)	.001
Adoption Status × Divorce	0.26 (2, 956)	.77

Note. Mean levels of delinquency (as indexed by the Delinquency Behavior Index (DBI), an Conduct Disorder (CD) symptom count, and a composite indicator of CD and the DBI (CD/DBI)) were compared across adoption status and timing of divorce using a 2x3 HLM design (to adjust for non-independent observations within families). Type III tests of the fixed effects are presented above. Adoption status (i.e., ADOP, BIO) and timing of divorce (i.e., never divorced, at least one rearing parent was divorced in a prior marriage (before child's lifetime), divorced during child's lifetime) were entered as main effects. The interaction between timing of divorce and adoption status (i.e., Adoption Status × Divorce; does the association between timing of divorce and delinquency vary across adopted and non-adopted youth?) was also examined.

Appendix 1

Mean levels of adolescent delinquency by adoption status and parental divorce history

	Never Divorced Mean (SD)	Divorced before having child Mean (SD)	Divorced after having child Mean (SD)
ADOP			
DBI	.00 (.99)	.06 (.93)	.40 (.94)
CD	−.05 (.95)	−.08 (.94)	.32 (1.17)
CD/DBI	−.05 (.95) (n=318–320)	.04 (.98) (n=51)	.38 (1.00) (n=28)
BIO			
DBI	−.11 (.98)	.00 (1.15)	.29 (1.09)
CD	−.04 (.99)	.12 (1.17)	.37 (1.18)
CD/DBI	−.07 (1.00) (n=259–261)	.02 (1.16) (n=22)	.44 (1.14) (n=36)

Note. Mean levels of delinquency (as indexed by the Delinquency Behavior Index (DBI), an extended Conduct Disorder (CD) symptom count, and a composite indicator of CD and the DBI (CD/DBI)) are presented across timing of divorce and adoption status. Means were adjusted for non-independent observations within families (i.e., means for adopted (ADOP) and non-adoptive (BIO) youth were computed first within families). As such, n's indicate the number of BIO and ADOP families (note that families with both an adopted and a biological child are therefore represented twice, whereas families with two adopted or two biological children are represented only once). Each delinquency measure was standardized to have a mean of zero and standard deviation of 1.0.