Aggressive Behavior Between Siblings and the Development of Externalizing Problems: Evidence From a Genetically Sensitive Study

Misaki N. Natsuaki and Xiaojia Ge
University of Minnesota, Twin Cities

David Reiss
Yale University

This study investigated the prospective links between sibling aggression and the development of externalizing problems using a multilevel modeling approach with a genetically sensitive design. The sample consisted of 780 adolescents (390 sibling pairs) who participated in 2 waves of the Nonshared Environment in Adolescent Development project. Sibling pairs with varying degree of genetic relatedness, including monozygotic twins, dizygotic twins, full siblings, half siblings, and genetically unrelated siblings, were included. The results showed that sibling aggression at Time 1 was significantly associated with the focal child’s externalizing problems at Time 2 after accounting for the intraclass correlations between siblings. Sibling aggression remained significant in predicting subsequent externalizing problems even after controlling for the levels of preexisting externalizing problems and mothers’ punitive parenting. This pattern of results was fairly robust across models with different informants. The findings provide converging evidence for the unique contribution of sibling aggression in understanding changes in externalizing problems during adolescence.

Keywords: siblings, deviancy training, externalizing problems, family

Ever since the publication of the seminal article by Plomin and Daniels (1987), there has been a burgeoning research on sibling differences (Mekos, Hetherington, & Reiss, 1996; Reiss, Neiderhiser, Hetherington, & Plomin, 2000). The other side of the coin, sibling similarity or resemblance, has largely been taken for granted, however. Sibling similarity, particularly in antisocial behavior, is broadly attributed to either shared genes or shared environment in behavioral genetic studies (Miles & Carey, 1997; Rhee & Waldman, 2002; Rowe, Rodgers, & Meseck-Bushey, 1992), both of which are typically left unmeasured (see Moffitt, 2005; Moffitt, Caspi, & Rutter, 2005). Sibling resemblance, however, could also result, at least in part, from day-to-day social interactions. Taking development of aggression, for example, Patterson and his colleagues (Patterson, 1986; Patterson, Dishion, & Bank, 1984) proposed a concept of deviancy training whereby sibling aversive behavioral exchanges provide potential training grounds for the development of delinquent behavior.

Although the concept of deviancy training has gained increased popularity among sibling researchers (e.g., Compton, Snyder, Schrepferman, Bank, & Shortt, 2003; Criss & Shaw, 2005; Garcia, Shaw, Winslow, & Yaggi, 2000; Slomkowski, Rende, Conger, Simons, & Conger, 2001; Snyder, Bank, & Burraatson, 2005), this concept, unfortunately, has not been thoroughly examined in the existing literature. Family studies that include sibling interaction measures are typically not genetically informed and thus cannot address the concern that siblings share genes as well as social environments. Genetically informed studies, on the other hand, often do not measure the interactions between siblings and cannot directly evaluate the deviancy training hypothesis. The Nonshared Environment in Adolescent Development (NEAD) project, a genetically sensitive, longitudinal study with assessment of family interactions, provides a rare opportunity to rigorously test the deviancy training hypothesis longitudinally while taking into account within-sibling correlations that vary by genetic relatedness between siblings. The central goal of this report, therefore, was to examine the effects of sibling aggression on the development of externalizing problems via a longitudinal, genetically sensitive design.

Sibling Interactions in the Development of Externalizing Behavior

Extending his coercion theory of parent–child interaction (Patterson et al., 1984), Patterson (1986) suggested that coercive
exchanges between siblings could provide a potential training ground for the development of antisocial behavior. Aggressive, coercive, and hostile interactions with brothers and sisters provide an arena for direct practices, observational learning, and reinforcement of problem behaviors that subsequently lead one to experience failures at school, with peers, and in future relationships. Through deviancy training, siblings become what Patterson (1984) called “fellow travelers” on the path to antisocial problems. Indeed, children referred to treatment for childhood conduct disorders often do not differ significantly from their nonreferred siblings in terms of levels of behavior problems (Dishion & Patterson, 2006).

Four methodological issues need to be addressed in order to rigorously test the sibling deviancy training hypothesis. First, because siblings grow up in the same family and are, in most cases, genetically related, their within-pair or intraclass correlations need to be accounted for. Second, because siblings are usually reared by the same parents, parental behaviors are likely an important third variable causing sibling similarity in their behavior. Third, caution needs to be exercised with respect to shared method variance, as using a single informant for measuring sibling aggression and outcome variables is likely to inflate the association between the two constructs (Bank, Dishion, Skinner, & Patterson, 1990). Finally, longitudinal analyses are required to demonstrate that siblings’ exchange of aggressive behaviors contributes to the development of externalizing problem behavior. In the sections that follow, we review the existing literature with regard to each of the four methodological issues.

Estimating Within-Sibling Correlations

Most of the existing sibling studies have simply correlated one sibling’s behavior to his or her sibling’s corresponding behavior, with little attention paid to intraclass correlations within sibling pairs (for an exception, see Kim, McHale, Crouter, & Osgood, 2007). Potential methodological concerns of such a strategy arise because siblings growing up in the same families are not statistically independent. Such a statistical interdependence may be partially due to siblings’ shared genetic factors, to their commonly experienced environmental factors, and/or to their daily interactions with one another. Furthermore, the magnitude of correlations between siblings is likely to vary systematically by genetic relatedness of siblings. For instance, it has been robustly replicated across numerous studies that within-sibling correlations in monozygotic (MZ) twin pairs are higher than those in dizygotic (DZ) twins or other types of siblings (Plomin, DeFries, & McClearn, 1990; Reiss et al., 2000). Although studies using behavioral genetic paradigms have been keenly aware of this genetic cascading effect, studies based on genetically uninformative sibling designs have been less attentive to this issue.

In this study, we employed a multilevel modeling approach developed by Guo and Wang (2002) to address these issues of intraclass correlations between siblings. This modeling strategy has several advantages. First, as mentioned earlier, siblings are nested in a family and are, thus, not independent observations. Multilevel modeling effectively handles nested data by treating individuals and families as Level 1 and Level 2 units, respectively. By doing so, this strategy models sibling effects while estimating within-pair sibling correlations, accounting for clustering of data in estimating standard errors of the regression coefficients (Raudenbush & Bryk, 2002). Second, siblings vary systematically in their genetic relatedness, ranging from MZ twins who share 100% of their genes to siblings in a stepfamily who are genetically unrelated. When applied to a genetically sensitive design, a multilevel modeling approach allows estimation of varying variance components and thus varying intraclass correlations by genetic relatedness of siblings (Guo & Wang, 2002). Third, unlike previous sibling research that implicitly assumed older siblings to be the teachers and young siblings to be the learners, this approach relaxes this assumption and allows a test for whether both younger and older siblings mutually influence each other. Although it is conceptually plausible that older siblings are more likely to be the influencer and younger siblings the influencees, exchanging aggressive interactions with a younger sibling on a regular basis can be a potential aggravator of the older sibling’s behavioral problems. In addition, if the siblings are close in age, the distinction between older and younger may become increasingly blurred. Reciprocal influences between siblings are, in fact, a core of the deviancy training hypothesis in that patterned exchanges of aggressive and coercive behaviors between siblings, rather than one-way influence from an older to a younger sibling, serve as a vehicle for training in deviant behaviors. As Patterson et al. (1984, p. 254) pointed out, “The effect of these negative microsocial exchanges is to shape the behavior of aggressor and victim simultaneously” (emphasis original). In this sense, each child in a sibling pair, regardless of birth order, is expected to wear two hats: one as a victim of his or her sibling’s aggressive behavior and the other as an aggressor toward his or her sibling. As multilevel modeling analysis pools younger and older siblings in one equation, it allows us to investigate such mutual influences. Finally, as Krull (2007) has recently shown, using multilevel analyses in sibling studies significantly increases one’s analytical power.

Controlling for Parental Influences

Sibling researchers have consistently emphasized that parents and siblings are subsystems that make up family ecology (Bank, Borraaston, & Snyder, 2004; Garcia et al., 2000; McHale & Pawletko, 1992; McHale, Updegraaff, Tucker, & Crouter, 2000; Snyder et al., 2005). Empirical examination of sibling and parental effects, however, has advanced rather independently. When siblings are found to be similar in their antisocial behaviors, it is plausible that it is the parents who train both children to be antisocial. This is an important issue when testing Patterson’s (1986) theory because, in his theory, parents who use unskilled discipline practices are considered to be the primary agents that drive the coercive cycle. Children who learn from their parents to use aggressive, coercive behavior in family interactions are more likely to be antisocial and to use similar techniques in interactions with others outside their households (Patterson, 1982; Patterson, Reid, & Dishion, 1992; Patterson & Stouthamer-Looier, 1984). It may well be the punitive parenting practices that influence all members in a family. Thus, it is important to evaluate whether negative exchanges between siblings are a significant contributor to the development of externalizing behavior beyond punitive
parenting (Garcia et al., 2000). In this study, we controlled mothers’ punitive discipline in estimating sibling effects.1

Indeed, several researchers have demonstrated the importance of assessing parental influences in estimating sibling effects. For example, Brody and his colleagues (Brody, Ge, et al., 2003; Brody, Kim, Murry, & Brown, 2003) have shown that the prediction of younger siblings’ outcomes is more accurate if it is based on older siblings’ characteristics plus parenting. There is also evidence to suggest that sibling conflict and parent–child relationships form distinctive constructs and that sibling interactions are predictive of antisocial behavior after controlling for the effects of parent–child interactions (Bank et al., 2004; Criss & Shaw, 2005; Farrington, 1995; Garcia et al., 2000; Lauritsen, 1993; Rowe & Gulley, 1992). McGue and his colleagues (McGue, 1999; McGue, Sharma, & Benson, 1996) also demonstrated that sibling and parental effects are distinctive in predicting adolescent alcohol use.

Circumventing Problems of Shared Method Variance

Measurement strategies, such as the use of a single informant to report on both predictors (e.g., self-reported negativity in sibling relationship) and criterion constructs (e.g., self-reported externalizing behavior), are subject to the problem of shared method variance (e.g., Bank et al., 1990). When both sibling interaction and outcome variables are reported by the same informant, their association is likely overestimated because of the method of data collection. In particular, inflation of estimates by shared method variance appears to be problematic for psychopathological variables, such as externalizing problems, because antisocial individuals tend to perceive neutral events as aggressive and to interpret themselves as victims of aggression (Dodge, 1980, 1993, 2006). In this study, we used multiple informants (i.e., sibling, mother, father) to assess sibling aggression and designed the analyses to create a mismatch between the informants who reported the predictor variable (sibling aggression) and the criterion variable (externalizing problems) to conservatively test the sibling deviance hypothesis.

Addressing Developmental Issues

Although a longitudinal design does not offer causal inference for a sibling’s role in the development of externalizing behavior, it provides a more definitive logical basis for inferring what would be likely to happen if one experienced antagonistic treatment from his or her sibling. There is an emerging body of literature that has examined longitudinal sibling effects. For instance, Compton et al. (2003) found that high levels of sibling coercion at age 6 were significantly associated with younger siblings’ antisocial behavior assessed 10 years later. Criss and Shaw (2005) recently reported that boys’ perception of antagonism and negativity with their sibling at age 10 was prospectively related to their antisocial behavior at ages 11–12. Dunn and Munn (1986), and Slomkowski et al. (2001) demonstrated sibling effects after controlling for earlier levels of externalizing problems. In this study, we applied a rigorous test of longitudinal sibling effects by controlling for baseline externalizing problems while accounting for interdependence of sibling data.

Analytical Strategies

As stated earlier, the major objective of the present study was to test the prospective effects of coercive, negative interactions between siblings on their later externalizing problems by overcoming several methodological limitations in previous research by (a) addressing the issue of intraclass correlations via a multilevel approach with a genetically sensitive design, (b) accounting for mothers’ punitive parenting practices and initial levels of externalizing problems, (c) adopting multiple sources of information in defining sibling aggression, and (d) examining developmental changes in a sample assessed longitudinally. The overall hypothesis was that sibling aggression would contribute to the subsequent development of externalizing problems.

In this study, we estimated a multilevel model in the following form (see Guo & Wang, 2002, for more detailed explanations):2

\[
Y_{ij(t)} = \beta_0 + \beta_1 x_{ij(t)} + \beta_2 x_{2ij(t)} + \cdots + \beta_p x_{pj(t)} + u_{ij(t)} + e_{ij(t)},
\]

where \(Y_{ij(t)}\) is the outcome variable, externalizing problems at Time 2 (T2), for a focal child i in sibling pair j; \(\beta_0\) is the intercept (random coefficient); and \(\beta_1, \beta_2, \ldots, \beta_p\) are fixed effect of Time 1 (T1) predictors, including externalizing problems, sibling’s aggression toward the focal child, maternal punitive parenting, and gender and age difference between siblings. It is important to note that the application of multilevel modeling to sibling data effectively pools both siblings from a family together; thus both siblings become the focal child whose externalizing problems were predicted as well as the sibling whose aggression was used as a predictor. In this model, \(u_i\) is the pair-specific random effect, and \(e_{ij}\) is the individual-specific random effect. To take into consideration different types of siblings, we denoted \(t(i)\), where \(t = m, d, f_{ot}, f_{ot^*}, h\), and \(c\), to represent MZ twins, DZ twins, full siblings in nondivorced families, full siblings in stepfamilies, half siblings, and genetically unrelated siblings. The intraclass correlations were obtained from \(\rho = \sigma^2_{a(t)} / (\sigma^2_{a(t)} + \sigma^2_{e(t)})\) by different sibling types.

We first report descriptive statistics and simple bivariate correlations. We then report intraclass correlations by type of sibling pairs. Finally, we present results based on the above-mentioned multilevel model to evaluate the effect of sibling aggression. We also computed \(r\) effect size (McCartney & Rosenthal, 2000; Ros-

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1 We also examined the effect of paternal punitive discipline at Time 1 on adolescents’ externalizing problems at Time 2. However, results indicated that paternal punitive discipline was not significantly associated with adolescents’ externalizing problems at Time 2. Because paternal punitive discipline was highly correlated with maternal punitive disciplines (\(r = .61\), to avoid multicollinearity problems when estimating two measures of parental punitive discipline simultaneously in one equation, we decided to limit our scope to maternal punitive discipline in this report.

2 The combined equation can also be presented in the following two-level form: for the Level 1 model, \(Y_{ij(t)} = \beta_{0(t)} + \beta_1 x_{ij(t)} + \beta_2 x_{2ij(t)} + \cdots + \beta_p x_{pj(t)} + e_{ij(t)}\); for the Level 2 model, \(\beta_{0(t)} = \beta_0 + u_{ij}\).
now, Rosenthal, & Rubin, 2000) to denote the magnitude of sibling aggression effect.

Method

Participants and Procedures

The present investigation is based on data from the NEAD project. The NEAD is a longitudinal study that assessed 720 same-sex twin and sibling pairs from a nationwide sample of two-parent families, including both nondivorced and stepfamilies, with a pair of adolescent siblings no more than 4 years apart in their age (Hetherington et al., 1999; Reiss et al., 2000). The parents of children in stepfamilies had to be married at least 5 years before data collection to ensure that none of the families were in the unstable early phases of family formation. The nondivorced families with full siblings were recruited through random digit dialing of 10,000 telephone numbers throughout the United States. Except for a small subsample of the other types of siblings who were also recruited through the random digit dialing procedures, most of the other types of siblings were recruited through a national market survey of 675,000 households. The 720 families were primarily middle class (the average family income was $25,000–$35,000 per year; 12% earned less than $20,000 per year, and 32% earned more than $50,000 per year). The upward skew distribution of family income is likely a consequence of sampling two-parent families. Ninety-four percent of the mothers and 93% of the fathers were Caucasian, with the average years of education of 13.6 and 14.0, respectively.

The NEAD sample consists of six types of siblings: MZ twins, DZ twins, full siblings living in nondivorced families, and full siblings, half siblings, and genetically unrelated siblings in stepfamilies. Zygosity of the twin pairs was rated in terms of physical similarity (e.g., eye and hair color) by the interviewers and parents as well as by self-reports, with a modified version of a zygosity questionnaire for adolescents (Nichols & Bilbro, 1966). The accuracy rate for this zygosity assigning method has been shown to be more than 95% accurate when compared with DNA tests (Nichols & Bilbro, 1966; Spitz, Moutier, Reed, Busnel, & Marchaland, 1996). If any differences in physical characteristics of the twins were identified, or if people were never confused about the twins’ identity, the twin pair was classified as DZ. Twelve of the twins could not be classified as either MZ or DZ with certainty and were excluded from these analyses.

During the T1 assessment, the adolescents (Sibling 1) ranged in age from 10 to 18 years, with a mean of 14.51 years ($SD = 2.20$). Their siblings (Sibling 2) ranged in age from 9 to 18 years, with a mean of 12.91 years ($SD = 2.21$). The T1 sample consisted of 708 sibling pairs, including 93 MZ twin pairs (47 brother–brother pairs, 46 sister–sister pairs), 99 DZ twin pairs (50 brother–brother pairs, 49 sister–sister pairs), 95 full siblings living in nondivorced families (48 brother–brother pairs, 47 sister–sister pairs), 182 full siblings living in stepfamilies (86 brother–brother pairs, 96 sister–sister pairs), 109 half siblings in stepfamilies (60 brother–brother pairs, 49 sister–sister pairs), and 130 genetically unrelated siblings living in stepfamilies (74 brother–brother pairs, 56 sister–sister pairs). Three years later, the follow-up study (T2) was conducted. Because the main focus of the project was to investigate family interactions within the home, the participating families were required to fulfill the two criteria: (a) the parents lived together, and (b) the two siblings had to be resident in the household at least half the time. Forty-two families were eliminated because of parental divorce, 3 to the death of a parent, and 243 to at least one of the children leaving home. The majority (94%) of eligible families agreed to participate. The sample size of the T2 assessment was 395 sibling pairs.

This study was based on siblings who participated in both waves of data collection and who provided the complete information regarding the externalizing problems at T2. These selection criteria resulted in 780 individuals from 390 sibling pairs (196 brother–brother pairs, 194 sister–sister pairs). The number of sibling pairs by type of siblings is as follows: 62 MZ twin pairs (27 brother–brother pairs, 35 sister–sister pairs), 73 DZ twin pairs (37 brother–brother pairs, 36 sister–sister pairs), 58 full sibling pairs living in nondivorced families (30 brother–brother pairs, 28 sister–sister pairs), 94 full sibling pairs in stepfamilies (45 brother–brother pairs, 49 sister–sister pairs), 60 half sibling pairs (35 brother–brother pairs, 25 sister–sister pairs), and 43 genetically unrelated sibling pairs in reconstituted families (22 brother–brother pairs, 21 sister–sister pairs). The average age of Sibling 1 in this analytical sample was 13.56 ($SD = 1.97$) and 16.16 years ($SD = 2.07$) for T1 and T2, respectively. For Sibling 2, the mean age was 12.08 ($SD = 1.89$) and 14.68 years ($SD = 1.84$) for T1 and T2, respectively. The average age difference between sibling dyads was 1.48 years ($SD = 1.32$).

Comparison between the families that participated in both T1 and T2 and the families whose data were available only for T1 revealed that there was no difference between these two groups in terms of demographic variables (i.e., socioeconomic status, income, parental education, marital duration, and sex of the siblings). However, children from the families that were not included in the T2 data collection had slightly higher externalizing problems (adolescents who were not included in T2: $M = 9.48$, $SD = 4.83$; adolescents who participated in both data collections: $M = 8.25$, $SD = 4.89$; $t = 4.72$, $p < .01$).

Measures

Externalizing problems. In T1 and T2, both siblings responded to a subscale from the Behavior Problems Index (BPI; Zill, 1985) to report their own externalizing problems. The BPI is an abbreviated form of the widely used Child Behavioral Checklist (Achenbach & Edelbrock, 1983). The BPI externalizing scale included 20 items, capturing a variety of child problem behaviors relating to aggression, impulsivity, school behavior, and interpersonal relationships. The sample items included being disobedient at home/at school, cheating and telling lies, being impulsive or acting without thinking, having a very strong temper, not getting along with others, and losing it easily. Under a 3-point scale, from not true to often true, each sibling reported the frequency of listed behavioral problems in the past 3 months. Higher scores indicated more frequent displays of externalizing problems. The alpha for the BPI externalizing problems was .86 for both T1 and T2.

Sibling aggression. Each sibling, mother, and father responded to a five-item subscale of the Sibling Inventory of Behavior (Hetherington & Clingempeel, 1992) to report the frequency of the child’s aggressive behavior toward his or her sibling. The Sibling Inventory of Behavior was originally developed by
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Schaef er and Edgerton (1981) to assess sibling relationships and was later expanded and revised by Hetherington and Clingempeel (1992). A sample item involves I have physical fights with my sibling (not just for fun). Each child rated his or her own aggressive behavior toward his or her sibling using a 5-point Likert scale (1 = never to 5 = always). Parents also rated each child’s aggressive behavior toward his or her sibling using the same 5-point scale. The higher scores indicated the more aggressive a child was toward his or her sibling. It is important to note that use of these three measures of sibling aggression (i.e., sibling, mother, and father reports) and self-reports of externalizing behavior provided an opportunity to create a mismatch between the predictor (i.e., sibling aggression) and the outcome (i.e., externalizing behavior at T2) in terms of reporters. Cronbach’s alphas across informants and waves ranged from .77 to .90 (M = .86), suggesting an acceptable reliability.

**Mother’s punitive parenting.** Parent Discipline Behavior (Hetherington & Clingempeel, 1992) is a questionnaire that assesses how often specific parenting behaviors occurred. A 43-item subscale was designed to measure maternal punitive discipline. At T1, adolescents reported, on a 7-point Likert scale (1 = not at all, 7 = more than once a day), the frequency of punitive discipline (e.g., yelling, pushing) their mothers used toward them. This measure has been used in previous studies (e.g., Feinberg, Reiss, Neiderhiser, & Hetherington, 2005; Hetherington & Clingempeel, 1992; Neiderhiser, Reiss, Hetherington, & Plomin, 1999; O’Connor, Hetherington, & Reiss, 1998; Reiss et al., 2000). The reliability was acceptable, with a Cronbach’s alpha of .90.

**Age difference between the focal child and sibling.** Although the sibling deviancy training hypothesis suggests mutual influences between older and younger siblings, previous literature has implied that the direction of deviancy training is from older siblings to younger ones. To examine this possibility, we computed relative age differences between siblings. We computed relative age difference scores by subtracting the sibling’s age from the focal child’s age. The sign of the relative difference indicates who is the older (+) or the younger (−) of the two. For twins (135 sibling pairs) and a small subset of the genetically unrelated siblings (4 sibling pairs), the siblings were the same age and their age difference was zero. This computation yielded a scale of age difference indicating that the higher the score was, the older the focal child was in comparison with his or her sibling. Relative difference scores are typically used to test the birth order hypothesis (Monahan, Buchanan, Maccoby, & Dornbusch, 1993), and have been used in previous literature on sibling differential treatment to identify which sibling received a particular treatment (Mekos et al., 1996). If a coefficient for an interaction term between age difference and sibling aggression is negative, it indicates that younger siblings are affected more by sibling aggression than older siblings.

**Results**

**Descriptive Statistics**

The means, standard deviations, and bivariate correlations of the study variables are presented in Table 1. The results show that the correlation coefficients among the study variables were all in the directions we expected. Specifically, externalizing problems were modestly stable across the two waves over 3 years. All three indicators of sibling aggression were significantly correlated to one another. They were also related to externalizing problems at both T1 and T2. As expected, mothers’ punitive discipline was positively associated with children’s externalizing problems at both T1 and T2.

**Multilevel Modeling Analyses**

Within-sibling intra class correlations. When all types of siblings were pooled for analysis, the zero-order correlation between siblings in terms of T2 externalizing problems was .21 (p < .01). Table 2 presents intra class correlations between siblings for T2 externalizing problems by type of siblings. These estimates were calculated from random effects in the unconditional models where T2 externalizing problems were the dependent variable. An important feature of this unconditional model was that we allowed variance components to vary by genetic relatedness of siblings. That is, each type of siblings (i.e., MZ twins, DZ twins, full siblings, half siblings, and genetically unrelated siblings) was allowed to have different variance components. As expected, the coefficient estimates indicated that the magnitude of the intra class correlations varied systematically by genetic relatedness, with the highest correlations for MZ twins, followed by DZ twins, full siblings, half siblings, and genetically unrelated siblings. Fisher’s r to Z transformation tests indicated that the magnitude of the coefficient for unrelated siblings was not statistically different from that for full siblings in nondivorced families (z = 0.59, ns) or stepfamilies (z = 0.49, ns) or for half siblings in stepfamilies (z = 1.04, ns).

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Means, Standard Deviations, and Bivariate Correlations Among the Study Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>Informant</td>
</tr>
<tr>
<td>1. Externalizing problems</td>
<td>T2</td>
</tr>
<tr>
<td>2. Externalizing problems</td>
<td>T1</td>
</tr>
<tr>
<td>3. Sibling aggression</td>
<td>T1</td>
</tr>
<tr>
<td>4. Sibling aggression</td>
<td>T1</td>
</tr>
<tr>
<td>5. Sibling aggression</td>
<td>T1</td>
</tr>
<tr>
<td>6. Mothers’ punitive discipline</td>
<td>T1</td>
</tr>
</tbody>
</table>

Note. N = 780. T1 = Time 1; T2 = Time 2. *p < .05. **p < .01.
Taken together, these results indicate that it is important to take account of the variance by genetic relatedness.

Testing the sibling deviancy training hypothesis. We performed a series of multilevel modeling analyses with SAS PROC MIXED. The results for the fixed effects from multilevel modeling are summarized in Table 3. All the predictors were centered at their means to simplify the interpretation of the intercepts. These three models were designed to examine whether sibling aggression exerted a prospective influence on the focal child’s externalizing problems, after controlling for variations in parenting, T1 externalizing problems, sex, and age difference between siblings. The three models differed in who reported sibling aggression (i.e., siblings, mothers, or fathers). As these informants were only modestly correlated, ranging from .22 to .53 (see Table 1), we conducted these analyses separately by informants (see Achenbach, McConaughy, & Howell, 1987). If similar results were conducted these analyses separately by informants (see Achenbach, McConaughy, & Howell, 1987). If similar results were conducted these analyses separately by informants (see Achenbach, McConaughy, & Howell, 1987).

Model 1 examined the effect of siblings’ self-reported aggression toward the focal child on the focal child’s externalizing problems, controlling for T1 externalizing problems, sex of the siblings, age differences between siblings, and mothers’ punitive discipline. As expected, T1 externalizing problems were positively associated with T2 externalizing problems (b = 0.36, p < .01), indicating its moderate stability over 3 years. The main effects of sex and age difference did not reach statistical significance. Consistent with our expectation, mothers’ punitive discipline at T1 was significantly correlated with children’s T2 externalizing problems (b = 0.12, p < .05). More important for this study, the effect of sibling aggression at T1, as reported by siblings themselves, was significantly associated with the focal child’s externalizing problems at T2 (b = 0.10, p < .01, r_effect size = .12). The magnitude of the sibling effect was small by the standard guideline of effect size (Cohen, 1988). This effect was not conditional to the birth order of the siblings.

Similar patterns of the results were obtained in Model 2, which included mothers’ report of sibling aggression. Mothers’ report of sibling aggression toward the focal child was a significant predictor of the focal child’s T2 externalizing problems (b = 0.11, p < .05, r_effect size = .11). Mothers’ punitive discipline remained significant (b = 0.12, p < .05). Comparably, fathers’ report of sibling aggression (Model 3) was also estimated to be statistically significant (b = 0.15, p < .01, r_effect size = .15). Again, mothers’ punitive discipline at T1 was associated with an increase in children’s externalizing problems at T2 (b = 0.11, p < .05).

Subsidiary analyses. We conducted a set of additional analyses to further investigate the robustness of the findings mentioned above. First, we examined whether the effect of sibling aggression differed by sex composition of sibling dyads (brother–brother vs. sister–sister dyads) by adding the interaction terms between sex and sibling aggression to Models 1, 2, and 3. Results indicated that none of these interaction terms was statistically significant. It is important for readers to note that we could not examine cross-sex sibling effects because the NEAD included only same-sex siblings.

Second, to see whether our results from multilevel modeling analyses hold in cross-lagged models, which considered stabilities

Table 2
Within-Sibling Intraclass Correlations for Externalizing Problems at Time 2

<table>
<thead>
<tr>
<th>Sibling type</th>
<th>N (pairs)</th>
<th>Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>MZ twins</td>
<td>62</td>
<td>.59</td>
</tr>
<tr>
<td>DZ twins</td>
<td>73</td>
<td>.21</td>
</tr>
<tr>
<td>Full siblings in nondivorced families</td>
<td>58</td>
<td>.10</td>
</tr>
<tr>
<td>Full siblings in stepfamilies</td>
<td>94</td>
<td>.13</td>
</tr>
<tr>
<td>Half siblings</td>
<td>60</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Genetically unrelated siblings</td>
<td>43</td>
<td>.22</td>
</tr>
</tbody>
</table>

Note. MZ = monozygotic; DZ = dizygotic.

Table 3
Fixed Effects for Externalizing Problems at Time 2

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1 Coefficient</th>
<th>SE</th>
<th>Model 2 Coefficient</th>
<th>SE</th>
<th>Model 3 Coefficient</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>8.20**</td>
<td>0.24</td>
<td>8.23**</td>
<td>0.23</td>
<td>8.27**</td>
<td>0.23</td>
</tr>
<tr>
<td>Externalizing problems at Time 1</td>
<td>0.36**</td>
<td>0.03</td>
<td>0.36**</td>
<td>0.03</td>
<td>0.36**</td>
<td>0.03</td>
</tr>
<tr>
<td>Sexa</td>
<td>.03</td>
<td>0.33</td>
<td>.03</td>
<td>0.33</td>
<td>.03</td>
<td>0.33</td>
</tr>
<tr>
<td>Age difference between siblingsb</td>
<td>-.01</td>
<td>0.08</td>
<td>-.02</td>
<td>0.08</td>
<td>-.01</td>
<td>0.08</td>
</tr>
<tr>
<td>Mother’s punitive discipline at Time 1</td>
<td>.12*</td>
<td>0.05</td>
<td>.12*</td>
<td>0.05</td>
<td>.11*</td>
<td>0.05</td>
</tr>
<tr>
<td>Sibling aggression at Time 1</td>
<td>.10**</td>
<td>0.04</td>
<td>.11*</td>
<td>0.05</td>
<td>.15**</td>
<td>0.05</td>
</tr>
<tr>
<td>Sibling aggression at Time 1 × Age Differenceb</td>
<td>.01</td>
<td>0.02</td>
<td>.04</td>
<td>0.03</td>
<td>.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Intercept</td>
<td>4474.1</td>
<td></td>
<td>4495.7</td>
<td></td>
<td>4472.5</td>
<td></td>
</tr>
</tbody>
</table>

Note. All the predictors are centered at their means. T1 = Time 1; T2 = Time 2; AIC = Akaike’s Information Criterion.

* Sex = 0 for girls, 1 for boys. b Age difference between siblings is a relative difference score calculated by subtracting the sibling’s age from the focal child’s age.

*p < .05. **p < .01.
of study constructs over time, we ran three cross-lagged models with different informants of sibling aggression. As presented in Table 4, T1 sibling aggression significantly predicted T2 externalizing problems ($\beta_{23}$), after considering stabilities of sibling aggression ($\beta_{43}$) and externalizing problems ($\psi_{43}$), and cross-lagged effects from T1 externalizing problems to T2 sibling aggression ($\beta_{41}$). The cross-lagged effects from sibling aggression to later externalizing problems ($\beta_{23}$) were statistically significant across all three informants.

Discussion

Similarity between siblings’ antisocial behavior is a phenomenon that requires explanations (Dishion & Patterson, 2006). This study took a new look at deviancy training, one of the mechanisms that operates to make siblings more alike. Application of a multilevel modeling approach to multi-informant, longitudinal sibling data combined with a genetically sensitive design allowed us to examine prospective sibling effects while estimating intraclass correlations among sibling pairs who varied in degree of genetic relatedness, avoiding shared method variance by using multiple reporters of sibling aggression, approximating causal inferences with longitudinal data, and controlling for initial levels of the dependent measure and parental influences. Incorporating all these methodological improvements in one study enabled us to examine the sibling deviancy training hypothesis more rigorously. The results generated in this study are fairly straightforward: Sibling aggression does have a modest yet significant effect on the development of externalizing problems. Indeed, the findings from this study provide support for the assertion that patterns of irritable and aggressive exchanges provide behavioral contingencies for siblings to become fellow travelers on the path to antisocial behaviors (Patterson, 1984). Such an effect of sibling aggression was not moderated by age difference between siblings, indicating that sibling deviancy training is not constrained to just one-way direction from older to younger siblings.

It is important to point out that the magnitude of the effects is quite modest, in comparison with what was summarized by Dishion and Patterson (2006). We believe that one of the reasons for such a difference is that we simultaneously considered parenting effects and estimated intraclass correlations. In addition, readers are reminded that the effect size of sibling aggression ranged from .11 to .15, which is considered a small effect by the commonly applied guideline (Cohen, 1988). However, some researchers also caution that dismissing small effects as trivial could be erroneous (Fern & Monroe, 1996; McCartney & Rosenthal, 2000). Given the complexity of human behavior, effect size may be necessarily small in outcomes with multiple determinants (Ahadi & Diener, 1989). For this study, despite the modest to even small effect size of the direct estimate of sibling deviancy training, the remarkable consistency obtained from multiple informants provides some assurance for the observed effect.

Our confidence in the present finding is significantly enhanced by the methodological strengths embedded in this study design. Most, if not all, analyses of sibling data have not considered the issue of intraclass correlations. However, ignoring intraclass correlations likely serves to inflate sibling effects because siblings raised in the same families are not (statistically) independent: They share not only their biological endowment (in genetically related pairs, of course) but also their social environment (home, peers, school, and neighborhood). The use of a multilevel modeling strategy in the present study, particularly when applied to genetically sensitive data, to carefully model within-sibling intraclass correlations by genetic relatedness, is consistent with Krull’s (2007) proposal that this approach helps reduce bias as well as increase the power in analyzing sibling data.

The sheer fact that siblings do not just live by themselves but with their parents necessitates the inclusion of parental influences in investigating sibling effects. Parents and siblings have long been recognized as subsystems in the same family ecology (Bank et al., 2004; Garcia et al., 2000; McHale & Pawletko, 1992; McHale et al., 2000; Snyder et al., 2005). With some notable exceptions (Bank et al., 2004; Criss & Shaw, 2005; Garcia et al., 2000; Rowe & Gulley, 1992), however, few studies estimated sibling effects while controlling for parental influences—a highly likely candidate as the third variable that gives rise to a sibling correlation. In this study, we controlled mothers’ punitive discipline, an important parenting variable that has been repeatedly shown to be a significant predictor of externalizing problems. Our results are also consistent with those of Farrington (1995), Lauritsen (1993), and McGue and his colleagues (McGue, 1999; McGue et al., 1996; Walden, McGue, Iacono, Burt, & Elkins, 2004), all of whom reported that sibling effects on externalizing behaviors or delinquency are independent of the impact of other salient influences such as individual, peer, and parental characteristics.

Table 4
Coefficient Estimates of the Cross-Lagged Model

<table>
<thead>
<tr>
<th>Model</th>
<th>Informant of sibling aggression</th>
<th>$\beta_{23}$</th>
<th>$\beta_{41}$</th>
<th>$\beta_{21}$</th>
<th>$\beta_{43}$</th>
<th>$\psi_{13}$</th>
<th>$\psi_{24}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sibling</td>
<td>.08*</td>
<td>.04</td>
<td>.37**</td>
<td>.40**</td>
<td>.10**</td>
<td>.08**</td>
</tr>
<tr>
<td>2</td>
<td>Mother</td>
<td>.11**</td>
<td>.01</td>
<td>.61**</td>
<td>.40**</td>
<td>.13**</td>
<td>.10**</td>
</tr>
<tr>
<td>3</td>
<td>Father</td>
<td>.12**</td>
<td>.00</td>
<td>.67**</td>
<td>.40**</td>
<td>.10**</td>
<td>.03</td>
</tr>
</tbody>
</table>

Note. $\beta_{23}$ represents cross-lagged effect from sibling aggression at Time 1 (T1) to externalizing problems at Time 2 (T2); $\beta_{41}$ indicates the cross-lagged effect from externalizing problems at T1 to sibling aggression at Time 2; $\beta_{21}$ and $\beta_{43}$ indicate the stabilities of sibling aggression and externalizing problems between T1 and T2, respectively; $\psi_{13}$ and $\psi_{24}$ are the contemporaneous correlations between sibling aggression and externalizing problems at T1 and T2, respectively.

* $p < .05$. ** $p < .01$. 
This study also used multiple sources of information in examining the sibling effects. Problems associated with shared method variance are well known in family research (Bank et al., 1990). Our use of a mismatched reporter design whereby four family members independently reported information regarding sibling aggression (sibling, mother, and father reports) and externalizing problems (self-reports) provided a conservative approach to circumvent, at least in part, this methodological problem. Results from mother, father, and sibling reports converged to indicate that there is a significant, though modest, effect of sibling aggression on the development of externalizing problems. The consistency across informants is remarkable, which also increases our confidence in the observed effect.

Given the high continuity observed in behavioral research (Patterson, 1993), the most obvious third variable to be controlled for is perhaps the variable itself measured in an earlier point in time. Controlling for the initial level in predicting externalizing problems represents another methodological strength in our examination of changes in developmental research. Indeed, we found that externalizing symptoms assessed at T1 were the most significant predictors of the same variable at T2, with a magnitude of .36. It is especially reassuring that although the magnitude of its effect is rather modest, sibling aggression remains a significant predictor of externalizing problems at T2 after controlling for externalizing problems at T1. This indicates that sibling aggression exerts an impact on changes in externalizing problems from T1 to T2, beyond behavioral continuity over 3 years.

Several limitations of this study need to be considered when interpreting the study results, however. First, as with many other studies, results may not be generalized beyond the population represented by the present sample, which was from largely White, working- and middle-class families with siblings close in age. In addition, although the NEAD project was designed to encompass diversity of family structures (including divorced but reconstituted families), it included neither single-parent families nor sibling pairs of opposite sex. With increased complexity in family structures and diversified ethnic and cultural backgrounds in contemporary society, it is necessary to replicate the present findings with samples comprising other racial and cultural groups and family structures with heterogeneous socioeconomic characteristics. Second, sibling aggression was based on a brief scale (a five-item subscale of the Sibling Inventory of Behavior). Given that interaction between siblings can be complex, a measure that assesses sibling behavior more extensively may be recommended in future efforts in replicating our results. Third, although sibling aggression in this report incorporates perceptions of multiple informants, it was reported rather than observed directly. Dishion and Patterson (2006) have pointed out that observational data tend to yield larger correlations between sibling deviance than self-reports. Having direct observational data on microsocial exchanges of aggressive behavior between siblings would have provided a dynamic perspective on this phenomenon. It is worth noting that the NEAD project did directly observe sibling interactions. We are currently in the process of recording the dyadic sibling interactions using a microsocial coding scheme designed to identify sibling deviancy training (see Neiderhiser, Reiss, & Hetherington, 2007, for more details). Fourth, only about 56% of the original sample was eligible to participate in the longitudinal study (T2). Because the T2 assessment was focused on family interactions within the household, only those families that still had all four participants (i.e., two siblings, mother, and father) residing together were asked to fully participate. Fifth, the current investigation is based on only two waves of data. More detailed analysis of changes in externalizing problems, such as curvilinear changes in externalizing problems with respect to age (Moffitt, 1993) and long-term effects of sibling aggression, requires additional follow-ups. Finally, it is important to note that this study used a quantitative behavioral genetic design. Research that directly collects DNA data may help pinpoint contributions of specific genes more precisely in estimating sibling influence on externalizing problems.

Despite these aforementioned limitations, this study provides a rare opportunity for identifying sibling aggression’s role in the development of externalizing problems. Our results provide a supportive evidence for Patterson’s (1986) sibling deviancy training hypothesis, indicating that aversive behavioral transactions between siblings can prospectively unfold to the development of general externalizing problems. The results that children growing up with aggressive siblings are at a greater risk for developing externalizing problems suggest that sibling interaction is an important additional venue for the existing preventive interventions for children’s problem behaviors (Brody, 1998). Particularly, the results inform us of the possibility that successful interventions may need to address all members in a family, as interventions targeted for one child in a family could be undermined by siblings’ and parents’ aggressive behaviors.

References
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