

A Children of Twins Study of parental divorce and offspring psychopathology

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Background: Although parental divorce is associated with increased substance use and internalizing problems, experiencing the separation of one’s parents may not cause these outcomes. The relations may be due to genetic or environmental selection factors, characteristics that lead to both marital separation and offspring functioning. **Method:** We used the Children of Twins (CoT) Design to explore whether unmeasured genetic or environmental factors related to the twin parent, and measured characteristics of both parents, account for the association between parental divorce and offspring substance use and internalizing problems. **Results:** The association between parental divorce and offspring substance use problems remained robust when controlling for genetic and environmental risk from the twin parent associated with parental divorce, and measured characteristics of both parents. The results do not prove, but are consistent with, a causal connection. In contrast, the analyses suggest that shared genetic liability in parents and their offspring accounts for the increased risk of internalizing problems in adult offspring from divorced families. **Conclusions:** The study illustrates that unmeasured genetic and environmental selection factors must be considered when studying parental divorce. In explaining associations between parental divorce and young-adult adjustment, our evidence suggests that selection versus causal mechanisms may operate differently for substance abuse (a causal relation) and internalizing problems (an artifact of selection). The CoT design only controls for the genetic and environmental characteristics of one parent; thus, additional genetically informed analyses are needed. **Keywords:** Behavioural genetics, divorce, substance use, depression, alcohol abuse, children of twins. **Abbreviations:** CoT: Children of Twins; DZ: dizygotic twins; MZ: monozygotic twins; SCL: Symptom Checklist.

Parental divorce is correlated with many substance use, behavioral, and emotional problems, but why parental marital instability causes these problems continues to be debated (Amato, 2000; Emery, 1999; Hetherington, 1999). Research in the social sciences has generally assumed that associations between divorce and offspring adjustment are due to causal mechanisms (e.g., the stress-adjustment hypothesis; Hetherington, 1999). Most studies of divorce have, therefore, focused on environmental process that may mediate the association between divorce and offspring adjustment, such as deleterious parenting practices, conflict between parents, loss of contact with non-custodial fathers, and economic factors (Amato, 2000).

But, characteristics of parents or families that lead to divorce and difficulties in the children, referred to as selection factors, may account for the documented correlations. For instance, maternal anti-social traits may lead to both marital instability and offspring conduct problems, so that the association between parental divorce and child externalizing may not be causal (Emery, Waldron, Kitzmann, & Aaron, 1999). Genetic factors could also be selection factors. Twin studies have shown genetic contribu-

tions to divorce risk (McGue & Lykken, 1992). Because parents provide their children with both their genes and family environment, genetic factors transmitted from divorce-prone parents to their children could also account for the divorce-offspring associations. Indeed, the results of genetically informative studies have led some prominent psychologists to suggest that the family environment in general (Rowe, 1994), and divorce in particular (Harris, 1998), has no lasting effects on children.

Given the ongoing debate in the scientific literature and public at large regarding divorce and the importance of marriage (e.g., McLanahan, Donahue, & Haskins, 2005), researchers need to rigorously test the underlying causal processes responsible for problems associated with family structure. Most existent studies of parental divorce have used unrelated offspring as comparison group for children from divorced families (e.g., Emery, Waldron, Kitzmann, & Aaron, 1999; Hetherington, 1993). These studies have relied on statistical approaches to control for selection factors; the analyses included measured characteristics of mothers, such as a history of delinquency, to statistically ‘account’ for the differences between divorced and intact families. However, the approach may be flawed. Statistical controls for measured characteristics may not

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account for all possible selection factors. For instance, the salient variables may not have been assessed in the study.

The countless environmental and genetic selection factors inherent in intergenerational relations, therefore, require that research take advantage of quasi-experiments that specifically test alternative hypotheses (Rutter, Pickles, Murray, & Eaves, 2001). In particular, research needs to use designs that untangle the co-occurring genetic and environmental risk processes that occur in families. Researchers have tried to account for unmeasured selection factors, including common genetic liabilities, by using various approaches, including one adoption study of the consequence of parental divorce for young children (O'Connor, Caspi, DeFries, & Plomin, 2000) and sibling comparisons – parents separated after an older sibling had left the home but younger children directly experienced the separation (e.g., Case, Lin, & McLanahan, 2001). However, both approaches require numerous assumptions that may limit the findings (Rutter et al., 2001; Sigle-Rushton & McLanahan, 2004).

The current study used the Children of Twins (CoT) Design (D'Onofrio et al., 2003; Gottesman & Bertelsen, 1989; Heath, Kendler, Eaves, & Markell, 1985; Silberg & Eaves, 2004) to study the underlying processes responsible for greater levels of psychopathology in the offspring of divorced parents. The strength of the CoT Design lies in its ability to control for environmental and genetic factors that are not measured by using different comparison groups for children in divorced families. Instead of using unrelated offspring in intact families as the control group, the CoT approach compares cousins – offspring of adult twins discordant for divorce (where one co-twin was divorced and the other co-twin was not). The comparison of cousins from discordant fraternal (dizygotic, DZ) twins controls for common environmental factors that make offspring from the extended family similar. Controlling for these factors may be essential to the study of parental divorce because environmental factors shared by adult siblings and their offspring appear to account for the intergenerational transmission of alcohol problems, not the causal influence of parental alcoholism (Slutske et al., submitted). Offspring of discordant identical (monozygotic, MZ) twins similarly share environmental influences, but the cousins of MZ twins are also genetically related as half-siblings – each set of cousins receives the same genetic risk associated with parental divorce from the twin parent. The comparison of children of identical twins, therefore, holds constant genetic factors from the twin parents that could account for problems associated with parental divorce. Thus, the CoT Design uses methodological controls (rather than statistical) to account for unmeasured

environmental and genetic factors related to the adult twins. Because the approach can control for these selection factors, the CoT Design can help pull apart the genetic and environmental causal processes that typically go together in traditional family studies.

We must note that the design does not account for environmental factors that only influence one twin and their children (D'Onofrio et al., 2003) or the environmental and genetic influences from the spouse of the twins (Eaves, Silberg, & Maes, 2005). To help account for these limitations of the design, the present study also statistically controlled for measured characteristics of the adult twins and their spouses (Rutter et al., 2001), including each parent's level of education, alcohol consumption, alcohol problems, cigarette use, emotional problems, and depression. The measures were selected because they have been shown to predict divorce (Amato, 2000), and we wanted to statistically control for the intergenerational transmission of psychopathology when exploring the effects of parental divorce. The analyses, therefore, represent a more detailed study of possible selection factors than previous studies of parental divorce that have only controlled for characteristics of mothers (e.g., Emery, Waldron, Kitzmann, & Aaron, 1999).

Previous CoT research using an Australian sample found that the higher risk of psychopathology (D'Onofrio et al., 2005) and adjustment problems (D'Onofrio et al., 2006) associated with parental divorce were generally consistent with a causal connection. However, it is difficult to know whether the results, based on a high-risk sample in Australia, would generalize to other populations. The current article adds to the research on the consequences of parental divorce by using a larger sample in the United States that utilized a different sampling strategy than the previous CoT study of divorce.¹ The overall aim of the current study was to rigorously explore whether the association between parental divorce and offspring psychopathology is (a) consistent with a causal association or (b) due to selection factors. Resolving the question could have large implication for family policy (Amato, 2000; Emery, 1999). The analyses will also help future research to target the precise biological, psychological, and/or social factors that either mediate or account for the problems associated with parental divorce.

¹ A full univariate twin analysis of divorce in the sample indicated that the percentage of variation in divorce accounted for by genetic factors (h^2) was 15% (95% confidence interval = 4–20%). Shared environmental influences were not large (c^2 = 4%, 0–6%), whereas nonshared environmental influences accounted for most of the variation (e^2 = 81%, 77–85%). Additional information is available in the online appendix.

Method

Samples

Adult twins and their spouses. The Virginia 30,000 contains 14,763 twins who were ascertained from two sources. First, public records from Virginia were utilized to obtain addresses for twins born between 1915 and 1971. Second, a group of twins were recruited by their response to an advertisement in the newsletter of the American Association of Retired Persons (AARP). The response rate for the twin questionnaires was 69.8%. The average age of the twins was 51.8. Although the age range was large (14–94), a majority of the twins were between 33 (25th percentile) and 66 (75th percentile) years old. The majority of the twins (63.9%) were female. The sample was exclusively Caucasian because of funding constraints. Although the Virginia 30,000 is a volunteer sample, the rates of marital instability are consistent with national estimates for Caucasian women.²

A questionnaire was sent to the participating twins that asked them to provide the names and addresses of family members, including spouses, siblings, parents and children. A modified version of the questionnaire was then sent to the family members. The response rate for all of the relatives was 44.7% (total $n = 14,930$), but the sample was generally comparable to the US population with respect to religious affiliation and income (Truett et al., 1994). The sample included 4,391 spouses of the twins, with a mean age of 55.6 yrs old. Approximately 57.3% of the spouses were male. More specifics concerning the entire Virginia 30,000 can be found elsewhere (Truett et al., 1994).

Offspring of twins. The offspring sample included 4,800 responses, a 41% response rate (offspring comprised 32% of the relatives' sample).³ The average age of the offspring was 35.5 years. The range of ages in the offspring (16–79 years) was also large, but a majority of the respondents were between the ages of 30 (25th%) and 40 years old (75th%). The offspring sample included more females (60.6%) than males. Of the offspring, 22.1% reported a history of parental divorce or marital separation. With respect to the marital status in the offspring, 17.4% were single, 56.9% were married, 12.2% were remarried, 8.4% were currently separated or divorced, 4.3% were cohabitating, and .8% were widowed.

Measures

Adult twins and their spouses. The mailed survey included questions about twinning, demographics, health, personality, and attitudes. Questions concern-

ing marital instability included current marital status (seven categories), date of separation (if divorced/separated), years together with current spouse/partner, and number of times married. Based on these responses, a lifetime history of marital instability, which included both divorce and separation, was calculated for each individual. Individuals reporting current divorce or separation, a history of divorce, or multiple marriages (excluding widows) were classified as having marital instability. Zygosity determination was based on questions concerning childhood similarity and recognition confusion, which has been found to be over 95% accurate (Kasriel & Eaves, 1976). Twin contact was based on two items answered by the twins. The items assessed (a) the frequency each twin saw each other and (b) how often the twins communicated (e.g., by telephone), both measured on six-point scales.

Measured characteristics of the twins and their spouses were included in the analyses to control for possible selection factors. Educational level was based on a six-point scale. Frequency of alcohol consumption was assessed on a seven-point scale, ranging from never to more than once per day. Lifetime diagnoses of medical problems were based on a list of common health problems on which respondents were asked to indicate whether they had ever been diagnosed or treated by a physician and age of onset. The list included alcohol problems and depression. The questionnaire also included items assessing lifetime cigarette use. Emotional difficulties were measured by the Symptom Checklist (SCL; Derogatis, Lipman, & Covi, 1973). The SCL included 30 items using a five-point scale. The total SCL score was calculated as the total number of responses divided by the number of non-missing items and scaled as a Z-score.

Offspring of twins. Psychopathology variables in the offspring included reported lifetime history of alcohol problems (a diagnosis or treatment by a physician) and emotional difficulties measured by the SCL (individuals in the top 20% were considered to be high on emotional problems). Analyses of other outcome variables are available in the online appendix and elsewhere (D'Onofrio, 2005).

Data analysis

Risks of offspring psychopathology by family structure and twin zygosity. The risks for each categorical variable were calculated separately by family structure and zygosity to provide descriptive estimates. First, the risks are presented for unrelated offspring in intact and divorced families to establish the divorce effect. Second, the risks were broken down by family structure and twin zygosity. Family structure was separated into offspring from the divorced co-twin and the non-divorced co-twin in discordant pairs.⁴ The comparison of offspring of discordant pairs contrasts cousins who were differentially exposed to parental divorce. The approach helps explore causal processes, as

² In the adult sample 18.4% reported a lifetime history of divorce or marital separation. The Kaplan–Meier nonparametric estimate of the lifetime risk of marital instability (Probability = .44, 95% Confidence Interval = .43–.46) is consistent with the probability of separation (.42) from first marriages for non-Hispanic white women in the United States (Bramlett & Mosher, 2002).

³ See the online appendix for information regarding differential response rates in offspring from intact and divorced families.

⁴ Risks for offspring from twin families concordant for divorce and never separating can be found elsewhere (D'Onofrio, 2005).

the association between parental divorce and offspring adjustment should be found at all levels, including within twin-families. Comparing the risk in these groups of offspring separately for MZ and DZ twins suggests which processes are responsible for the intergenerational transmission (Gottesman & Bertelsen, 1989). In brief, if offspring from the divorced MZ co-twins have more adjustment problems than their cousins from intact households, the findings would be consistent with a causal hypothesis because the comparison controls for environmental factors common to the adult twins and their offspring *and* genetic risk associated with divorce from the twin parent. However, if the difference between offspring of the discordant MZ twins is smaller than the comparison of unrelated offspring, the pattern would suggest that selection factors account for part of the relation between parental divorce and offspring adjustment. The comparison of offspring of MZ twins provides a greater control for genetic factors related to parental divorce than the comparison of DZ twins. Therefore, if the problems associated with parental divorce were due to genetic factors, the differences between the children of discordant MZ twins would be smaller than the difference between offspring of discordant DZ twins. Formal statistical testing of the various comparisons were conducted using regression-based analyses.

Regression-based analyses of CoT approach with measured covariates. Estimates of the divorce effects, the difference between offspring from intact and divorced homes, using the different comparison groups were estimated using regression-based analyses, referred to as hierarchical linear models (HLMs).⁵ The HLMs also included the measured characteristics of the adult twins and their spouses to account for selection factors that the CoT Design is unable to control. Three-level HLMs were used to analyze the influence of parental divorce because of the three nested levels in the CoT Design (multiple offspring were nested under co-twins, who were nested under twin pairs). The HLMs for lifetime alcohol problems estimated the divorce effects contingent on the age of the offspring to account for the right censoring. A logistic model was fit for emotional problems, controlling for age and age² of the offspring. Algebraic representations and details about the specific HLMs are found elsewhere (D'Onofrio et al., 2005). The HLMs were fit to five datasets in which missing scores for the adult twin and spouse covariates were estimated through multiple imputation (Little & Rubin, 1987) to account for missing data. The estimates of the divorce effect (distributed as logits), with significance levels, and odds ratios (OR) will be presented.

Model one estimated the relation between parental marital instability and the offspring outcome by comparing children of divorced families to unrelated offspring of intact families. The model provides a parameter referred to as the phenotypic association.

⁵ For the genetically informed analyses 692 offspring were not included because of missing information about their age, their aunt or uncle's marital status, or the zygosity of the twin pair. There were also missing data for the specific measures. In all cases, individuals included in the analyses and those dropped due to missing values did not differ (D'Onofrio, 2005).

Model two estimated the same divorce effect but also included the following measures for both parents (the adult twin and their spouse): educational level, frequency of alcohol consumption, lifetime history of alcohol problems, lifetime cigarette use, emotional difficulties measured by the SCL (continuously distributed), and lifetime history of depression. As a result, model two represents the traditional approach to control for selection factors.

Model three estimated the between twin-families effect and the influence of the within twin-family effect. The between twin-families effect roughly estimates the comparison of unrelated offspring. The more important parameter, the within twin-family estimate, used contrast codes to compare offspring of discordant twins – the parameter estimates the differences between cousins differentially exposed to parental divorce. Therefore, the within twin-family divorce effect is a purer measure of the consequences of parental divorce. Model four compared offspring of discordant twins and included the measured covariates.

Model five compared offspring of MZ twins discordant for divorce. The within MZ twin-family effect represents the strongest test of the association between marital instability and offspring characteristics in the CoT Design because the comparison is not confounded by genetic or environmental factors related to the twins. A lower divorce effect in the MZ discordant families than the phenotypic effect would indicate selection factors are important. The model also included the difference (DZ – MZ) in the magnitude of the divorce effect between the discordant MZ and DZ twin families. Again, a larger within divorce effect in discordant DZ families would suggest that genetic factors are important in the intergenerational association. Finally, model six included the measured covariates to the previous model. Model six, therefore, combines the statistical controls and methodological controls of the CoT Design.⁶

Results

Risks of offspring psychopathology by family structure and twin zygosity

The lifetime risks for the offspring variables using different comparison groups are presented in Table 1. The comparison of unrelated offspring illustrates that parental divorce is associated with increased risk for lifetime alcohol problems (1.0 vs. 3.2) and emotional problems (18.8 vs. 24.6), replicating previous research. However, the comparison of offspring of discordant twins suggests the underlying causal mechanisms depend on the outcome measure. For alcohol problems, the risks in the offspring of discordant DZ (1.8 vs. 3.1) *and* MZ twins (1.4 vs. 4.2) are consistent with the comparison of unrelated offspring, suggesting that

⁶ The main effect of zygosity and a measure of twin contact was also included in the HLMs to control for these variables because they can confound the parameter estimates (D'Onofrio et al., 2003). However, including the variables did not change the parameters associated with parental divorce.

Table 1 Risk of offspring psychopathology by zygosity and family structure

Family Structure	Lifetime alcohol problems ^a		Emotional problems ^b	
	Risk	N	Risk	N
Unrelated offspring ^c				
Intact	1.0	1498	18.8	1769
Divorced	3.2	380	24.6	439
Offspring of discordant fraternal twins				
Intact	1.8	277	17.0	277
Divorced	3.1	225	25.7	222
Offspring of discordant identical twins				
Intact	1.4	341	24.5	338
Divorced	4.2	312	24.7	308

Note. ^aRisks of lifetime alcohol problems are percentages based on Kaplan–Meier nonparametric survival analysis at the last age all groups could be compared. ^bRisks for emotional problems, as measured by the top 20% on the SCL, are based on crude percentages. ^cThe unrelated offspring comparison only uses offspring from one co-twin per twin family.

unmeasured genetic and environmental confounds do not confound the intergenerational association. The results are in contrast to the risk for emotional problems as measured by the SCL. The difference in the offspring of discordant DZ twins (17.0 vs. 25.7) was consistent with the comparison of unrelated offspring, but there was no difference in the offspring of discordant MZ twins (24.5 vs. 24.7). The pattern of results suggests that the associations between internalizing problems and parental divorce may be genetically mediated.

Regression-based analyses of CoT approach with measured covariates

All of the parameter estimates from the HLMs are shown in Table 2. When compared to unrelated families, offspring whose parents were separated were more likely to have ever been diagnosed or treated for alcohol problems ($b = .74, SE = .04, p < .001, OR = 2.10$). Parental marital instability was still associated with lifetime history alcohol problems when statistical controls were utilized for measures of both parents' characteristics in model two ($b = .66, SE = .09, p < .001, OR = 1.94$). It is difficult to interpret the coefficients for the parental covariates because they are the result of a simultaneous regression. Each parameter identifies the *unique* relation between the measures of parental characteristics and offspring adjustment while controlling for every other measure in the analysis. Model three compared the offspring of discordant twins (cousins), regardless of zygosity type. The within twin-family divorce effect ($b = .86, SE = .06, p < .001, OR = 2.37$) was consistent with comparison of phenotypic divorce effect in model one. The association between marital instability and offspring alcohol problems was still robust when the statistical controls for parental characteristics were included in model four ($b = .81, SE = .11, p < .001, OR = 2.25$). In model five, the magnitude of the intergenerational association remained large even when offspring from discordant MZ twins were compared ($b = .71, SE = .12, p < .001, OR = 2.03$). The difference in the parameter estimates of divorce in the discordant

Table 2 Parameter estimates for hierarchical linear models

Parameter	Models												
	Lifetime history of alcohol problems						Emotional problems						
	1	2	3	4	5	6	1	2	3	4	5	6	
Divorce effect													
Phenotypic	.74*	.66*					.37*	.32*					
Between			.65*	.49*	.65*	.49*			.46*	.39*	.46*	.39*	
Within			.86*	.81*					.26*	.24			
Within MZ					.71*	.69*					-.06	-.05	
Within (DZ-MZ)					.35	.38					.62*	.58*	
Offspring gender	.79*	.79*	.79*	.79*	.79*	.79*	-.51*	-.50*	-.51*	-.50*	-.50*	-.50*	
Twin parent													
Education		-.23*		-.23*		-.23*		-.04		-.04		-.04	
Alcohol freq.		-.06		-.06		-.06		.03		.02		.02	
LT alcohol probs.		.86*		.85*		.86*		-.82*		-.81*		-.81*	
LT cigarette use		.53*		.53*		.53*		-.04		-.04		-.04	
Emotional diff.		.02		.02		.02		.22*		.21*		.21*	
LT depression		.21		.21		.21		.15		.14		.14	
Spouse													
Education		.18		.18		.18		-.04		-.04		-.04	
Alcohol freq.		.20		.20		.20		-.06		-.05		-.05	
LT alcohol probs.		.66		.67		.67		.25		.25		.25	
LT cigarette use		-.11		-.11		-.11		.18		.17		.17	
Emotional diff.		-.14		-.14		-.14		.10		.10		.10	
LT depression		-.31		-.31		-.31		.40		.30		.30	

Note. LT is lifetime. Parameters associated with parental divorce are distributed as logits. * $p < .05$.

fraternal and identical families ($b_{DZ-MZ} = .35$, $SE = .91$, $p = .70$) implied the possibility of a small influence of genetic confounds, but the estimate was not statistically significant. The use of statistical controls in model six did not significantly reduce the overall magnitude of the association with parental divorce in offspring of discordant MZ families ($b = .69$, $SE = .12$, $p < .001$, $OR = 1.99$). Odds ratios for the divorce effects for each model are also presented in Figure 1. As the figure shows, the magnitude of the divorce effect remained large despite the various methodological (e.g., comparison of cousins) and statistical controls for selection factors. The magnitude of the effect in model six indicates that parental divorce is associated with a two-fold increase in the lifetime probability of being diagnosed or treated for an alcohol problem, even when non-measured genetic and environmental factors associated with the twin parent and measured characteristics of both parents are taken into account.⁷

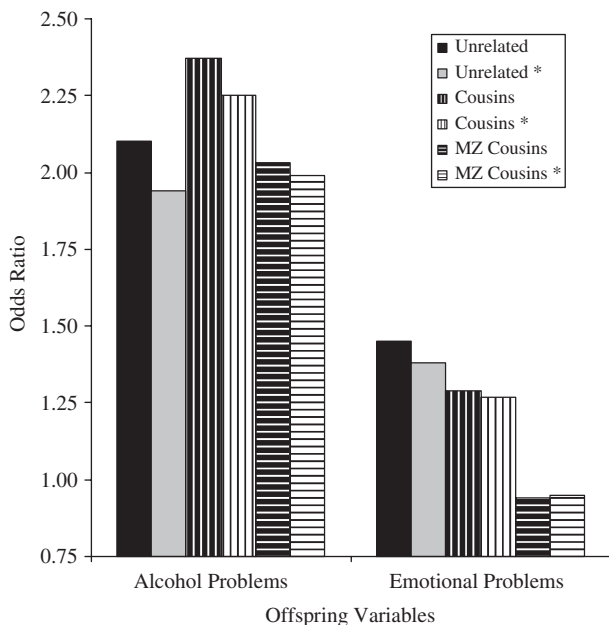


Figure 1 Divorce effects using different control groups and statistical controls. Note. *The comparison statistically controlled for measured parental characteristics. The comparison of cousins was the within twin-family divorce effect, regardless of the zygosity of the twins. The MZ cousins comparison was the divorce effect in offspring of MZ twins discordant for divorce.

Emotional difficulties

Parental marital instability was associated with emotional difficulties, as estimated in model one ($b = .37$, $SE = .08$, $p < .001$, $OR = 1.45$). Because

⁷ Lifetime history of cigarette smoking was also robustly associated with parental divorce (results not shown) using the CoT Design and the measured covariates (D'Onofrio, 2005). Additional information is available in the online appendix.

the outcome measure is not a lifetime measure of adjustment, a multilevel logistic regression was performed, controlling for the offspring's age and age². The divorce effect was not reduced greatly when parental covariates were included in the model two ($b = .32$, $SE = .12$, $p < .01$, $OR = 1.38$). In model three, the comparison of cousins from twin families discordant for divorce revealed a somewhat smaller divorce effect ($b = .26$, $SE = .12$, $p < .05$, $OR = 1.29$), and the measured covariates in model four only slightly reduced the association ($b = .24$, $SE = .18$, $p = .19$, $OR = 1.27$). In contrast, there was no divorce effect in offspring of discordant MZ twins in model five ($b = -.06$, $SE = .14$, $p = .66$, $OR = .94$), and the difference between the MZ and DZ within-family effect was large ($b_{DZ-MZ} = .62$, $SE = .20$, $p < .005$). The results suggest that genetic factors may account for intergenerational association. The same pattern of results occurred when the parental covariates were included in model six; there was no divorce effect in offspring of MZ twins ($b = -.05$, $SE = .24$, $p = .82$, $OR = .95$), and the difference between the offspring of DZ and MZ twins was large ($b = .58$, $SE = .36$, $p = .06$).^{8,9} Figure 1 shows how the comparison of offspring of discordant MZ twins controls for unmeasured confounds that are responsible for the intergenerational association.

Discussion

The current article examined the consequences of divorce for young adult offspring using a genetically informed design. The use of the CoT Design indicated that the underlying processes responsible for offspring difficulties related to divorce depend on the outcome being explored, providing support for both the causal and selection hypotheses. For substance use problems the CoT Design provided estimates of the intergenerational associations that were consistent with a causal connection.⁷ The findings for the substance use problems replicate a CoT Study of parental divorce in Australia (D'Onofrio et al., 2005), further suggesting that environmental processes preceding and following divorce, such as marital conflict, parenting difficulties, and socioeconomic factors (Amato, 2000), are responsible for higher levels of externalizing problems in adult offspring from divorced families.

In contrast, the relation between marital instability and offspring internalizing problems (assessed by the SCL⁸ and lifetime history of depression⁹) was fully accounted for by selection factors. The pattern of the divorce effects indicates that common genetic

⁸ Similar results were obtained from HLMs of SCL as a continuously-distributed measure of emotional difficulties (D'Onofrio, 2005).

⁹ Lifetime history of depression followed the same pattern as results for emotional problems measured by the SCL. Additional information is available in the online appendix.

liability in both generations may be responsible for the intergenerational association. The results imply that offspring of divorced parents would have had increased depressive symptoms even if their parents had not divorced.

It is important to note that the findings are consistent with several other studies. Intervention studies targeting family processes in divorced families have generally reduced externalizing problems associated with parental divorce but not internalizing difficulties (Wolchik et al., 2002). Furthermore, personality characteristics, particularly negative emotionality, have been found to mediate the influence of genetic factors on divorce (Jockin, McGue, & Lykken, 1996). Genetic risk for negative emotionality may influence parents' risk for divorce and be transmitted to their offspring. As such, the results call into question the interpretation of previous research that suggests parental divorce causes offspring clinical depression (Wallerstein, Lewis, & Blakeslee, 2000). Interventions for offspring of divorced parents will, therefore, have to target a group of offspring who are particularly at risk biologically for internalizing problems.

Selection factors did not account for the higher rates of internalizing problems associated with parental divorce in the previous study (D'Onofrio et al., 2005). The different measures of internalizing problems used in the two studies may account for the seemingly discrepant findings. Cross-cultural differences in responses to divorce could also alter the findings, although reviews suggest that parental divorce influences offspring similarly in Australia and the United States (Rodgers, 1996). Differences in the sampling techniques could explain the discrepant findings. The CoT Study in Australia was based on a high-risk sample of twin families (D'Onofrio et al., 2005), whereas the current study utilized a population-based, but volunteer sample. The studies could differ in family characteristics, such as marital conflict, that have been shown to moderate the effects of parental (e.g., Amato, Loomis, & Booth, 1995). The findings must, therefore, be replicated in other samples.

There are a number of limitations inherent in the CoT Design and the sample. First, we interpret differences among offspring of MZ twins discordant for marital instability cautiously because the CoT Design, like all research designs based on non-randomized assignment to conditions, cannot prove causation unambiguously. Reciprocal influences from the offspring to the adults, environmental risk factors within twin-families associated with divorce, genetic and environmental influence of the twins' spouses, and assortative mating may confound the findings (D'Onofrio et al., 2003; Eaves, Silberg, & Maes, 2005). The approach also requires large sample sizes to precisely measure genetic confounds (Heath, Kendler, Eaves, & Markell, 1985). Nevertheless, the analyses represent one of the first attempts to explore

unmeasured genetic and environmental confounds in the long-term adjustment problems associated with parental divorce. Moreover, the approach has different, if not fewer, assumptions than other genetically informed designs that study environmental risk factors that siblings share (D'Onofrio et al., 2003). The analyses also statistically controlled for demographic characteristics, substance use, and emotional adjustment of *both* parents, an important advancement in the study of parental divorce.

Second, the sample was not representative of all families in the United States. Sampling was based on volunteer participation and was restricted to Caucasian families due to funding constraints. However, the lifetime risk of divorce in the adult twin sample was consistent with rates from epidemiological Caucasian samples in the US, and the magnitude of the divorce effects are commensurate with previous research (Amato, 2000). The results are also limited to adults, as the role of selection factors may depend on the age of the offspring (Cherlin, Chase-Lansdale, & McRae, 1998). Furthermore, parental divorce may engender higher levels of emotionally-laden thoughts, referred to as sub-clinical distress (Lauermann-Billings & Emery, 2000), that do not constitute major depression.

Third, the measure of lifetime history of alcohol problems was not a formal diagnosis of alcohol abuse or dependence; rather the variable assessed diagnosis or treatment. It is important to note, however, that the findings for alcohol problems were consistent with other measures of substance use and problematic use in the sample, suggesting the results are not an artifact of measurement. Fourth, the current analyses did not explore whether genetic factors also moderate the influence parental divorce (O'Connor, Caspi, DeFries, & Plomin, 2000).

Finally, analyses attempting to specifically identify the environmental or genetic processes were beyond the scope of the current article. Additional studies will need to further specify the environmental processes responsible for the increased substance use problems associated with parental divorce. Life-course variables, such as the offspring's own divorce, may mediate the association between parental divorce and problems in adulthood (e.g., Amato, 2000). Likewise, future research will need to explore the specific genetic processes associated with internalizing problems, which may be related to personality factors (Jockin, McGue, & Lykken, 1996).

Overall, the results indicate that merely associating environmental risk factors and child outcomes has limited utility because environmental and genetic risk factors are correlated within families. Researchers need to use quasi-experimental approaches before drawing causal inferences about environmental risk factors (Rutter et al., 2001). The current analyses support causal inferences with respect to parental divorce and substance use problems. Parental divorce, however, may only be a

marker for genetic risk associated with emotional problems in adulthood, not a *causal* risk factor.

Supplementary material

The following supplementary material is available for this article: Appendix.

This material is available as part of the online article from: <http://www.blackwell-synergy.com/doi/abs/10.1111/j.1469-7610.2007.01741.x>

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