Social Experiences in Kindergarten and Academic Achievement in Grade 1: A Monozygotic Twin Difference Study

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Abstract

The first goal of this study was to examine how different types of social experiences in kindergarten relate to grade 1 academic achievement, while controlling for possible genetic and shared environmental influences through the use of the Monozygotic (MZ)-twin difference method. Social experiences in kindergarten included: relationship quality with the larger peer group (i.e., rejection and victimization), relationship quality with one's best friend, and relationship quality with the teacher. Control variables included parental hostility-coercion, child cognitive skills and externalizing problems and equivalent social experiences in grade 1. 223 MZ twin pairs aged 6 years at time 1 (T1) and 7 years at time 2 (T2) participated in the study. Results showed that within-pair differences in peer rejection and in poor teacher-child relationship quality at T1 uniquely predicted differences in MZ twins' academic achievement at T2. Mechanisms that could account for the possible causal role of these social experiences in regard to children's school achievement are discussed.

Keywords: Academic Performance, Peer Relations, Friendship, Teacher-Child Relationship, Monozygotic Twins

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Academic achievement during the early grades is a critical determinant of later school success and psychosocial adjustment (Alexander, Entwisle, & Kabbani, 2001; Jimerson, Egeland, Sroufe, & Carlson, 2000). In turn, academic achievement is predicted by children's cognitive maturity and socio-family characteristics (Duncan et al., 2007; Ladd, Birch, & Buhs, 1999). It is also predicted by children's social experiences in the classroom (Buhs, 2005; Ladd, Buhs, & Troop, 2002; Parker, Rubin, Price, & DeRosier, 1995; Rubin, Bukowski, & Parker, 1998; Wentzel, Barry, & Caldwell, 2004). In particular, experiences with peers, both at the group and at the dyadic level, and experiences with the teacher are likely to support child learning. Surprisingly, these distinct social experiences have not yet been examined together, such that their unique contribution to academic outcomes remains unknown. Moreover, no studies examined the contribution of social experiences to later academic achievement while controlling for possible confounders such as genetic makeup and socio-family background. The present study examined the contribution of experiences with peers in the classroom, both at the group and at the dyad level, and of experiences with the teacher on children's academic achievement while controlling for genetic and shared environmental factors through the use of the MZ-twin difference method (Vitaro, Brendgen, & Arseneault, 2009).

Social Experiences and Academic Achievement

An important goal of early education is to ensure that children develop the capacity to build positive relations with peers and blend easily into their social group. The importance of developing strong interpersonal skills is supported by studies showing that rejection by peers predicts a decline in academic performance during the early grades (Buhs & Ladd, 2001; Buhs,

Ladd, & Herald, 2006; Ladd, Kochenderfer, & Coleman, 1997), as well as later in school (Juvonen, Nishina, & Graham, 2000; Schwartz, Gorman, Nakamoto, & Toblin, 2005; Véronneau, Vitaro, Brendgen, Dishion, & Tremblay, 2010). Peer group rejection occurs when a non trivial number of peers dislike a given child (Bukowski & Hoza, 1989). Despite its strong predictive power, peer rejection refers to an affective reaction (i.e., dislike), rather than to a behavior, and many peers do not act upon their negative attitudes towards others (Boivin & Hymel, 1997). Hence, peer rejection results more in reduced opportunities for positive interactions than in actual negative interactions with peers. Only on occasion does peer rejection lead to peer victimization, which has also been found to predict academic problems at school entry or in later elementary school (Hatzichristou & Hopf, 1996; O'Neil, Welsh, Parke, Wang, & Strand, 1997; Schwartz, Gorman, Nakamoto, & McKay, 2006; Schwartz et al., 2005; Wentzel & Caldwell, 1997). Given their partial empirical overlap (Boivin, Hymel, & Hodges, 2001), it is not clear whether peer rejection and peer victimization uniquely predict academic achievement. To our knowledge, only two longitudinal studies (both from Ladd and colleagues) have examined the contribution of both peer experiences to school achievement. Ladd et al. (1999) found that low peer acceptance, but not peer victimization, in the Fall of kindergarten predicted a decrease in school performance (i.e., academic readiness) by the Spring of the same academic year. In a follow-up study, Buhs and colleagues (2006) found that peer exclusion (similar to peer rejection) during the early grades, but not peer abuse (similar to peer victimization), was a significant predictor of poor academic achievement by the end of elementary school. They also showed that this prediction was mediated by reduced classroom participation (i.e., self-regulatory skills and positive orientation towards schoolwork).

These findings suggest that peer victimization does not play a role in early school performance when controlling for peer rejection. When not controlling for peer rejection, a few studies found significant cross-sectional or longitudinal associations between peer victimization and academic performance (Nakamoto & Schwartz, 2010; O'Neil et al., 1997; Perry, Hodges, & Egan, 2001; Schwartz et al., 2005), although other studies did not even without such control (Iyer, Kochenderfer-Ladd, Eisenberg, & Thompson, 2010; Woods & Wolke, 2004). In sum, it is likely that peer victimization does not predict school achievement above and beyond peer rejection. However, the empirical evidence to support this claim is scarce. Accordingly, the present study considered both experiences simultaneously in predicting early academic performance.

Peer rejection and peer victimization reflect the quality of children's social experiences at the group level, but not at the dyadic level, such as children's experiences with their best friend. A positive relationship with a friend has been found to predict academic competence, independently of experiences at the group level (Erath, Flanagan, & Bierman, 2008; Ladd, Kochenderfer, & Coleman, 1996). By enhancing motivation towards school and supporting academic work, a positive friendship could positively influence school performance (Wentzel, 2009). However, friendships do not only entail positive experiences. They also include conflicts and, sometimes, aggressive acts from the friend that are reminiscent of aggressive victimization by the peer group (Crick & Nelson, 2002; Daniels, Quigley, Menard, & Spence, 2010; Mishna, Wiener, & Pepler, 2008; Waasdorp, Bagdi, & Bradshaw, 2010). These negative features of friendship quality are partly independent of any positive features that are also present (Berndt, 1996). Hence, to reflect the overall quality of a friendship, both dimensions are required. Since only the positive features of friendship have been examined in regard to academic achievement

in past studies, it is unclear whether low quality friendships (i.e., that are characterized by a high level of negative features and a low level of positive features) can hinder academic achievement once negative experiences with the general peer group (peer rejection and peer victimization) are controlled.

The quality of the child-teacher relationship also predicts academic achievement (Baker, 2006; Birch & Ladd, 1997; Brendgen, Wanner, & Vitaro, 2006; Hamre & Pianta, 2001). Students who enjoy a positive and warm relationship with their teacher tend to perform better academically than those who experience a negative and conflicting relationship. However, the quality of the teacher-child relationship and the quality of social experiences at the group level are correlated. This may be because peers and teachers influence each other or because they react in a similar way to children's characteristics (Howes, Hamilton, & Matheson, 1994; Mercer & DeRosier, 2008). Two studies have shown that the quality of the teacher-adolescent relationship predicts academic outcomes over and above experiences with peers (Furrer & Skinner, 2003; Wentzel & Asher, 1995), but it is not clear if this is also the case with younger students. It is not clear either whether the quality of the child-teacher relationship or experiences with peers or friends play a role once possible genetic confounds are controlled.

Genetically Driven Links?

Quantitative twin studies suggest that genetic factors predict an important portion of children's early academic performance (Harlaar, Dale, & Plomin, 2005; Lemelin et al., 2007; Oliver et al., 2004; Walker, Petrill, Spinath, & Plomin, 2004). Importantly, however, only approximately 50% of the variance with respect to twins' academic performance at school entry is explained by genes (.41 in the present study). The rest of the variance is accounted mostly by non shared environmental factors (Byrne et al., 2008; Harlaar et al., 2005; Oliver et al., 2004;

Walker et al., 2004), or equally by shared and non shared environmental factors (Lemelin et al., 2007). As suggested by past studies, social experiences with peers and the teacher may be especially important non shared environmental factors. These factors are referred to as non-shared because they tend to result in twin dissimilarity (Plomin & Daniels, 1987). However, the links between experiences with peers or the teacher and academic performance can also result from evocative Gene-Environment correlations (rGE), (Plomin, DeFries, & Loehlin, 1977; Rutter, Moffitt, & Caspi, 2006; Shanahan & Hofer, 2005). An evocative rGE refers to a process whereby individuals' genetic dispositions to a phenotypic manifestation such as low academic achievement (or its precursor, i.e., low cognitive skills) evoke specific reactions from the environment such as rejection by the peer group, victimization by classmates, low quality friendships, or a low quality relationship with the teacher. In other words, the links between social experiences and academic achievement may be partially or completely explained by common underlying genetic influences. To date, however, no study has controlled for possible rGE when examining the links between academic functioning and social experiences with peers, friends, or teacher.

In the present study, putative genetic effects were controlled through the use of the monozygotic (MZ) twin difference method (Moffitt & Caspi, 2007; Pike, Reiss, Hetherington, & Plomin, 1996; Rutter, Pickles, Murray, & Eaves, 2001; Vitaro et al., 2009). With this method, within-MZ-pair-differences in peer, friend, and teacher experiences can be related to within-MZ-pair-differences in academic achievement. This is a direct and powerful method to identify specific non shared environmental factors that play a role independently of genetic factors, which are controlled because reared-together MZ twins share 100% of their genes. Reared-together MZ twins also share a number of socio-family and school environmental influences. In consequence,

virtually all *shared* environmental factors that might play a role with respect to academic achievement would also be controlled with the MZ twin difference method. However, other *non shared* factors -- such as a negative parent-child relationship, which has also been found to predict children's peer and teacher experiences (Pianta, 1999) as well as academic achievement (McLoyd, 1998) -- may need to be specifically controlled in the MZ twin difference method in order to examine peer and teacher experiences unencumbered by other social factors known to influence academic achievement. In the present study, differences in parental hostility-coercion as well as baseline differences in twins' pre-academic skills (i.e., school readiness) and in externalized behavior problems (i.e., inattention, hyperactivity, disruptive behavior) were controlled because these variables have been found to predict academic performance (Duncan et al., 2007) as well as negative experiences with peers and the teacher (Brendgen, Wanner, Vitaro, Bukowski, & Tremblay, 2007; Hughes, Luo, Kwok, & Loyd, 2008; Pianta & Stuhlman, 2004). Finally, to determine whether peer and teacher experiences in kindergarten have a lingering effect on academic performance one year later, we controlled for concurrent within-pair differences in peer and teacher experiences in grade 1 (see Figure 1 for the full tested model).

Sex as a Possible Moderator

Most of the studies that examined the links between social experiences with peers or the teacher and academic performance during the first school years did not examine sex differences The results of those that did were mixed. In some studies, no sex differences were found (Brendgen, Vitaro, Doyle, Markiewicz, & Bukowski, 2002; Chen, Chang, & He, 2003). In other studies, girls were found to be more affected by the consequences of interpersonal conflict with their peers or their teacher than boys (Crick & Zahn-Waxler, 2003; Greco & Morris, 2005; Little & Garber, 2004; Royer, Provost, Tarabulsy, & Coutu, 2008). Still other studies found that boys

were affected more than girls by conflict with their peers or their friends or by the quality of the relationship with their teacher (Ladd et al., 1996). Consequently, a second goal of the present study was to investigate whether the pattern of results applied equally to male and female twin pairs. Because sample size is relatively small for moderator analysis, this goal was viewed as exploratory. To address these objectives, we used a sample of MZ twins who were followed over a one-year period from kindergarten to grade 1. We focused on this age period for two reasons. First, academic performance in the first grade predicts later school success (Ensminger & Slusarcick, 1992). Second, the links between social experiences in kindergarten and academic achievement in grade 1 are not likely to have been "contaminated" by previous social reputation or school performance.

Method

Participants

The 223 MZ twin pairs (117 female pairs) who participated in the present study were part of an ongoing population-based longitudinal study (The Quebec Newborn Twin Study, QNTS) of twins from the greater Montreal area in the Province of Quebec, Canada. Twins were recruited at birth between November 1995 and July 1998 (N = 648 twin pairs; 254 MZ twin pairs). Eighty-four percent of the families were of European descent, 3% were of African descent, 2% were of Asian descent, and 2% were Native North Americans. The remaining families (9%) did not provide ethnicity information.

The zygosity of same sex twins was assessed at 18 months based on physical resemblance using the Zygosity Questionnaire for Young Twins (ZQYT; Goldsmith, 1991). For a subsample of these same-sex twin pairs who had no obvious physical differences based on face shape, ear shape, hair color, and eye color as indicators (n = 123), DNA was collected to test for

10 highly polymorphous genetic markers. The comparison of zygosity based on the similarity of these genetic markers with zygosity based on the ZQYT revealed a 94% correspondence rate, which is similar to rates obtained in older twin samples (Forget-Dubois et al., 2003). However, since the misdiagnosed cases were likely incorrectly classified as MZ on the basis of the ZQYT, we genotyped all the other pairs with no obvious differences and classified them according to genotyping results. However, we were unable to genotype 17% of these pairs because of parental refusal. For those pairs that could not be genotyped, we re-administered the ZQYT twice after age 18 months and used independent observers to cross-validate parent reports. Dubious cases (*n* = 21) were excluded from the data set.

When children were 5 months old, we compared our twin sample with a representative sample of singletons born in large urban centers in the province of Quebec on family and demographic characteristics (Santé Québec, Jetté, Desrosiers, & Tremblay, 1998). The same percentage of parents in both sample (95%) lived together at the birth of their child(ren); 44% of twins versus 45% of singletons were the first born children in their family; 66% of twin's mothers and 60% of twins' fathers were between 25 and 34 years old compared to 66% of mothers and 63% of fathers for the singletons; 17% of twins mothers and 14% of the twins' fathers had not finished high school compared to 12% and 14% of mothers and fathers respectively for the singletons; the same proportion of mothers (28%) and fathers (27%) in both samples held a university degree; 83% of the twin parents and 79% of singleton parents were employed; 10% of the twin families and 9% of the singleton families received social welfare or unemployment insurance; finally 30% of the twin families and 29% of the singleton families had an annual total income of less than CAN$30,000, 44% (42%) had an annual total income between CAN$30,000 and CAN$59,999; and 27% (29%) had an annual total income of more

than CAN$60,000. These results indicate extremely similar socio-demographic profiles in the twin sample and the representative sample of single births.

The sample was followed longitudinally at 5, 18, 30, 48, 60, 72 and 84 months of age. The present paper uses data from the last two collections when the children were in kindergarten (T1) and grade 1 (T2), although data from past waves were used to compute control variables. The mean age at T1 was 72.7 months (*SD* = 3.6) and 84.5 months (*SD* = 3.5) at T2. To be included in the present study, children needed to have valid data on at least two measures in kindergarten and two measures in grade 1. One hundred fifty pairs had valid data on all the study measures, including control variables. The remaining 73 participating pairs with occasional missing data were included in the analyses using the Full Information Maximum Likelihood method (Arbuckle & Wothke, 1999). In consequence, attrition in this study was 12.2% (254 MZ pairs in the original sample – 223 participating MZ pairs in the present study = 31 MZ pairs lost from the study). Fathers in the remaining study sample had a slightly higher level of education than fathers of the twins who were lost from the study. Retained MZ twins did not differ from non-retained twins in regard to parent-rated temperament at 5 months of age and the remaining socio-demographic measures.

Measures and Procedure

All instruments were administered either in English (21%) or in French (79%), depending on the language spoken by the children, the parents, and the teachers. Instruments that were administered in French but were originally designed in English were translated into French and then translated back into English. Bilingual judges verified the semantic similarity between the back-translated items and the original items in the questionnaire. Prior to data collection, active written consent from the parents of all the children in the classroom was obtained. Data

collection took place in the spring of the school year, to ensure that the teacher and the children were well acquainted with each other. The instruments were approved by the University of Montreal's Institutional Review Board and the school board administrators. Different informants were involved in the data collection: parents provided information about control variables (i.e., parent hostility-coercion); peers were used to assess peer rejection and peer victimization; twins provided data about the relationship quality with their best friend; teachers assessed their relationship with each twin; they also rated twins' cognitive, behavioral, and academic functioning. In kindergarten, 70% of the twin pairs attended different classrooms, whereas 73% of twins did so in first grade.

Peer rejection. At T1 and T2, each twin's level of peer rejection was assessed through peer nominations. Specifically, booklets of several pages with photographs of all the children in a given class were handed out. Two research assistants ensured that all children recognized the photos of all their classmates by presenting them individually. Using one page of the booklet for each new question, the children in the class were asked to circle the photos of three classmates they liked most to play with (positive nominations) and three classmates they least liked to play with (negative nominations). The total number of positive and negative nominations received by each twin were calculated and z-standardized within classroom to account for variability in classroom size (Coie, Dodge, & Coppotelli, 1982). In the literature, a composite score of peer social preference is then usually created by subtracting negative nominations from positive nominations such that a higher score indicates more popularity in the peer group (Buhs & Ladd, 2001; Coie et al., 1982). For the purposes of the present study, however, positive nominations were subtracted from negative nominations such that a higher score reflected more peer rejection. A high level of this variable thus indicated negative social experiences just like all

other measures of social experiences with peers and with teachers used in this study (see next). Mean, standard deviation, range as well as skewness and kurtosis for peer rejection and for all other variables are presented in Table 1.

Peer victimization. At T1 and T2, victimization by peers was also assessed through peer nominations. On the next pages of the booklet used to assess positive and negative peer nominations, the children were asked to circle the photos of two children who best fit a series of positive and negative descriptors. Each descriptor was read out aloud to the class by one of the two research assistants while the other ensured the ratings remained confidential. The two descriptors used to assess peer victimization were selected from the Victimization subscale of the modified Peer Nomination Inventory (Perry, Kusel, & Perry, 1988): "He/she gets hit and pushed by other kids" and "He/she gets called names by other kids". The Victimization subscale of the modified Peer Nomination Inventory has been shown to have good predictive validity and test-retest reliability. Although only two items were used due to the young age of the children, even single-item peer nomination assessments tend to be highly reliable because the scoring is generated on the basis of multiple respondents (e.g., Hodges, Malone, & Perry, 1997; Perry et al., 1988). Moreover, since peer abuse is usually witnessed by other children but not always by adults (O'Connell, Pepler, & Craig, 1999), peers are an excellent source for evaluating the occurrence of peer abuse (Juvonen et al., 2000; Pellegrini & Bartini, 2000).

The total number of nominations was calculated for each participant across both victimization items. Given the moderate correlation between the two peer victimization items ($r = .47$, $p < .001$), the two items were combined into a single peer victimization scale. Following usual procedures for peer-nomination data (Cillessen, 2009), the raw scores of peer the peer

victimization scale were *z*-standardized within classroom to account for differences in classroom size.

Friendship quality with the best friend. At T1 and T2, a research assistant individually administered a modified version of the Friendship Features Interview for Young Children (FFIYC; Ladd et al., 1996) to each twin in reference to his/her nominated best friend in the classroom. Since the majority of the twins were in different classrooms, the best friends were necessarily different for twins from the same pair in these cases. However, when the twins from the same pair were in the same classroom, the second (or third, if necessary) nominated friend was selected when a twin had nominated the same best friend as his or her co-twin. In no case did twins from the same pair nominate the same three friends. Moreover, the twins in the same classroom were specifically instructed not to nominate their co-twin as best friend. For the purpose of this study, three positive and three negative items of the modified version of the FFIYC were used. The three positive items tapped into aspects such as companionship, pleasure, and support. The three negative items tapped into perceived conflict among friends and coercive behaviors initiated by the friend. Each item could be rated 0 (never), 1 (one or two times), 2 (often), or 3 (very often). To be in line with the other measures, we reverse coded the three positive items and added them to the three negative items such that a high total score reflected a low quality relationship (i.e., a relationship with more negative than positive features) (Cronbach's = .74).

Teacher-child relationship. At T1 and T2, teacher ratings of conflict and closeness with the child were collected using items from the Teacher-Child Relationships Scale (STRS). The STRS (Pianta, Steinberg, & Rollins, 1995) is a measure of teacher-perceived relationships with individual students. Conflict items are designed to obtain information about perceived negativity

within the relationship whereas closeness items assess the extent to which the relationship is warm, affectionate, and involves open communication. Significant test-retest correlations and high internal consistency for both conflict and closeness subscales have been established (Pianta et al., 1995). The STRS has also demonstrated predictive and concurrent validity, and is related to current and future academic skills, behavioral adjustment, risk of retention, disciplinary infractions, and peer relations (Birch & Ladd, 1998; Hamre & Pianta, 2001; Pianta et al., 1995). Due to time constraints, each aspect was assessed using two items (Closeness: 'I share an affectionate, warm relationship with this child' and 'This child openly shares his/her feelings and experiences with me'; Conflict: 'This child and I always seem to be struggling with each other' and 'Despite my best efforts, I am uncomfortable with how this child and I get along'). Items were rated on a Likert-type scale ranging from 0 'definitely does not apply' to 4 'definitely applies'. Again, to be in line with the other measures, closeness items were reverse coded and added to the conflict items such that a high total score reflected a low quality teacher-child relationship as perceived by the teacher (Cronbach's alpha = .76).

Control variables. Mothers provided information on their *parenting practices* with respect to each twin when the children were 48- and 60-months-old (T-1). Mothers rated their parenting behaviors using the Parental Cognitions and Conduct toward the Infant Scale (PACOTIS; Boivin, Pérusse et al., 2005). The PACOTIS is a 23-item scale assessing mothers' perceptions about their self-efficacy and their parental impact with regard to their child's behavior as well as their tendency to act in a hostile-coercive or overprotective manner towards their child. Only the hostile-coercive parenting scale was used in this study (e.g., 'How often do you yell at the child?', 'Inflict physical punishment'). Each item could be scored on a six point scale, with higher scores indicating more hostility-coercion. Cronbach's alphas were .76 at 48

months and .79 at 60 months. Given the relatively high correlation between the 48- and the 60-month ratings (r = .62), a total score was calculated across the two data points.

Children's *pre-academic skills* at T1 were assessed with the use of the language and cognitive development scale of the Early Development Instrument (EDI) (Janus & Offord, 2007). The EDI is a multidimensional questionnaire completed by the teacher. Besides cognitive and language development, it taps into several other aspects of child development (physical health, social competence, emotional maturity, communication skills, and general knowledge). We used the language and cognitive development scale because this scale has been shown to reliably predict academic achievement in grade 1 (Forget-Dubois et al., 2007). Its predictive value is comparable to the predictive value of standardized school readiness tests such as the Lollipop (Chew, 1989) and the Peabody Picture Vocabulary Test (Dunn & Dunn, 1997; Hymel, Le Mare, & McKee, in press). The language and cognitive development scale is comprised of 4 sub-domains: Basic numeracy skills, Basic literacy skills, Advanced literacy skills, and Memory. The items of the EDI are rated on different scales. Some items are rated as yes/no and others are rated using 3-point or 5-point Likert scales. Following Janus and Offord's (2007) recommendations, we recoded all items on a scale of 0 to 10. Using this approach, the items of the four subscales were combined into an overall language and cognitive development score (alpha = .88).

At T1, teachers also rated twins' *externalizing problems* over the past 6 months using 12 items from the Social Behavior Questionnaire (SBQ; Tremblay, Vitaro, Gagnon, Piché, & Royer, 1992). These items covered different aspects of externalizing problems in young children: aggression (e.g., gets into fights), opposition (e.g., rebellious, disobedient), hyperactivity (e.g., can't stay still, hyperactive), and inattention (e.g., easily distracted, can't focus). Ratings for each

item ranged from 0 (“does not apply”), to 1 (“applies sometimes”) and 2 (“applies often”). For each child, individual item scores were added to compute scale scores. Internal consistency for the behavioral pathway scale was acceptable (Cronbach’s alpha = .91).

Academic achievement. Children’s academic performance at T2 was assessed using teacher ratings of school performance in four domains (reading, writing, mathematics, and overall achievement). This method of assessing children’s academic performance has been demonstrated to be valid and highly correlated with other measures of school achievement (Demaray & Elliott, 1998; Feinberg & Shapiro, 2003; Hoge & Coladarci, 1989). For each domain, teachers compared the performance of a specific twin relative to his or her classmates on a 5-point Likert scale, where 1 indicated *clearly under average*, 3 indicated *average*, and 5 indicated *clearly above average*. The four assessments were very highly correlated (with *r*s ranging between .74 and .90) and a total school achievement score was therefore calculated (mean of the four ratings) and used in the analyses. Cronbach’s α was .94.

Results

Preliminary Analyses: Individual Scores

We used each twin’s individual scores to first examine the distributional properties of the measures. The descriptive statistics and distributional properties for all study variables are presented in Table 1. Kurtosis and skewness were within the acceptable range. We also verified whether the bivariate correlations between individual scores on all study variables were in the expected direction (Table 2). Since the individual child served as the unit of analysis for these correlations, nonindependence of the data for each pair of twins was accounted for through the use of bivariate correlations derived from a multivariate within twin-pair correlation matrix. Following recommendations by Schielzeth (2010), we z-standardized all independent variables

prior to analysis. This strategy has the advantage that it facilitates the interpretation and comparison of the relative importance of predictors within models by evaluating and comparing the coefficient estimates rather than the p values of effects (Gelman & Hill, 2007).

The correlation pattern illustrated in Table 2 reveals no collinearity problem. It also demonstrates the validity of the pattern of results. First, all three control variables (i.e., parental hostility-coercion, pre-academic skills, and externalized problems in kindergarten) were significantly or nearly significantly related to the outcome, i.e., grade 1 academic achievement. The same control variables were also concurrently related to three of the four social predictors (i.e., peer rejection, peer victimization, and teacher-child relationship). Second, two of the four social predictors in kindergarten (i.e., peer rejection and teacher-child relationship) were predictively related to grade 1 academic achievement. Finally, all four social predictors were moderately stable from kindergarten to grade 1 despite changes in classroom composition and teacher.

Table 3 shows the intra-twin pair correlations with respect to the study variables. MZ twins were similar but not identical with respect to cognitive abilities and academic performance. They were also highly similar on the control variables. Finally, they were moderately similar with respect to social experiences at T1 and T2, except for relationship quality with the best friend at T1.

Preliminary Analyses: Difference Scores

Following the strategy most commonly used in MZ-differences studies (Moffitt & Caspi, 2007; Pike et al., 1996), twin-difference scores were first derived by subtracting one twin's scores from his or her co-twin's score. Twin order in the subtraction equation was determined at random. As such, a high positive value on a given difference score meant that one twin had a

higher value on that variable than his or her co-twin, and vice-versa for a high negative difference. Table 4 presents distributional properties of the difference scores for the whole sample. As can be seen, skewness and kurtosis were in the acceptable range for all difference scores.

We also examined bivariate correlations between difference scores on the predictor, control, and outcome variables. As reported in Table 5, MZ-twin differences in pre-academic skills at T1 were related to MZ-twin differences in academic performance at T2. Within-pair differences in children's parental hostility-coercion and externalizing problems at T1 were also correlated with differences in academic performance at T2, albeit modestly. Finally and importantly, differences in peer rejection and in the quality of the teacher-child relationship at T1 were moderately correlated with differences in twins' academic performance at T2. The negative sign of the correlations indicates that, compared to their co-twin, twins who were more rejected by their peers or had a more conflictual relationship with their teacher in kindergarten also performed less well academically in grade 1. In contrast, differences in peer victimization and in friendship quality at T1 were not correlated with differences in twins' academic performance at T2. Concurrent correlations between differences in T2 social experiences and differences in T2 academic performance were similar to the correlations between differences in T1 social experiences and differences in T2 academic performance, but weaker. Overall, the correlations amongst difference scores were more modest compared to correlations involving individual scores. It is important to keep in mind that such a pattern is expected given that all relations are estimated while controlling for familial aggregation and genetic contribution.

Main Analyses

Model tests were performed with the Mplus Version 6 software package (Muthén & Muthén, 1998-2010) as a two-group path analysis with manifest variables, with sex as the grouping variable. These analyses were conducted using Full Information Maximum Likelihood (FIML) estimation, which is the default in Mplus to account for occasional missing data (28% of data points in the present sample) when using maximum likelihood estimation for continuous variables. Model fit was assessed using the chi-square statistic, the comparative fit index (CFI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). According to Kline (2005), CFI values of .90 or higher, RMSEA values of .05 or lower, and SRMR values of .10 or lower indicate good model fit. Cross-group equality constraints were tested using nested model-chi-square difference tests. Table 6 presents the fit statistics of the different model tests.

We first tested a fully saturated model (Model 1) that included direct effects of the control variables (i.e., within-pair differences in T-1 parental hostility-coercion, differences in T1 pre-academic skills, differences in T1 externalizing problems) and of the T1 main predictors of interest (i.e., differences in T1 peer rejection, differences in T1 peer victimization, differences in T1 low friendship quality, and differences in T1 low relationship quality with the teacher; i.e., the social predictors) on the outcome (i.e., differences in T2 academic performance). Notably, we wanted to test whether the predictive effects of differences in T1 social predictors on differences in T2 academic performance reflected a long-lasting effect. Therefore, difference scores on the corresponding T2 social variables (i.e., peer rejection, peer victimization, negative friendship quality, and negative quality of the teacher-child relationship) were also added to the initial model as predictors of differences in T2 academic performance. In addition, direct effects from all T1 control and from all T1 social predictor variables to the T2 predictor variables were

included and within-time predictors were allowed to covary. In this initial model (Model 1), no cross-group equality constraints were specified on any of the estimated parameters. This fully saturated model (Model 1), where all parameters were freely estimated across sex, necessarily fit the data perfectly.

Next, we tested whether the regression coefficients of T2 academic performance onto the T1 control variables, onto the T1 social predictors and onto the T2 social predictors were equal for males and females. Including cross-group equality constraints on these directional paths in Model 2 did not result in a significant drop in fit, $\Delta \chi^2 (11) = 15.34$, $p = .17$. In the following model (Model 3), we added cross-sex equality constraints with respect to the remaining direct effects from the T1 control variables and from the T1 social predictors to the T2 social predictors. This model (Model 3) showed a significantly worse fit than the preceding one (Model 2), $\Delta \chi^2 (16) = 26.42$, $p = .05$. An acceptable model fit, $\Delta \chi^2 (13) = 12.33$, $p = .50$, was obtained after freeing up three parameters (Model 3a).

The results from the final best fitting model (Model 3a) are depicted in Figure 2. As can be seen, within-pair differences in two of the three T1 control variables were significantly related to within-pair differences in T2 academic performance. Specifically, differences in T1 externalizing problems (B = -.20, SE = .11, p =.06) as well as in T1 pre-academic skills (B = .28, SE = .11, p =.01) were related to increased differences in T2 academic performance. Of the T1 social predictors, differences in peer rejection and differences in the negative teacher-child relationship were also associated with differences in T2 academic performance (B = -.25, SE = .11, p =.02 for peer rejection, and B = -.24, SE = .11, p =.03 for negative teacher-child relationship). Hence, the twin who was more rejected by his-her peers or who had a worse relationship with the teacher at T1 showed a worse academic performance at T2 than his or her

co-twin. In addition, differences in T1 negative teacher-child relationship predicted differences in T2 negative teacher-child relationship for girls only (B = .25, SE = .12, *p* =.03), which in turn were related with increased differences in T2 academic performance for girls and boys (B = -.20, SE = .08, *p* =.02). In addition to these direct and indirect paths predicting to academic performance at T2, differences in T1 externalizing problems were linked to greater differences in T2 peer victimization for boys (B = .27, SE = .13, *p* =.05), and to greater differences in a negative teacher-child relationship at T2 for girls and boys (B = .18, SE = .09, *p* =.04).

Supplementary Analyses

Although for the vast majority of twin pairs in our sample both members attended different classrooms, some of them attended the same classroom. Dissimilarity between the two members of a twin pair may be inflated when they attend different classrooms, due to rater effects. Alternatively, similarity between the two members of a twin pair may be inflated when they attend the same classroom, as a consequence of classroom effects (Byrne et al., 2010; Kovas, Haworth, Dale, & Plomin, 2007). Both scenarios may affect the variability of the MZ difference scores and, consequently, the associations between within-pair differences in the predictor or control variables and within-pair differences in the outcome variable (i.e., within-pair differences in academic performance). A comparison of the intra-class correlations for twin pairs where both members were in the same classroom versus those where the two members were in different classrooms showed that the scores of the members of the same pair were significantly correlated with each other, independent of whether they were in the same or in different classrooms, with only one exception (i.e., friendship quality at T1). However, chi-square difference tests revealed that twin pairs where both members were in the same classroom were significantly more similar to each other than twin pairs where members attended different

classrooms on almost half of the study variables (i.e., pre-academic skills and externalized problems in kindergarten, peer rejection in kindergarten and grade 1, teacher-child relationship in kindergarten and grade 1), with χ^2 (df = 1) varying between 5.24 and 19.89, all *p*s < .05.

Although the outcome variable was not among these variables, it was nevertheless deemed important to examine whether differences in intra-class correlations translated into differential associations of the control variables and of the T1 and T2 social predictor variables with the dependent variable for twin pairs where both members were in the same classroom compared to those where the two members were in different classrooms. The very small number of twin pairs (*n* = 50) where both members were in the same classroom prohibited a formal two-group analysis of the full model tested above. We therefore performed a series of comparisons of all the bivariate correlations of the control variables and of the T1 and T2 social predictor variables with the dependent variable for twin pairs in the same classroom and twins in different classrooms. Only two comparisons were statistically significant, *p*s < .05: one involved the correlation between differences in T1 pre-academic skills and differences in T2 school performance, which was stronger in twins who were in the same classroom; the other involved the correlation between differences in T1 peer victimization and differences in T2 school performance, which was only significant in twins who were in the same classroom. Hence, because the vast majority of associations did not differ between the two sub-groups, analyses were performed with the whole sample to maximize statistical power.

Discussion

The first goal of this study was to investigate whether within-pair differences in four types of negative social experiences in kindergarten uniquely predicted within-pair differences in MZ twins' school performance in grade 1 while accounting for possible genetic influences,

shared environmental influences, and within-pair differences in pre-academic skills, externalizing problems, and parents' hostility-coercion. To examine whether the effects of kindergarten social experiences reflected enduring effects on academic performance a year later, we also controlled for equivalent grade 1 social experiences. The second goal was to test whether sex played a moderating role in regard to these associations.

Results revealed that initial differences in peer rejection and the quality of the teacher-child relationship at school entry predicted differences in academic performance a year later. Conversely, differences in peer victimization and in friendship quality did not make unique contributions to differences in grade 1 academic performance. The quality of the teacher-child relationship in grade 1 made an additional contribution whereas concurrent peer rejection did not. Because of the stability of differences in the quality of the teacher-child relationship from kindergarten to grade 1 for girls, differences in the quality of the teacher-child relationship in kindergarten made an additional contribution through the effect of concurrent grade 1 teacher-child relationship. Finally, within-pair differences in externalizing problems in kindergarten also contributed to predict within-pair differences in academic performance in grade 1, both directly and indirectly through within-pair differences in the quality of the teacher-child relationship. Within-pair differences in externalizing problems in kindergarten also predicted an increase in within-pair differences in boys' peer victimization. However, both peer victimization in kindergarten and grade 1 as well as friendship quality played no role with respect to academic performance in grade 1. Finally, few differences between boys and girls were found. These results and their possible implications are discussed in turn.

Peer Rejection

In line with results by Ladd and his collaborators (Buhs & Ladd, 2001; Buhs et al., 2006; Ladd et al., 1997), differences in peer rejection in kindergarten played an important role in predicting differences in twins' academic achievement one year later, even after controlling for differences in pre-academic skills, externalizing problems, parental hostile treatment, concurrent grade 1 peer victimization and relationship quality with the best friend and the teacher, and possible gene-environment correlations. This result is, to date, the most compelling demonstration in a non experimental setting of the adverse 'effect' of peer rejection on academic performance. How could peer rejection contribute to lowered academic performance? As mentioned earlier, peer rejection is based on a subjective perception of the peer group, and may not always involve a high frequency of negative encounters between disliked children and their peers. Rather, peer rejection may be detrimental because it reduces a child's learning and socialization opportunities, which in turn become linked to reduced academic achievement. It is also possible that children who are rejected by their peers become increasingly disengaged from school and increasingly disruptive (Buhs et al., 2006; Ladd & Dinella, 2009). As shown by the present findings, externalizing problems in turn can contribute to reduced academic performance. Children who are rejected by their peers may also be at increased risk of affiliating with other rejected children, many of whom may be disruptive and low achieving at school (Vitaro, Pedersen, & Brendgen, 2007). Disruptive-low achieving peers in turn may be more likely to distract their friends from constructive classroom-oriented activities and are less likely to provide support for academic work (Boivin, Vitaro, & Poulin, 2005; Ladd & Dinella, 2009). These alternative pathways are not mutually exclusive.

The fact that within-pair differences in peer rejection at T2 did not contribute additively to within-pair differences in academic performance deserves a comment. It is possible that peer

rejection plays a stronger role early on and that other processes that are set into motion by peer rejection (e.g., affiliation with deviant peers) take over, as this seems to be the case in other areas of functioning (Vitaro et al., 2007). It would nevertheless be somewhat surprising, however, if such processes take place so quickly in children's development, i.e., across the kindergarten-grade 1 interval.

Teacher-Child Relationship

A low quality relationship with the kindergarten teacher also played a unique and important role with respect to first grade academic achievement. For girls, it actually played a double role, first directly and second indirectly by setting the stage for the type of relationship children would experience with their teacher in grade 1, which in turn would also influence their academic performance. One explanation for the links between differences in teacher-child relationship, both in kindergarten and grade 1, and differences in academic achievement may be that a teacher who perceives the relationship with a child as of low quality may provide less attention and less support to this child, resulting in reduced learning opportunities (Birch & Ladd, 1997). Like for peer rejection, a poor quality teacher-child relationship seems to passively operate through lost opportunities or lost stimulation for learning. However, unlike peer rejection, the effects of a low quality relationship with the teacher accumulates over time as both kindergarten and grade 1 experiences made an independent contribution in predicting grade 1 academic performance. This consistent finding supports current literature on the role of the teacher-student relationship with respect to academic outcomes, independent of experiences with peers and of any gene-environment correlation (Furrer & Skinner, 2003; Wentzel & Asher, 1995). It also expands the current literature by showing that this effect is cumulative and already underway during the first years of schooling.

Friendship Quality

A low quality relationship with a best friend was not related to child academic performance, not in terms of within-pair difference scores or in terms of individual scores. Nevertheless, although school-related processes may not directly result from this type of social experience, conflict and low support from a friend might impair children's academic performance indirectly, e.g., by disrupting their motivation to learn or their behavioral functioning in the classroom. The possibility for an indirect effect is supported by a recent study showing that a low friendship quality does indeed foster an increase in children's externalizing problems from kindergarten to grade 1 (Vitaro et al., 2011). This possible indirect pathway could reconcile the present findings with studies that found a link between young children's friendship quality and school adjustment (Ladd et al., 1996). It is also possible, however, that the link found in past studies between friendship quality and academic performance might have resulted from an uncontrolled gene-environment correlation and consequently be spurious. More research is needed to clarify this issue.

Peer Victimization

Within-pair differences in peer victimization at T1 or T2 did not predict differences in academic performance. This result contrasts with findings from other studies that reported a predictive role of peer victimization (Nakamoto & Schwartz, 2010; Schwartz et al., 2005). Three lines of explanation are possible. First, the fact that other negative peer experiences such as peer rejection were not controlled in studies that found a significant role of peer victimization might explain the apparent discrepancy. Once peer rejection is taken into account, peer victimization does not seem to contribute to later academic performance (Buhs et al., 2006; Ladd et al., 1999). Second, within-pair differences in peer victimization, both at T1 and at T2, were not related to

within-pair differences in academic performance at the bivariate level, whereas individual scores were, suggesting that the apparent effect of peer victimization on children's academic performance in past studies could be due to common underlying genetic (or shared environmental) influences. For example, children who are at risk for peer victimization for genetic reasons may also be at risk for low academic performance. Once this confound due to familial aggregation is controlled, as in the present study, the link between peer victimization and academic performance disappears. Third, moderating variables may be involved, such that peer victimization may still predict academic performance for some children. For example, compared to victimized children who have reciprocal friends to buffer them from peer harassment, victimized children who have no friends have been shown to be prone to emotional problems (Hodges, Boivin, Vitaro, & Bukowski, 1999), which in turn may put them at risk for low school achievement.

Parent Hostility-Coercion and Children's Externalizing Problems

Differences in parent hostility-coercion did not predict differences in academic achievement. They were, however, related to children's pre-academic skills assessed at T1, albeit marginally. Hence, differences in parent hostility-coercion could be indirectly related to academic achievement through their link with children's pre-academic abilities (which were predictive of children's academic performance). Since parents tend to treat children from the same family relatively similarly, as indexed by a high intra-class correlation on parental hostility-coercion scores, a larger sample may be required to show that small differences in parental treatment can make a difference with respect to important elements such as school readiness.

Differences in externalizing problems at T1 contributed to differences in academic performance at T2, both directly and indirectly: directly because they disrupt children's learning

in and outside the classroom and indirectly because they foster a conflictual relationship with the teacher (Brendgen et al., 2007). These results are in line with past studies showing the unique role of children's externalizing problems in predicting a degradation in academic performance (Duncan et al., 2007; Galéra, Melchior, Chastang, Bouvard, & Fombonne, 2009). The present results also go one step further by indicating the unique impact of children's externalizing problems on the teacher-child relationship and on peer victimization.

Gender Differences, Classroom effects, and Stability of Social Experiences

It is interesting to note that the role of peer rejection and of the teacher-child relationship in predicting academic achievement appears to be similar for boys and girls. This conclusion, however, is not definitive given our limited power to detect sex differences, particularly in the context of the MZ-difference method which tends to yield modest effects. Morover, two pathways differed for boys and girls: a) an indirect link between within-pair differences in the teacher-child relationship in kindergarten and within-pair differences in academic performance in grade 1 (via within-pair differences in the teacher-child relationship in grade 1) that was limited to girls, and b) a direct link between within-pair differences in externalizing problems in kindergarten and within-pair differences in peer victimization in grade 1 that was limited to boys. Hence, specific dyadic experiences, such as the quality of the teacher-child relationship, might have more indirect lingering effects for girls than for boys.

Also in line with past findings (Byrne et al., 2010), twins in the same classroom tended to be perceived as being more similar to each other than twins from different classrooms. This pattern could reflect a classroom effect that would increase the similarity among twins attending the same classroom. It could also reflect rater bias that would make twins in different classrooms look less similar than they really are or twins in the same classroom look more similar than they

really are. Keeping together pairs from the same and from different classrooms did not seem to overly bias our findings, however, since the comparisons of the bivariate correlations between the predictor variables and the dependent variable (i.e., academic performance) revealed very few differences between twin pairs in the same classroom and those in different classrooms.

Individual scores with respect to all four types of social experiences were moderately stable from kindergarten to grade 1, as indicated by bivariate correlations ranging from .26 for friendship quality to .49 for peer rejection. However, the stability of within-pair difference scores was virtually nil. This result deserves a comment: difference scores represent non-shared experiences that are not affected by either genes or shared environmental factors. These non-shared experiences do not depend on the children's characteristics but on the characteristics of their (non-shared) environment and are therefore more or less random and consequently not predictable from one year to the next in terms of difference scores. The fact that the present study showed a predictive association between these non-shared social experiences and children's scholastic development further underlines the power of the MZ difference method to reveal a probable causal link between these variables, although the study design is essentially correlational.

Limitations and Conclusions

The present study has a number of strengths, including a) the use of different informants for the predictors and the outcome, thus reducing the risk of inflated associations attributable to shared method variance, b) strong internal validity through the control of a number of important possible confounders, thus reducing the risk of spurious links, c) the use of a longitudinal perspective, thus clarifying the directionality of the links, and, d) the use of the discordant MZ-twin method, thus eliminating the risk of inflated linkages between environmental factors and

children's outcomes as a result of familial aggregation, including genetic contributions. An additional asset of this study was to examine simultaneously the links between four social environmental factors (i.e., peer rejection, peer victimization, low relationship quality with the teacher, and low friendship quality), thus controlling for their possible overlap.

The present study also has limitations that need to be kept in mind when interpreting the results. These include: a) the use of paper and pencil measures only, b) the use of a single informant and a single instrument to assess each construct; c) the use of teacher judgments instead of standardized tests to assess children's academic performance; although the two measures are highly correlated, the overlap is not perfect, d) a small sample size that might have resulted in reduced power, especially for testing moderated effects, e) limited external validity given the ethnic and age composition of the sample, although the sample is comparable to the general population of families with children in the sampled neighborhood, and f) a short and specific developmental period, from Kindergarten to Grade 1. This last point is particularly important since different results may be found for older children with respect to the relative role of social experiences. For example, the quality of the teacher-child relationship could become less important over time. In contrast, the quality of the relationship with friends could become increasingly important. In addition, the reliance on a MZ twin sample to achieve high internal validity might also have reduced external validity to some extent. This possible limitation was examined by comparing mean scores between MZ pairs and a representative sample of same age singletons on many of the same measures used in this study. The results (not presented but available on request) did not reveal any statistically significant differences between the two samples on any of the available measures. These findings are also in line with other research showing strong similarities between twins and singletons with respect to peer experiences and

friendship features (Koch, 1966; Thorpe, 2003) or social-psychological adjustment during childhood (Moilanen et al., 1999).

Despite these limitations, the present study adds unique information about the important and possibly causal role of two social experiences in kindergarten in predicting child achievement in first grade: peer rejection and a low quality teacher-child relationship. Future research should examine whether the apparent consequences of these early social experiences on academic achievement persist over time and whether their effects accumulate for children who experience them repeatedly over the school years. These studies should include as many correlated social experiences as possible to control for their overlap. They should also control for possible gene-environment correlations and include sufficient children from both genders and different socio-economic status to properly test for moderated effects. Finally, they should focus on the intra- and inter-individual mechanisms that could account for the non spurious effects observed.

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Table 1

Means, Standard Deviations (SD), Skewness, and Kurtosis of Individual Scores

Measure	Mean (SD)	Skewness	Kurtosis
T_{-1} Parent hostility-coercion	13.24 (2.89)	0.45	0.64
T_1 Peer rejection[1]	-0.29 (0.93)	0.54	0.23
T_2 Peer rejection	-0.20 (0.91)	0.70	0.12
T_1 Peer victimization[1]	-0.15 (0.86)	1.10	1.25
T_2 Peer victimization	-0.11 (0.87)	0.85	-0.01
T_1 Low quality friendship	2.49 (2.17)	0.80	0.12
T_2 Low quality friendship	2.70 (2.20)	0.51	-0.45
T_1 Low quality relationship with teacher	14.12 (3.41)	1.01	1.14
T_2 Low quality relationship with teacher	14.51 (3.58)	0.74	0.50
T_1 Twins' externalizing problems	6.18 (5.85)	1.03	0.35
T_1 Twins' pre-academic skills	1.16 (13.65)	-0.79	0.30
T_2 Twins' academic achievement	3.28 (1.03)	-0.39	-0.25

Note. [1] Scores standardized within the classroom. T_1 = Kindergarten; T_2 = Grade 1.

Table 2

Bivariate Correlations among Individual Scores, Adjusting for Non Independence

Variables	1	2	3	4	5	6	7	8	9	10	11
1- T_{-1} Parent hostility-coercion											
2- T_1 Peer rejection	.24*										
3- T_2 Peer rejection	.08	.49*									
4- T_1 Peer victimization	.04	.23**	.20**								
5- T_2 Peer victimization	.13*	.16*	.27**	.34**							
6- T_1 Low quality friendship	.11†	.18*	.11†	.01	-.08						
7- T_2 Low quality friendship	.16*	.11†	.24*	.02	.03	.26**					
8- T_1 Low quality relationship with teacher	.02	.25**	.23**	.33*	.21**	.10†	-.01				
9- T_2 Low quality relationship with teacher	.02	.22*	.34**	.24**	.27**	.04	.09	.38**			
10- T_1 Twin's externalizing problems	.18**	.39**	.35**	.43**	.31**	.06	.04	.56**	.37**		

11- T_1 Twin's pre-academic skills	.05	-.24**	-.17*	-.13*	-.08	-.09	-.07	-.31**	-.06	-.37**	
12- T_2 Twins' academic achievement	-.14†	-.25**	-.29**	-.15†	-.16*	.04	.07	-.20**	-.24**	-.25**	.43**

Note: † $p < .10$; * $p < .05$; ** $p < .01$; T_1: Kindergarten; T_2: Grade 1. Correlations are derived from a multivariate within twin-pair correlation matrix

Table 3

Intra-pair Correlations Reflecting the Degree of Similarity between MZ Twins With Respect to the Study Variables

Variables	r
T_{-1} Parent hostility-coercion	0.81***
T_1 Peer rejection	0.48***
T_2 Peer rejection	0.63***
T_1 Peer victimization	0.29***
T_2 Peer victimization	0.35***
T_1 Low quality friendship	0.04
T_2 Low quality friendship	0.28***
T_1 Low quality relationship with teacher	0.48***
T_2 Low quality relationship with teacher	0.54***
T_1 Twins' externalizing problems	0.73***
T_1 Twins' pre-academic skills	0.79***
T_2 Twins' academic achievement	0.76***

Note. * $p < .05$; ** $p < .01$; *** $p < .0001$. T_1 = Kindergarten; T_2 = Grade 1.

Table 4

Means, Standard Deviations (SD), Skewness and Kurtosis of Difference Scores

Measure	Mean (SD)	Skewness	Kurtosis
ΔT_{-1} Parent hostility-coercion	0.06 (1.78)	-0.69	3.94
ΔT_1 Peer rejection[1]	-0.08 (0.95)	-0.17	1.41
ΔT_2 Peer rejection	-0.08 (0.81)	-0.14	0.85
ΔT_1 Peer victimization[2]	-0.21 (1.01)	-0.24	0.81
ΔT_2 Peer victimization	-0.12 (0.99)	0.14	0.85
ΔT_1 Low quality friendship	0.03 (3.02)	-0.24	0.54
ΔT_2 Low quality friendship	-0.17 (2.65)	0.08	0.14
ΔT_1 Low quality relationship with teacher	-0.01 (3.49)	0.13	1.30
ΔT_2 Low quality relationship with teacher	0.24 (3.43)	-0.26	0.88
ΔT_1 Twins' externalizing problems	-0.40 (4.31)	0.23	1.06
ΔT_1 Twins' pre-academic skills	1.07 (8.84)	0.51	2.10
ΔT_2 Twins' academic achievement	0.01 (0.71)	0.14	0.59

Note. [1] Scores standardized within the classroom. Δ: within-pair difference score. T_1 = Kindergarten; T_2 = Grade 1.

Table 5

Bivariate Correlations among Difference Scores

	Variables	1	2	3	4	5	6	7	8	9	10	11	12
1-	Δ T_{-1} Parent hostility-coercion												
2-	Δ T_1 Peer rejection	0.09											
3-	Δ T_2 Peer rejection	-0.10	-0.09										
4-	Δ T_1 Peer victimization	0.02	0.07	-0.07									
5-	Δ T_2 Peer victimization	0.03	-0.02	-0.13†	-0.08								
6-	Δ T_1 Low quality friendship	-0.07	0.03	-0.06	0.01	-0.10							
7-	Δ T_2 Low quality friendship	0.07	-0.04	0.01	0.11	0.10	0.13						
8-	Δ T_1 Low quality relationship with teacher	-0.12	0.12	0.09	0.12	0.04	0.08	-0.17†					
9-	Δ T_2 Low quality relationship with teacher	-0.03	-0.02	-0.02	0.02	0.12	-0.02	0.01	0.00				
10-	Δ T_1 Twins' externalizing	-0.03	0.23**	0.00	-0.01	0.02	0.02	-0.00	0.36***	0.12			

	problems											
11-	Δ T_1 Twins' pre-academic skills	-0.15†	-0.10	0.09	0.05	0.12	-0.17*	0.03	-0.09	0.16†	-0.13	
12-	Δ T_2 Twins' academic achievement	-0.12	-0.26*	-0.15†	-0.06	-0.10	0.03	0.08	-0.22*	-0.17*	-0.25**	0.23*

Note. † $p < .10$; * $p < .05$; ** $p < .01$. Δ: within-pair difference score. T_1: Kindergarten; T_2 Grade 1.

Table 6

Two-Group Path Analyses Testing Predictive Effects on T2 Differences in Twins' Academic Achievement as Dependent Variable, with Sex as a Grouping Factor

	LL (np)	CFI	RMSEA	SRMR	χ^2 (df)	*p*
Model 1	-2599.04 (180)	1	0	0	0 (0)	--
Model 2	-2606.71 (169)	.91	.06	.04	15.34 (11)	.17
Model 3	-2619.92 (153)	.68	.07	.06	41.75 (27)	.04
Model 3a	-2612.88 (156)	.92	.04	.05	27.67 (24)	.27

Note: *N* = 223. LL = Log Likelihood; np = number of parameters; CFI: Comparative Fit Index; RMSEA: Root Mean Square Error of Approximation; CI: Confidence Interval; SRMR: Standardized Root Mean Square Error; χ^2-difference test; df = degrees of freedom.

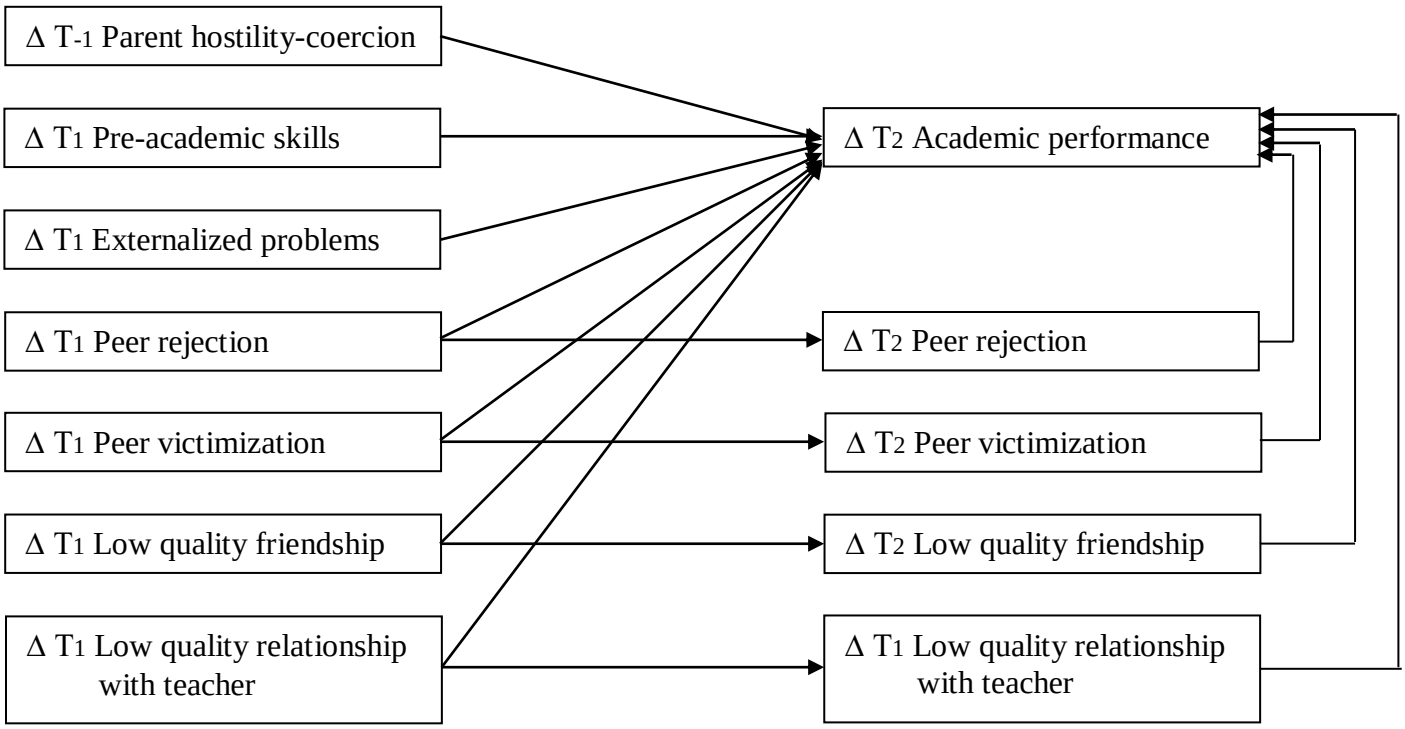

Figure 1. Illustration of the estimated initial model (Model 1); cross-sectional associations are not illustrated to reduce complexity of the figure, although they were part of the model. Δ: within-pair difference score. T1= kindergarten; T2 = grade 1.

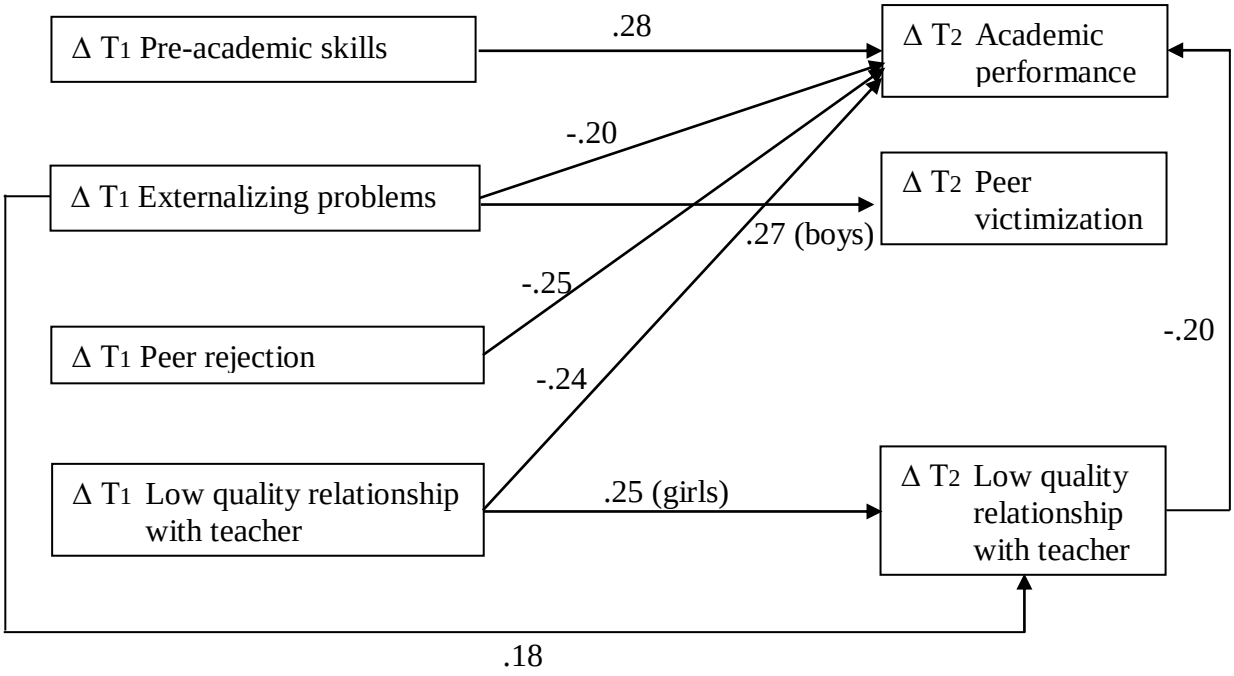

Figure 2. Results from the path analysis linking T1 differences in predictors to T2 differences in twins' academic achievement, while controlling for T2 differences in predictors and T1 differences in control variables (Model 2c). Although all possible paths were estimated (see text), only paths with coefficients that were significant at $p = .05$ or less are reported for parsimony of presentation. Also for parsimony, links among T1 and T2 variables are not included in the Figure but were included in model testing. Standardized coefficients provided. $N = 223$. G: girls; B: boys. Δ: within-pair difference score. T1= kindergarten; T2 = grade 1.