

A Longitudinal Investigation of the Associations Among Parenting, Deviant Peer Affiliation, and Externalizing Behaviors: A Monozygotic Twin Differences Design

Jinqin Hou,¹ Zhiyan Chen,¹ Misaki N. Natsuaki,² Xinying Li,¹ Xiaodong Yang,¹ Jie Zhang,¹ and Jianxin Zhang¹

¹Key Laboratory of Mental Health, Institute of Psychology, Chinese Academy of Sciences, Beijing, China

²Department of Psychology, University of California, Riverside, CA, USA

Non-shared parenting and deviant peer affiliation are linked to differences in externalizing behaviors between twins. However, few studies have examined these two non-shared environments simultaneously. The present study examined the transactional roles of differential parenting (i.e., warmth and hostility) and deviant peer affiliation on monozygotic (MZ) twin differences in externalizing behaviors using a two-wave longitudinal study of twins and their parents. The sample consisted of 520 pairs of MZ twins (46.5% males, 53.5% females), with a mean age of 13.86 years ($SD = 2.10$) at the T1 assessment, residing in Beijing, China. The association between non-shared hostility in parenting and adolescent externalizing behaviors was mainly explained by a child-driven effect whereby the twin with a higher level of externalizing behaviors than his or her co-twin was more likely to receive more hostility from the parents. Similarly, the relationship between deviant peer affiliation and adolescent externalizing behaviors supported the selection effect whereby the twin with a higher level of externalizing behaviors than his or her co-twin was more likely to affiliate with deviant peers. The theoretical and practical implications of these findings are discussed.

■ **Keywords:** non-shared environment, parenting, deviant peer affiliation, externalizing behaviors, twins

Siblings who are born and raised by the same parents are often remarkably different from one another, even for monozygotic (MZ) twins who have identical genetic makeup (Kendler, 1993; Plomin & Daniels, 1987; Rowe, 1981). Child-specific experiences that contribute to the uniqueness of each sibling are referred to as non-shared environment (Plomin & Daniels, 1987; Rowe, 1981). In a recent review, Plomin and Daniels (2011) reiterated the important effect of non-shared environment on individual development. Since the seminal paper by Plomin and Daniels (1987), extensive efforts have focused on identifying the environment that is specific to each child and associating these non-shared experiences with sibling differences in developmental outcomes. Moreover, researchers have attempted to investigate the causal nature of the relationship between differential experiences and differences in siblings' behaviors (Plomin et al., 2001). However, rigorous testing of non-shared environmental influence is difficult because of the complex interplay between genes and environments, such as

gene–environment correlation and gene–environment interaction (Plomin et al., 1977; Rutter & Silberg, 2002). One way to address this challenge is through the MZ differences approach. This approach has proven to be an effective way to investigate non-shared environmental influence because reared-together MZ twins share 100% of their genetic materials and shared environment. Accordingly, differences between MZ twins are due to non-shared environmental influences (Burt et al., 2006; Deater-Deckard et al., 2001).

Differential parenting and deviant peer affiliation have been documented as two prominent non-shared environments that account for twins' differences in externalizing

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ADDRESS FOR CORRESPONDENCE: Jianxin Zhang, Key Laboratory of Mental Health, Institute of Psychology, Chinese Academy of Sciences, Mingze Building 334, A-4 Da-tun Road, Chaoyang District, Beijing 100101, China. E-mail: zhangjx@psych.ac.cn

behaviors (Plomin & Daniels, 2011). However, the literature on differential parenting and deviant peer affiliation has developed rather independently, limiting the opportunity to investigate the unique effect of these two non-shared environments as well as the relationship between the two. The overarching aim of the present study was to elucidate the roles of non-shared environments by examining the interplay among parental warmth and hostility, deviant peer affiliation, and externalizing behaviors using the MZ differences design.

Influences of Non-Shared Parenting

Empirical evidence has shown that differential negativity and hostility in parenting behaviors are significantly correlated with MZ differences in conduct behaviors in childhood (Asbury et al., 2003; Viding et al., 2009) and in adolescence (Pike et al., 1996). Longitudinal studies have advanced this knowledge further by showing that a twin who receives less maternal warmth and more negativity at the age of 5 years has more behavioral problems than his co-twin at the age of 7 years (Caspi et al., 2004; Mullineaux et al., 2009). However, the majority of studies have interpreted these findings within a parent-driven framework in which differential parenting is assumed to influence sibling differences in externalizing behaviors. Very few studies have examined the child-driven model in which twin differences in externalizing behaviors may elicit differential parental behaviors. However, it is well known in non-twin literature that children with externalizing problems elicit harsher and less positive parenting from parents (Burke et al., 2008). To date, we know of only one study that has attempted to examine the impact of both child- and parent-driven effects on association between non-shared parent-child conflict and twins' differential externalizing symptoms (Burt et al., 2006), but the study found neither child- nor parent-driven effects with the community sample. Prompted by the mounting evidence that has elucidated the bi-directional relationships between parenting and externalizing behaviors in both phenotypic studies and behavioral genetic studies (Burt et al., 2005; Ge et al., 1996; Neiderhiser et al., 1999), the current study examined the influences of both parent- and child-driven effects on the association between non-shared parenting behaviors and twin differences in externalizing problems.

An additional feature of this study is its investigation of fathers' parenting behavior. Empirical studies have indicated that the roles of mothers and fathers in children's development are distinct and complementary (Chen et al., 2000; Connell & Goodman, 2002; Stolz et al., 2005). Given this knowledge, the present study examined the roles of mothers and fathers separately.

Influences of Non-Shared Deviant Peer Affiliation

There is a consensus among scholars that peer group is an important environment in adolescence (Harris, 1998).

Empirical work has shown that every sibling develops peer relationships that are unique to him or her and that serve as non-shared environments that make siblings different (Bullock et al., 2006; Iervolino et al., 2002). For example, Iervolino and colleagues (2002) found that the majority of the variance in adolescents' self-reported peer group delinquency was explained by non-shared environment. Similar results were found in another study that used teachers' report of peer deviance and observers' ratings of deviant peer processes (Bullock et al., 2006). Interestingly, twin differences in deviant peer affiliation and in externalizing behaviors appear to be reciprocally associated via socialization and selection effects, depending on the developmental stage (Burt et al., 2009; Kendler et al., 2008; Vitaro et al., 2011). For instance, Vitaro and his colleagues (2011) found that twin differences in the aggression levels of friends significantly predicted increased differences between the twins in aggression in childhood, supporting the socialization effect. Two other studies focusing on adolescents supported the selection effect, indicating that individuals with more externalizing behaviors than their co-twins selectively affiliated with more deviant peers similar to themselves (Burt et al., 2009; Kendler et al., 2008).

The Transactional Model of Development

To further illuminate the pathways by which non-shared parenting, deviant peer affiliation, and sibling differences in externalizing problems are related, we used the transactional model of development (Sameroff, 1975) as our theoretical framework. According to the transactional model, the development of a child is a product of continuous bidirectional interaction of the child and the environment. Transactions between the child and the environment go beyond relationships between parents and children; children and their parents are also involved in many ecological settings that change and are changed by their participants, such as peer groups. This view is consistent with Bronfenbrenner's (1979) bioecological theory, which suggests that the inter-relationships among multiple settings affect child development. Previous studies have focused on the bidirectional relationship between non-shared parenting behavior and twins' differences in externalizing behaviors (Burt et al., 2006; Caspi et al., 2004) as well as the bidirectional relationship between non-shared deviant peer affiliation and twins' differences in externalizing behaviors (Burt et al., 2009; Vitaro et al., 2011). However, to our knowledge, no study has focused on the relationship between parenting and deviant peer affiliation in terms of a non-shared environmental mediation effect in adolescence. Therefore, the current study addresses this gap in the literature by evaluating the bidirectional relationship between non-shared parenting behavior and non-shared deviant peer affiliation.

The Present Study

The aim of the current study was to examine the effect of non-shared environments on twins' differential externalizing behaviors from a transactional perspective using a cross-lagged design. First, the reciprocal relationship was examined between non-shared parental warmth/hostility and twins' differences in externalizing behaviors. Mounting evidence has indicated that child's oppositional behaviors elicit conflictive reactions from his or her parents (Anderson et al., 1986; Burt et al., 2005; Ge et al., 1996). Extending this finding further, we expected the child-driven effect was also evident in non-shared parent-child interactions; that is, the twin with more externalizing behaviors would elicit more parental hostility and less warmth than his or her co-twin. Second, the reciprocal relationship was examined between non-shared deviant peer affiliation and twins' differences in externalizing behaviors. We expected to observe the social selection effect; we hypothesized that twins with more externalizing behaviors would affiliate with more deviant peers than their co-twins. Third, our examination explored the relationship between the two non-shared environments, that is, parenting and deviant peer affiliation in influencing twin differences in externalizing problems.

Method

Participants

The current investigation was based on the data from the Beijing Twin Study (BeTwiSt). The BeTwiSt is an ongoing longitudinal investigation of 1,387 families with one pair of school-aged twins residing in Beijing, China. Detailed information regarding sampling and recruitment is available in the study by Chen et al. (2013). The BeTwiSt consists of different types of twins, including MZ twins, same-sex dizygotic (DZ) twins, and different-sex DZ twins. Zygosity was determined by both zygosity questionnaire (Cohen et al., 1975; Goldsmith, 1991) and DNA testing. Approximately 10.5% of zygosity was identified by questionnaires, with a 90.6% predictive accuracy, and 89.5% of zygosity was identified by DNA (Chen et al., 2010). The present investigation is based on the first two waves of the BeTwiSt. The first wave of data collection (T1) was conducted in 2008–2009, followed by the second data collection (T2) in 2010–2011.

The analytical sample for this study focused on MZ twins who lived together, and 77.5% (520 out of 671 MZ twin pairs) of the MZ twins met the criterion. Therefore, the present study consisted of 520 same-sex MZ pairs (242 males, 278 females) who were reared together, and roughly 1.5 years after the T1 assessment, 396 (76.2% of the original sample) pairs of MZ participants completed the T2 assessment. There was no difference in behavioral problems or deviant peer affiliation between the twins who completed the T2 assessment and those who did not. However, those who did not complete the T2 assessment reported higher maternal hostility than those who completed the assessment

($t = 2.33, p < .01$). The age of participants in the current investigation ranged from 10 to 18 years, with an average age of 13.86 years ($SD = 2.10$) at the T1 assessment. Approximately 95.6% of the twins resided with both parents; 0.8% of them experienced parental separation, and 3.6% of them experienced parental divorce by the T2 assessment. Approximately 92% of the sample was Han Chinese, and 30% of the parents had a college degree or higher. The average age of mothers and fathers at T1 were 39.78 years ($SD = 3.98$) and 41.32 years ($SD = 4.24$), respectively. More than 90% of the families had an average or well-off family economic condition.

Measures

In each wave, mothers and fathers reported their own warmth and hostility toward each twin, and one of the parents reported the twins' externalizing behaviors and deviant peer affiliation of both twins (approximately 67% of the reporters of the parent report were mothers). The adolescents reported their perceived maternal and paternal warmth and hostility, their own externalizing behaviors, and their deviant peer affiliation.

Parental warmth and hostility. At T1 and T2, mothers and fathers reported their own parenting behaviors (i.e., warmth and hostility) toward each twin, and each twin reported the parental warmth and hostility he or she received from the mother and the father. Parental warmth and hostility were measured via scales adapted from the Iowa Youth and Families Project (Conger et al., 1995). Using a 5-point scale ranging from 1 (*never*) to 5 (*always*), participants rated items intended to measure two dimensions of their mothers' and fathers' parenting: warmth and hostility. These measures of parental warmth and hostility have been used in previous studies conducted in the United States (Ge et al., 1996; Kim et al., 2003) and have been validated in a Chinese adolescent sample (Guo et al., 2011). *Parental warmth* (seven items, with Cronbach's alpha ranging from 0.85 to 0.91 for mothers', fathers', and adolescents' reports) measured the frequency with which parents expressed warmth and support toward their children. The correlation between adolescent-report and mother-report on this dimension was 0.37 ($p < .01$) and the correlation between adolescent-report and father-report was 0.36 ($p < .01$) at the T1 assessment. At the T2 assessment, these were 0.42 ($p < .01$) and 0.40 ($p < .01$), respectively. *Parental hostility* (six items, with Cronbach's alpha ranging from 0.83 to 0.86 for three informants) indicated how often parents expressed specific negativity and anger toward their children. The correlation between adolescent-report and mother-report on this dimension was 0.36 ($p < .01$) and the correlation between adolescent-report and father-report was 0.34 ($p < .01$) at the T1 assessment. At the T2 assessment, these were 0.46 ($p < .01$) and 0.43 ($p < .01$), respectively.

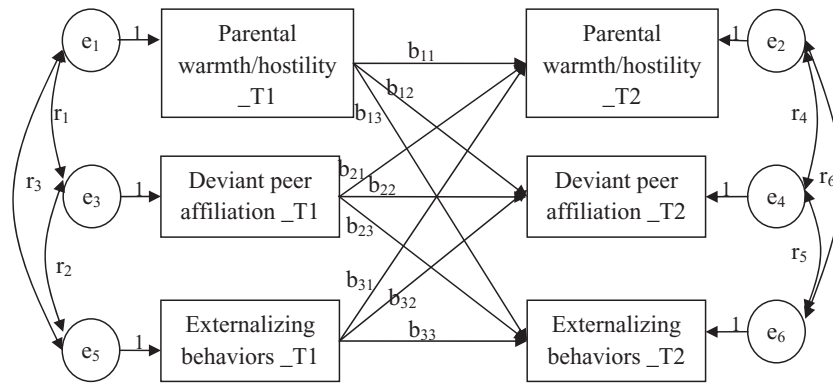


FIGURE 1

Cross-lagged model of twin differences scores in parental warmth/hostility, deviant peer affiliation, and externalizing behaviors across two waves. Cross-wave paths (i.e., partial regression coefficients) are indicated by a 'b' followed by two numerals. Within wave correlations are indicated by an 'r' followed by a single numeral. The residual variance is represented by an 'e' followed by a single numeral.

In order to capture the unique information provided by different informants, the average scores of the adolescents' and parents' reports on parental warmth and hostility were used in the current study (see Burt et al., 2006). Then we subtracted the score of a randomly assigned twin from that of the co-twin to create the MZ differences scores for parental warmth and hostility for mothers and fathers.

Externalizing behaviors. The aggressive and delinquent subscales of the Youth Self-Report Inventory (YSR; Achenbach & Rescorla, 2001) were used to assess adolescents' externalizing behaviors. On a 3-point scale of 0 (*not true*), 1 (*somewhat or sometimes true*), and 2 (*very true or often true*), adolescents indicated the extent to which they had committed specific behaviors in the past six months at the T1 and T2 assessments ($\alpha = 0.92$ at both assessments). This measure was translated into Chinese and used widely in previous research (e.g., Leung et al., 2006). Parents responded to the Children Behavior Checklist (CBCL; Achenbach & Rescorla, 2001) to measure their children's problem behaviors ($\alpha = 0.92$ at both assessments). The correlations between adolescents' and parents' reports at the T1 and T2 assessments were 0.43 ($p < .01$) and 0.42 ($p < .01$), respectively. The average scores for the adolescents' and parents' reports of externalizing behaviors were computed, and these scores were used to create the twin differences score by subtracting a twin's score from his/her co-twin's score.

Deviant peer affiliation. Twins and parents reported deviant peer affiliation at T1 and T2 using an instrument adapted from the National Youth Survey (Elliott et al., 1989). Twins and their parents were instructed to provide ratings for each twin's peer group, with items scored using a 3-choice response format (1 = *none of my/my child's friends are like that*, 2 = *just a few of my/my child's friends are like that*, 3 = *most of my/my child's friends are like that*). Item ratings were summed to yield a score indexing deviant

peer affiliation (15 items; e.g., 'My friends fight with others', 'their friends run away from home'). The deviant peer affiliation scale demonstrated good consistency reliability (0.87 at T1 and T2 for adolescents' reports; 0.89 at T1 and 0.86 at T2 for parents' report). The correlations between adolescent report and parental report at the T1 and T2 assessments were 0.38 ($p < .01$) and 0.34 ($p < .01$), respectively. Similarly, the average scores for the self- and parental reports on deviant peer affiliation were used to create the twin differences score for deviant peer affiliation.

Analytical Strategies

We used AMOS 17.0 (Arbuckle, 2003) to fit the hypothesized models for the MZ differences approach (Figure 1). The full information maximum likelihood (FIML) raw data technique was used to account for missing data (Little & Rubin, 1987). The cross-wave, within-trait coefficients shown in Figure 1 (i.e., b_{11} , b_{22} , b_{33}) indexed the stability of twin differences in parenting behaviors, deviant peer affiliation, and externalizing behaviors over time while controlling for the cross-lagged contributions of other traits. The cross-lagged coefficients allowed us to determine whether the association between twin differences in parental warmth/hostility and externalizing behaviors was parent-driven (b_{13}) or child-driven (b_{31}) and whether the relationship between deviant peer affiliation and externalizing behaviors was a socialization effect (b_{23}) or a selection effect (b_{32}). The reciprocal relationships between non-shared parenting behaviors and deviant peer affiliation (i.e., b_{12} , b_{21}) were examined after controlling for both stability and any cross-lagged contributions of other traits. Modeling analyses were conducted on signed sibling differences, allowing us to evaluate the direction of any significant effects. For example, a positive cross-lagged coefficient suggests that the twin with more of one trait evidences more of the other (see Burt et al., 2009).

TABLE 1
Descriptive Statistics for Individual Scores and Twin Difference Scores on Parental Warmth/Hostility, Externalizing Behavior, and Deviant Peer Affiliation at T1 and T2 Assessments

Measure	Individual scores			Sibling difference scores		
	M	SD	n	M	SD	n
M-warmth_T1	26.88	4.37	924	0.30	3.16	426
M-hostility_T1	14.36	3.46	945	0.06	2.33	444
F-warmth_T1	23.14	4.72	892	-0.02	3.40	407
F-hostility_T1	13.36	3.45	917	0.20	2.68	426
M-warmth_T2	26.25	4.44	950	-0.19	3.03	349
M-hostility_T2	14.01	3.55	956	-0.24	3.24	345
F-warmth_T2	24.65	5.07	917	-0.04	3.77	337
F-hostility_T2	13.06	3.55	935	-0.18	2.31	348
EXT_T1	7.07	5.31	945	0.05	3.79	441
EXT_T2	7.12	6.01	729	-0.03	4.57	345
Peer_T1	2.36	2.59	945	-0.12	2.27	450
Peer_T2	2.40	2.79	759	0.06	2.37	374

Note: M = mother; F = father; EXT_T1 and T2 = externalizing symptoms at the T1 and T2 assessments; Peer_T1 and T2 = deviant peer affiliation at the T1 and T2 assessments.

Results

Descriptive Statistics

Means, standard deviations, and bivariate correlations of the study variables are presented in Tables 1 and 2. The twin differences in parental warmth and hostility showed moderate stability across two waves ($r = .17-.37, p < .01$). Twins' differences in externalizing behaviors were also moderately stable over time ($r = .37, p < .01$).

Cross-Lagged Analyses

Table 3 shows the results for the interplay among differential parental warmth/hostility, differential deviant peer affiliation, and differential externalizing behaviors. First, twin differences in externalizing behaviors at T1 significantly predicted differential parental hostility at T2 ($b_{31} = 0.12, p < .05$ for maternal hostility and $b_{31} = 0.14, p < .05$ for paternal hostility) after controlling for stability and the relationship between differential deviant peer affiliation and differential externalizing behaviors. Second, twin

differences in externalizing behaviors at T1 significantly predicted twin differences in deviant peer affiliation at T2 ($b_{32} = 0.15-0.17, p < .01$) after controlling for stability and the relationship between differential parenting behaviors and differential externalizing behaviors longitudinally. Third, differential deviant peer affiliation at T1 marginally negatively predicted differential parental hostility at T2 ($b_{21} = -0.10, p < .1$ for maternal hostility and $b_{21} = -0.11, p < .1$ for paternal hostility).

To examine the possibility of whether the aforementioned model functioned differently depending on the gender of the child, we conducted a series of multi-group cross-lagged models by gender. When we constrained the parameter estimates of interest across gender, the fit was good ($\chi^2_{(4)} = 2.76-9.00$ for parental warmth/hostility, *ns*). This finding indicated that the non-shared interplay among parenting, deviant peer affiliation, and externalizing behaviors did not vary across gender of the twin.

Discussion

The aims of the present study were to explore the roles of two types of non-shared environments, parenting (i.e., warmth and hostility), and deviant peer affiliation in differentiating twins' externalizing behaviors. This is one of the first attempts to apply a longitudinal MZ twin differences design to examine the transactions between non-shared environments and externalizing problems. The cross-lagged analyses revealed little evidence in support of the non-shared parental hostility and deviant peer affiliation as a cause of twin differences. Instead, the findings suggested that each twin creates his or her own unique environmental niche in family and peer contexts based on his or her pre-existing externalizing behaviors.

Child-Driven Effect and Selection Effect in Adolescence

The child-driven effect was evident between non-shared parental hostility and twin differences in externalizing be-

TABLE 2
Correlations Among Twin Differences Scores on Parenting, Deviant Peer Affiliation and Externalizing Symptoms at T1 and T2 Assessments

Measure	1	2	3	4	5	6	7	8	9	10	11	12
1. M-warmth_T1	1.00											
2. M-hostility_T1	-0.24**	1.00										
3. F-warmth_T1	0.45**	-0.14**	1.00									
4. F-hostility_T1	-0.14**	0.45**	-0.26**	1.00								
5. M-warmth_T2	0.23**	-0.10	0.24**	-0.13	1.00							
6. M-hostility_T2	-0.05	0.37**	0.01	0.21**	-0.14*	1.00						
7. F-warmth_T2	0.19**	0.01	0.37**	-0.21**	0.52**	-0.07	1.00					
8. F-hostility_T2	-0.06	0.18**	-0.02	0.17**	-0.10	0.22**	-0.21**	1.00				
9. EXT differences_T1	-0.15**	0.12**	-0.12**	0.19**	-0.06	0.17**	-0.02	0.12*	1.00			
10. EXT difference_T2	-0.02	0.10	-0.13**	0.10	-0.20**	0.12*	-0.14*	0.24**	0.37**	1.00		
11. Peer difference_T1	-0.19**	0.07	-0.15**	0.19**	-0.02	-0.04	-0.00	-0.04	0.30**	0.17**	1.00	
12. Peer difference_T2	-0.01	-0.02	-0.08	0.08	-0.17**	0.01	-0.12*	0.07	0.12*	0.51**	0.09	1.00

Note: M = mother; F = father; EXT differences_T1 and T2 = twin differences in externalizing symptoms at T1 and T2 assessments; Peer differences_T1 and T2 = twin differences in deviant peer affiliation at T1 and T2 assessments.* $p < .05$;** $p < .01$.

TABLE 3
Standardized Path Estimates from the MZ Differences Cross-Wave Model

Model	Pathways									Model fit			
	b ₁₁	b ₂₂	b ₃₃	b ₁₂	b ₁₃	b ₂₁	b ₂₃	b ₃₁	b ₃₂	χ ²	df	AIC	RMSEA
M-Warmth	0.24****	0.06	0.38****	0.01	0.05	0.04	0.05	-0.07	0.16***	5.15	4	67.15	0.02
M-Hostility	0.38****	0.05	0.37****	-0.06	0.00	-0.10*	0.04	0.12**	0.17***	3.70	4	65.70	0.00
F-Warmth	0.41****	0.05	0.37****	-0.08	-0.08	0.06	0.04	0.00	0.15***	5.31	4	67.31	0.03
F-Hostility	0.17***	0.05	0.38****	0.07	0.02	-0.11*	0.04	0.14**	0.15***	3.27	4	65.27	0.00

Note: The pathways and correlations correspond to those presented in Figure 1. **** $p < .001$; *** $p < .01$; ** $p < .05$; * $p < .1$.

haviors such that the twin with a higher level of externalizing problems was more likely to elicit parental hostility than his or her co-twin. The discrepancy between the present study and the study by Burt et al. (2006), which did not find a child-driven effect, may be a function of different dimensions of parenting. The present investigation was more concerned with the affective component of parental behavior toward each twin, whereas Burt et al. (2006) focused on parent-child conflict. Second, we found evidence for a selection effect in that the twin with higher levels of externalizing behaviors was more inclined to affiliate with deviant peers than his or her co-twin. This finding remains significant even after controlling for the stability of twin differences in externalizing behaviors and parenting behaviors. This finding is consistent with a recent study on adolescent twins in the United States (Burt et al., 2009), which found that deviant peer affiliation appears to be a non-shared environmental consequence of externalizing behaviors rather than a non-shared environmental cause of these behaviors. As youths gain greater independence and begin spending more time with peers outside their home during adolescence (Shaw & Bell, 1993), they begin to actively shape their social environment and experiences (Pardini et al., 2005; Scarr & McCartney, 1983). Overall, these findings provide evidence that the child need to be considered as an active influencer (and potential driver) of socialization (Plomin & Daniels, 2011). The environmental niches that each twin chose in the context of family and peer were not independent. Interestingly, the twin with more deviant peers, in turn, received less hostility from the parents than the co-twin. One plausible interpretation of these findings is that parents withdraw from rather than confront their children (Brown, 1990; Patterson, 1970, 1982) as their effort to avoid further damaging the parent-child relationship (Dishion et al., 1996; Monahan et al., 2009). The present study advances knowledge by showing that a non-shared environment mediation effect partially accounts for the transactional relationship between parenting behavior and deviant peer affiliation.

Given the current finding that twins' differences in externalizing behaviors in adolescence is a precursor of non-shared parental hostility and deviant peers, rather than vice versa, one question remains: What accounted for MZ differences in externalizing behaviors in the first place? Empirical research identifies non-shared parenting (Caspi

et al., 2004; Mullineaux et al., 2009), non-shared peer group (Vitaro et al., 2011), and different perceptions of classroom (Oliver et al., 2008) to be the contributors of MZ twins' differences in externalizing behaviors in childhood. However, the causal relations of non-shared parenting and peer group appear to be limited in adolescence. Generally speaking, the existing findings are consistent with the proposal that non-shared environment should be reconceptualized as a factor that transiently shapes adolescents' behaviors at a given age (Burt et al., 2009; Turkheimer & Waldron, 2000). That is, non-shared environmental influences at any given age (e.g., childhood) are significantly different from those at any other age (e.g., adolescence; Plomin et al., 2001). Furthermore, there is a body of literature suggesting that parenting has effect on externalizing behaviors via shared environmental mechanisms in adolescence (e.g., Burt et al., 2005, 2007; Klahr et al., 2011). Thus, differential parenting (and peer relations) in childhood may still exert a direct influence on twin differences in externalizing behavior, which further influences differential parenting and peer experiences in adolescence.

The current study generated several implications. First, studies of non-shared environments and children's externalizing problems need to pay attention to the reciprocal effect between differential experiences and differential outcomes because these exist in a dynamic cycle. Second, researchers are encouraged to examine the interplay between different non-shared environments (e.g., family, peers) on adolescent development. As the transaction model suggests, non-shared environments in different contexts appear to be interactive, rather than independent. Acknowledgment of this complexity in the structure of multiple contexts may accelerate the progress in future studies of non-shared environmental influences.

Strengths and Limitations

Several methodological strengths bolstered the credence of the findings reported in this study. First, to our knowledge, this is the first study to examine relations between two different types of non-shared environments in a longitudinal study of MZ twins by considering their stability and relationship with externalizing behaviors. Second, data from multiple informants (i.e., father, mother, and twins) were used in this study to fully capture adolescent behaviors and the family environment.

However, several methodological limitations warrant caution in the interpretation of the results. First, our measure of deviant peer affiliation was based on questionnaires. Thus, it remains uncertain whether our measure reflected the twins' differences in exposure to deviant peers who were not shared by the twins or the twins' differences in perceptions of peers whom the twins shared. However, empirical evidence suggested that the individual perceptions of the environment are also important to development (Iannotti & Bush, 1992). Second, as mentioned, the origins of MZ twin differences in externalizing behaviors at T1 remain unexplored. Thus, future researchers should examine childhood precursors of MZ twin differences in externalizing behaviors. Third, only two waves of data were available for this study, making it difficult to delineate complex pathways among parenting, deviant peers, and the development of externalizing problems over an extended period. Fourth, the magnitude of effects observed in this study, albeit statistically significant, was rather modest. This limitation is important when translating the present results to a prevention or intervention framework. It should be emphasized, however, that effect sizes are plausibly and even necessarily small given the complexity in human behaviors (Ahadi & Diener, 1989).

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