



Published in final edited form as:

*Dev Psychol.* 2009 July ; 45(4): 1009–1018. doi:10.1037/a0015698.

## Aggressive Behavior between Siblings and the Development of Externalizing Problems: Evidence from a Genetically Sensitive Study

**Misaki N. Natsuaki,**

University of Minnesota, Twin Cities

**Xiaoja Ge,**

University of Minnesota, Twin Cities

**David Reiss,** and

Yale University

**Jenae M. Neiderhiser**

Pennsylvania State University

### Abstract

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 two waves of the Nonshared Environment for Adolescent Development (NEAD) 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 intra-class correlations between siblings. Sibling aggression remained significant in predicting subsequent externalizing problems even after controlling for the levels of pre-existing externalizing problems and mothers' punitive parenting. This pattern of results was fairly robust across models using 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 paper 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, & Meseckbushey, 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.

While 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, & Burraston, 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 for 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 using 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) suggests 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 non-referred 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 are, in most cases, genetically related, their within-pair or intra-class correlations need to be accounted for. Second, because siblings are usually reared by the same parent(s), 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 aversive 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 intra-class 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). While 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 intra-class 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-one and level-two 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% their genes to siblings in a stepfamily who are genetically unrelated. When applied to a genetically sensitive design, multilevel modeling approach allows estimation of varying variance components and thus varying intra-class correlations by genetic relatedness of siblings (Guo & Wang, 2002). Third, unlike previous sibling research that implicitly assumes 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 influencee, 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, “(t)he 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 towards 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, Burraston, & Snyder, 2004; Garcia et al., 2000; McHale & Pawletko, 1992; McHale, Updegraff, 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 of their households (Patterson, 1982; Patterson, Reid, & Dishion, 1992;

Patterson & Stouthamer-Loeber, 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 above and beyond punitive parenting (Garcia et al., 2000). In this study, we controlled mothers' punitive discipline in estimating sibling effects<sup>1</sup>.

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 sibling's outcomes is more accurate if it is based on older sibling's 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 were 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 him/herself as a victim of aggression (Dodge, 1980, 1993, 2006). In this study, we used multiple informants (i.e., sibling, mother, father) to assess sibling's 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 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 his sibling at age 10 was prospectively related to their antisocial behavior at ages 11–12. Dunn and Munn (1986) similarly reported that physical aggression by one's sibling was prospectively related to one's physical aggression six months later. Similar results have been reported by Slomkowski et al. (2001) who showed that older sibling hostility was related to younger siblings' delinquency three years later. Although the study by Compton et al. (2003) did not control for the earlier levels of antisocial behavior, several

---

<sup>1</sup>We also examined the effect of paternal punitive discipline at T1 on adolescents externalizing problems at T2. However, results indicated that paternal punitive discipline was not significantly associated with adolescents' externalizing problems at T2. 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.

studies such as the ones conducted by Criss and Shaw (2005), 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 intra-class correlations using a multilevel approach with a genetically sensitive design; (b) accounting for mother's 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)<sup>2</sup>,

$$Y_{ij(t)} = \beta_0 + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \dots + \beta_p x_{pij} + u_{j(t)} + e_{ij(t)}$$

Where  $Y_{ij}$  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),  $\beta_1 x_{1ij}$  through  $\beta_p x_{pij}$  are fixed effect of Time 1 (T1) predictors, including externalizing problems, sibling's aggression toward the focal child, and maternal punitive parenting at T1, 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,  $u_j$  is the pair-specific random effect, and  $e_{ij}$  is the individual-specific random effect. To take into consideration of different types of siblings, we denoted  $(t)$ , where  $t = m, d, f_{nd}, f_s, h,$  and  $c$ , to represent MZ twins, DZ twins, full sibling in nondivorced families, full siblings in stepfamilies, half siblings, and genetically unrelated siblings. The intra-class correlations were obtained from  $\rho = \sigma^2_{u(t)} / (\sigma^2_{u(t)} + \sigma^2_{e(t)})$  by different sibling types.

We first report descriptive statistics and simple bivariate correlations. We then report intra-class correlations by type of sibling pairs. Finally, we present results based on the abovementioned multilevel model to evaluate the effect of sibling aggression. We also computed  $r$  effect size (McCartney & Rosenthal, 2000; Rosnow, Rosenthal, & Rubin, 2000) to denote the magnitude of sibling aggression effect.

## Method

### Participants and Procedures

The present investigation is based on data from the Nonshared Environment in Adolescent Development (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

<sup>2</sup>The combined equation can be also presented in the following two-level form: For the level-1 model,  $Y_{ij(t)} = \beta_0j(t) + \beta_1x_{1ij} + \beta_2x_{2ij} + \dots + \beta_px_{pij} + e_{ij(t)}$ ; for the level-2 model,  $\beta_0j(t) = \beta_0 + u_j(t)$ .

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 (RDD) of 10,000 telephone numbers throughout the United States. Except for a small sub-sample of the other types of siblings who were also recruited through the RDD 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 6 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 were 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 to 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 twin's 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 Time 1 assessment (T1), the adolescents (Sibling 1) ranged in age from 10 to 18 years, with a mean of 14.51 ( $SD = 2.20$ ). Their siblings (Sibling 2) ranged in age from 9 to 18 years, with a mean of 12.91 ( $SD = 2.21$ ). 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 of the time. Forty-two families were eliminated due to parental divorce, three 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 ages of Sibling 1 in

this analytical sample were 13.56 ( $SD = 1.97$ ) and 16.16 ( $SD = 2.07$ ) for T1 and T2, respectively. For Sibling 2, the mean ages were 12.08 ( $SD = 1.89$ ) and 14.68 ( $SD = 1.84$ ) for T1 and T2, respectively. The average age differences between sibling dyads were 1.48 years ( $SD = 1.32$ ).

Comparison between the families who 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., SES, 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 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 aggressiveness, impulsivity, school behavior, and interpersonal relationships. The sample items include *being disobedient at home/at school*, *cheating and telling lies*, *being impulsive or acting without thinking*, and *having a very strong temper, not getting along with others*, and *losing it easily*. Using a three-point scale, from *not true* to *often true*, each sibling reported the frequency of listed behavioral problems in the past three months. Higher scores indicated more frequent displays of externalizing problems. The alpha for the BPI externalizing problems was .86 for both for T1 and T2, respectively.

**Sibling aggression**—Each sibling, mother, and father responded to a 5-item subscale of the Sibling Inventory of Behavior (SIB; Hetherington & Clingempeel, 1992) to report the frequency of the child's aggressive behavior towards his or her sibling. The SIB was originally developed by Schaefer and Edgerton (1981) to assess sibling relationships that 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 (PDB; 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 Cronbach's alpha of 0.90.

**Age difference between the focal child and sibling**—While 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. In order to examine this possibility, we computed relative age differences between siblings. Relative age difference scores were computed 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 the higher the score was, the older one was in comparison to 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 are older siblings.

## Results

### Descriptive Statistics

The means, standard deviations, and bivariate correlations of the study variables are presented in Table 1. The results showed 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 three years. All three indicators of sibling aggression were significantly correlated to each other. 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 0.21,  $p < .01$ . 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- and half-siblings. The notable exception was for genetically unrelated siblings whose intra-class correlation ( $r = .22$ ) was seemingly higher than that of full and half siblings. Fisher's  $r$ -to- $z$  transformation tests indicated that the differences in the magnitude were not statistically significant between unrelated siblings and full siblings in nondivorced ( $z = 0.59$ , n.s.), or in stepfamilies ( $z = 0.49$ , n.s.), or half siblings ( $z = 1.04$ , n.s.). Taking 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, and fathers. As these informants were only modestly correlated, ranging from  $r_s = 0.22$  to  $0.53$  (see Table 1), we conducted these analyses separately by informants (see Achenbach, McConaughy, & Howell, 1987). If similar results were obtained across different informants on sibling aggression, it would lend further credence to the results.

Model 1 examined the effect of sibling's 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 three 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 importantly 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 ( $b = 0.10, p < .01, r_{\text{effect size}} = 0.12$ ). 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 that 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 ( $b = 0.11, p < .05, r_{\text{effect size}} = 0.11$ ). Mothers' punitive discipline remained significant ( $b = 0.12, p < .01$ ). Comparably, fathers' report of sibling aggression (Model 3) was, too, estimated to be statistically significant ( $b = 0.15, p < .01, r_{\text{effect size}} = 0.15$ ). 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 only included same-sex siblings.

Second, in order to see whether our results from multilevel modeling analyses hold in cross-lagged models, which considered stabilities 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 ( $\beta_{21}$ ), and externalizing problems ( $\beta_{43}$ ) between the two time points, contemporaneous correlations between sibling aggression ( $\psi_{13}$ ) and externalizing problems ( $\psi_{43}$ ), as well as 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 a multi-informant, longitudinal sibling data combined with a genetically

sensitive design allowed us to examine prospective sibling effects while estimating intra-class 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 of these methodological improvements in one study enabled us to more rigorously examine the sibling deviancy training hypothesis. 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 are quite modest, in comparison to 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 intra-class correlations. In addition, readers are reminded that the effect size of sibling aggression ranged from .11 to .15, which is considered to be 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 intra-class correlations. However, ignoring intra-class correlations likely serves to inflate sibling effects because siblings raised in the same families are not (statistically) independent: They not only share their biological endowment (in genetically related pairs, of course) but also their social environment (homes, 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 intra-class 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 mother's 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 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.

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, above and beyond behavioral continuity over three 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/cultural backgrounds in contemporary society, it is necessary to replicate the present findings using samples comprised of 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 SIB). 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 tended to yield larger correlations between sibling deviance than did 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 recoding 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, hence, 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 more precisely pinpoint contributions of specific genes 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 sibling's and parents' aggressive behaviors.

## Acknowledgments

We are grateful to Thomas J. Dishion, Brent M. Donnellan, and Daniel Shaw for their insightful comments on the earlier version of this manuscript. We also thank the children and parents for their participation to the study. The Nonshared Environment in Adolescent Development project was supported by NIMH Grants R01MH43373 and R01MH48825 and by the William T. Grant Foundation (PI: David Reiss) and by NIMH Grants R01 MH59014 (PI: Neiderhiser) and R01 MH065563 (PI: Slomkowski). Writing of this manuscript was supported by funds provided by the Institute of Child Development, University of Minnesota, Twin Cities. Correspondence regarding this article should be addressed to Misaki N. Natsuaki at Institute of Child Development, University of Minnesota, Twin Cities, 51 East River Parkway, Minneapolis, MN 55455.

## References

- Achenbach, T.M.; Edlbrock, C.S. *Manual for the Child Behavior Checklist and Revised Child Behavior Profile*. New York: Queen City Printers; 1983.
- Achenbach T.M., McConaughy S.H., Howell C.T. Child adolescent behavioral and emotional problems: Implications of cross-informant correlations for situational specificity. *Psychological Bulletin*. 1987; 101:213–232. [PubMed: 3562706]
- Ahadi S, Diener E. Multiple determinants and effect size. *Journal of Personality and Social Psychology*. 1989; 56:398–406.
- Bank L, Burraston B, Snyder J. Sibling conflict and ineffective parenting as predictors of adolescent boys' antisocial behavior and peer difficulties: Additive and interactional effects. *Journal of Research on Adolescence*. 2004; 14:99–125.
- Bank, L.; Dishion, T.J.; Skinner, M.; Patterson, G.R. Method variance in structural equation modeling: Living with "glop". In: Patterson, G.R., editor. *Aggression and depression in family interactions*. Hillsdale, NJ: Erlbaum; 1990. p. 247-280.
- Brody G.H. Sibling relationship quality: Its causes and consequences. *Annual Review of Psychology*. 1998; 49:1–24.
- Brody G.H, Ge X, Kim S.Y, Murry V, Simons R.L, Gibbons F.X, et al. Neighborhood disadvantage moderates associations of parenting and older sibling problem attitudes and behavior with conduct disorders in African American Children. *Journal of Consulting and Clinical Psychology*. 2003; 71:211–222. [PubMed: 12699016]
- Brody G.H, Kim S, Murry V, Brown A.C. Longitudinal direct and indirect pathways linking older sibling competence to the development of younger sibling competence. *Developmental Psychology*. 2003; 39:618–628. [PubMed: 12760528]
- Cohen, J. *Statistical power analysis for the behavioral sciences*. 2 ed.. Hillsdale, NJ: Erlbaum; 1988.
- Compton K, Snyder J, Schrepferman L, Bank L, Shortt J.W. The contribution of parents and siblings to antisocial and depressive behavior in adolescents: A double jeopardy coercion model. *Development and Psychopathology*. 2003; 15:163–182. [PubMed: 12848440]
- Criss M.A, Shaw D.S. Sibling relationships as contexts for delinquency training in low-income families. *Journal of Family Psychology*. 2005; 19:592–600. [PubMed: 16402874]

- Dishion, TJ.; Patterson, GR. The development and ecology of antisocial behavior in children and adolescents. In: Cicchetti, D.; Cohen, DJ., editors. *Developmental psychopathology*. 2nd ed.. Vol. Three. NY: John Wiley & Sons, Inc; 2006. p. 503-541. Risk, disorder, and adaptation
- Dodge KA. Social cognition and childrens aggressive behavior. *Child Development*. 1980; 51:162–170. [PubMed: 7363732]
- Dodge KA. Social cognitive mechanisms in the development of conduct disorder and depression. *Annual Review of Psychology*. 1993; 44:559–584.
- Dodge KA. Translational science in action: Hostile attributional style and the development of aggressive behavior problems. *Development and Psychopathology*. 2006; 18:791–814. [PubMed: 17152401]
- Dunn J, Munn P. Sibling quarrels and maternal intervention : Individual differences in understanding and aggression. *Journal of Child Psychology and Psychiatry and Allied Disciplines*. 1986; 27:583–595.
- Farrington DP. The development of offending and antisocial behavior from childhood: Key findings from the Cambridge Study in delinquent development. *Journal of Child Psychology and Psychiatry and Allied Disciplines*. 1995; 36:929–964.
- Feinberg ME, Reiss D, Neiderhiser JM, Hetherington EM. Differential association of family subsystem negativity on siblings' maladjustment: Using behavioral genetic methods to test process theory. *Journal of Family Psychology*. 2005; 19:601–610. [PubMed: 16402875]
- Fern EF, Monroe KB. Effect-size estimates: Issues and problems in interpretation. *Journal of Consumer Research*. 1996; 23:89–105.
- Garcia MM, Shaw DS, Winslow EB, Yaggi KE. Destructive sibling conflict and the development of conduct problems in young boys. *Developmental Psychology*. 2000; 36:44–53. [PubMed: 10645743]
- Guo G, Wang JM. The mixed or multilevel model for behavior genetic analysis. *Behavior Genetics*. 2002; 32:37–49. [PubMed: 11958541]
- Hetherington EM, Clingempeel WG. Coping with marital transitions: A family systems perspective. *Monographs of the Society for Research in Child Development*. 1992; 57(2–3 Serial No.227)
- Hetherington EM, Henderson SH, O'Connor TG, Insabella GM, Taylor LC, Anderson ER, et al. Adolescent siblings in stepfamilies: Family functioning and adolescent adjustment. *Monographs of the Society for Research in Child Development*. 1999; 64(4, Serial No.259)
- Kim JY, McHale SM, Crouter AC, Osgood DW. Longitudinal linkages between sibling relationships and adjustment from middle childhood through adolescence. *Developmental Psychology*. 2007; 43:960–973. [PubMed: 17605528]
- Krull JL. Using multilevel analyses with sibling data to increase analytic power: An illustration and simulation study. *Developmental Psychology*. 2007; 43:602–619. [PubMed: 17484574]
- Lauritsen JL. Sibling resemblance on juvenile delinquency: Finding from the National Youth Survey. *Criminology*. 1993; 31:387–407.
- McCartney K, Rosenthal R. Effect size, practical importance, and social policy for children. *Child Development*. 2000; 71:173–180. [PubMed: 10836571]
- McGue M. The behavioral genetics of alcoholism. *Current Directions in Psychological Science*. 1999; 8:109–115.
- McGue M, Sharma A, Benson P. Parent and sibling influences on adolescent alcohol use and misuse: Evidence from a US adoption cohort. *Journal of Studies on Alcohol*. 1996; 57:8–18. [PubMed: 8747496]
- McHale SM, Pawletko TM. Differential treatment of siblings in two family contexts. *Child Development*. 1992; 63:68–81.
- McHale SM, Updegraff KA, Tucker CJ, Crouter AC. Step in or stay out? Parents' roles in adolescent siblings' relationships. *Journal of Marriage and the Family*. 2000; 62:746–760.
- Mekos D, Hetherington EM, Reiss D. Sibling differences in problem behavior and parental treatment in nondivorced and remarried families. *Child Development*. 1996; 67:2148–2165. [PubMed: 9022235]
- Miles DR, Carey G. Genetic and environmental architecture of human aggression. *Journal of Personality and Social Psychology*. 1997; 72:207–217. [PubMed: 9008382]

- Moffitt TE. Adolescence-limited and life-course-persistent antisocial behavior: A developmental taxonomy. *Psychological Review*. 1993; 100:674–701. [PubMed: 8255953]
- Moffitt TE. The new look of behavioral genetics in developmental psychopathology: Gene-environment interplay in antisocial behaviors. *Psychological Bulletin*. 2005; 131:533–554. [PubMed: 16060801]
- Moffitt TE, Caspi A, Rutter M. Strategy for investigating interactions between measured genes and measured environments. *Archives of General Psychiatry*. 2005; 62:473–481. [PubMed: 15867100]
- Monahan SC, Buchanan CM, Maccoby EE, Dornbusch SM. Sibling differences in divorced families. *Child Development*. 1993; 64:152–168.
- Neiderhiser JM, Reiss D, Hetherington EM. The Nonshared Environment in Adolescent Development (NEAD) project: A longitudinal family study of twins and siblings from adolescence to young adulthood. *Twin Research and Human Genetics*. 2007; 10:74–83. [PubMed: 17539367]
- Neiderhiser JM, Reiss D, Hetherington EM, Plomin R. Relationships between parenting and adolescent adjustment over time: Genetic and environmental contributions. *Developmental Psychology*. 1999; 35:680–692. [PubMed: 10380859]
- Nichols RC, Bilbro WC Jr. The diagnosis of twin zygosity. *Acta Genetica et Statistica Medica*. 1966; 16:265–275. [PubMed: 4959152]
- O'Connor TG, Hetherington EM, Reiss D. Family systems and adolescent development: Shared and nonshared risk and protective factors in nondivorced and remarried families. *Development and Psychopathology*. 1998; 10:353–375. [PubMed: 9635228]
- Patterson, GR. A social learning approach: Vol. 3. Coercive family process. Eugene, OR: Castalia; 1982.
- Patterson, GR. Siblings: Fellow travelers in coercive family processes. In: Blanchard, RJ., editor. *Advances in the study of aggression*. New York: Academic Press; 1984. p. 174–213.
- Patterson, GR. The contribution of siblings to training for fighting: A microsocal analysis. In: Olweus, D.; Block, J.; Radke-Yarrow, M., editors. *Development of antisocial and prosocial behavior: Research theories and issues*. New York: Academic Press; 1986. p. 235–261.
- Patterson GR. Orderly change in a stable world: The antisocial trait as a chimera. *Journal of Consulting and Clinical Psychology*. 1993; 61:911–919. [PubMed: 8113492]
- Patterson GR, Dishion TJ, Bank L. Family interaction: A process model of deviancy training. *Aggressive Behavior*. 1984; 10:253–267.
- Patterson, GR.; Reid, J.; Dishion, TJ. A social interactional approach: Vol. 4 Antisocial boys. Eugene, OR: Castalia; 1992.
- Patterson GR, Stouthamer-Loeber M. The correlation of family management practices and delinquency. *Child Development*. 1984; 55:1299–1307. [PubMed: 6488958]
- Plomin R, Daniels D. Why are children in the same family so different from one another. *Behavioral and Brain Sciences*. 1987; 10:1–16.
- Plomin, R.; DeFries, JC.; McClearn, GE. *Behavioral genetics: A primer*. 2nd ed.. 1990.
- Raudenbush, SW.; Bryk, AS. *Hierarchical linear models: Applications and data analysis methods*. 2nd ed.. Thousand Oaks: Sage Publication; 2002.
- Reiss, D.; Neiderhiser, JM.; Hetherington, EM.; Plomin, R. *The relationship code: Deciphering genetic and social influences on adolescent development*. Cambridge, MA: Harvard University Press; 2000.
- Rhee SH, Waldman ID. Genetic and environmental influences on antisocial behavior: A meta-analysis of twin and adoption studies. *Psychological Bulletin*. 2002; 128:490–529. [PubMed: 12002699]
- Rosnow RL, Rosenthal R, Rubin DB. Contrasts and correlations in effect-size estimation. *Psychological Science*. 2000; 11:446–453. [PubMed: 11202488]
- Rowe DC, Gulley BL. Sibling effects on substance use and delinquency. *Criminology*. 1992; 30:217–233.
- Rowe DC, Rodgers JL, Meseckbushey S. Sibling delinquency and the family environment: Shared and unshared influences. *Child Development*. 1992; 63:59–67. [PubMed: 1551330]
- Schaefer, ES.; Edgerton, M. *The sibling inventory of behavior*. Chapel Hill, NC: University of North Carolina; 1981.

- Slomkowski C, Rende R, Conger KJ, Simons RL, Conger RD. Sisters, brothers, and delinquency: Evaluating social influence during early and middle adolescence. *Child Development*. 2001; 72:271–283. [PubMed: 11280484]
- Snyder J, Bank L, Burraston B. The consequences of antisocial behavior in older male siblings for younger brothers and sisters. *Journal of Family Psychology*. 2005; 19:643–653. [PubMed: 16402880]
- Spitz E, Moutier R, Reed T, Busnel MC, Marchaland C. Comparative diagnoses of twin zygosity by SSLP variant analysis, questionnaire, and dermatoglyphic analysis. *Behavior Genetics*. 1996; 26:55–63. [PubMed: 8852732]
- Walden B, McGue M, Iacono WG, Burt SA, Elkins I. Identifying shared environmental contributions to early substance use: The respective roles of peers and parents. *Journal of Abnormal Psychology*. 2004; 113:440–450. [PubMed: 15311989]
- Zill, N. Behavioral Problems Scale developed for the 1981 Child Health Supplement to the National Health Interview Survey. Washington, D.C: Child Trends, Inc; 1985.

**Table 1**  
Means, Standard Deviations, and Bivariate Correlations among the Study Variables

Variables	Informants	M	SD	1	2	3	4	5	6
1 Externalizing problems at Time 2	Self	8.35	4.80	1.00					
2 Externalizing problems at Time 1	Self	8.25	4.89	0.41**	1.00				
3 Sibling aggression at Time 1	Sibling	14.02	3.76	0.12**	0.10**	1.00			
4 Sibling aggression at Time 1	Mother	14.82	3.20	0.16**	0.13**	0.33**	1.00		
5 Sibling aggression at Time 1	Father	14.14	3.22	0.16**	0.10**	0.22**	0.53**	1.00	
6 Mothers' punitive discipline at Time 1	Self	3.98	3.08	0.21**	0.32**	0.09*	0.14**	0.12**	1.00

Note.

\*  $p < .05$ .

\*\*  $p < .01$ .  $N = 780$ .



**Table 2**

Within-Sibling Intraclass Correlations for Externalizing Problems at Time 2

	<u>N (pairs)</u>	<u>Correlation coefficients</u>
MZ twins	62	0.59
DZ twins	73	0.21
Full siblings in nondivorced families	58	0.10
Full siblings in stepfamilies	94	0.13
Half siblings	60	<0.01
Genetically unrelated siblings	43	0.22

Table 3

Fixed Effects for Externalizing Problems at Time 2

	Externalizing Problems at Time 2					
	Model 1		Model 2		Model 3	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
Intercept	8.20 **	0.24	8.23 **	0.23	8.27 **	0.23
Externalizing problems at Time 1	0.36 **	0.03	0.36 **	0.03	0.36 **	0.03
Sex <sup>a</sup>	0.36	0.33	0.34	0.33	0.28	0.33
Age difference between siblings <sup>b</sup>	-0.01	0.08	-0.02	0.08	-0.01	0.08
Mother's punitive discipline at Time 1	0.12 *	0.05	0.12 *	0.05	0.11 *	0.05
Sibling aggression at Time 1						
Sibling's report	0.10 **	0.04	--	--	--	--
Mother's report	--	--	0.11 *	0.05	--	--
Father's report	--	--	--	--	0.15 **	0.05
Sibling aggression at Time 1 × Age difference <sup>b</sup>						
Sibling's report	0.01	0.02	--	--	--	--
Mother's report	--	--	0.04	0.03	--	--
Father's report	--	--	--	--	0.02	0.02
AIC	4474.1		4495.7		4472.5	

Note.

<sup>a</sup> Sex=0 for girls, 1 for boys.

<sup>b</sup> Age difference between siblings is a relative difference score calculated by subtracting sibling's age from the focal child's age. All the predictors are centered at their means. AIC = Akaike's Information Criterion.

\* p<.05.

\*\* p<.01.

**Table 4**

Coefficient estimates of the cross-lagged model.

	Informant of sibling aggression		$\beta_{23}$	$\beta_{41}$	$\beta_{21}$	$\beta_{43}$	$\psi_{13}$	$\psi_{24}$
Model 1	Sibling		0.08*	0.04	0.37**	0.40**	0.10**	0.08**
Model 2	Mother		0.11**	0.01	0.61**	0.40**	0.15**	0.10**
Model 3	Father		0.12**	0.00	0.67**	0.40**	0.10**	0.03

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

\*  $p < .05$ ,

\*\*  $p < .01$ .