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Strong Genetic Contribution to Peer Relationship Difficulties at School Entry: Findings From a Longitudinal Twin Study

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This study assessed the genetic and environmental contributions to peer difficulties in the early school years. Twins' peer difficulties were assessed longitudinally in kindergarten (796 twins, M_{age} = 6.1 years), Grade 1 (948 twins, M_{age} = 7.1 years), and Grade 4 (868 twins, M_{age} = 10 years) through multiple informants. The multivariate results revealed that genetic factors accounted for a strong part of both yearly and stable peer difficulties. At the univariate level, the genetic contributions emerged progressively, as did a growing consensus among informants with respect to those who experienced peer difficulties. These results underline the need to intervene early and persistently, and to target the child and the peer context to prevent peer difficulties and their consequences.

Approximately 5%–10% of children experience chronic peer relationship difficulties, such as peer rejection and peer victimization (Hodges, Malone, & Perry, 1997; Juvonen, Graham, & Schuster, 2003; Kochenderfer & Ladd, 1996; Perry, Kusel, & Perry, 1988; Solberg & Olweus, 2003). These negative peer experiences play a central role in the development of emotional problems, including loneliness, depression, anxiety, and suicidal ideation, and are associated with increased physical health, conduct, and school problems (Arseneault et al., 2008; Boivin, Hymel, & Bukowski, 1995; Boulton & Underwood, 1992; Dodge et al., 2003; Kochenderfer & Ladd, 1996; Olweus, 1992; Rubin, Bukowski, & Parker, 2006). The prevalence of these difficulties and their associated mental and physical health problems underscore the need to study the early developmental course and determinants of these adverse peer relationship experiences.

Peer relationship difficulties have been proposed as distinctive developmental experiences (Harris, 1995), that is, experiences that contribute in a unique way to social and emotional development. (Please note: Throughout the article, we use peer relationship difficulties as a general term encompassing experiences of peer victimization and peer rejection. See details in following paragraph.) However, it is not clear whether peer relationship difficulties are truly unique environmental features of development and to what extent they originate from, and are conditioned by, personal and family factors. Documenting these questions is important for the early identification of children at risk and

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the planning of appropriate early preventive intervention.

As natural experiments, twin studies are well suited for the investigation of child and family factors in peer relationships. The twin design allows for disentangling genetic from environmental sources of variation on a given phenotype by comparing phenotypic similarity among monozygotic (MZ) twins, who share 100% of their genes, with that of dizygotic (DZ) twins, who share on average 50% of their genotype. It typically estimates the proportions of genetic, shared environmental, and non-shared environmental sources of variance for a measured characteristic. Higher phenotypic similarity favoring MZ versus DZ twins is assumed to reflect genetic sources of variance (i.e., heritability), whereas equivalent phenotypic similarity across levels of genetic relatedness represents shared environmental sources of variance. Nonshared environmental sources of variance (e.g., peer experiences that are unique to each twin) make twins of the same family grow apart in terms of their emotional and behavioral development, and thus contribute to differences between twins of the same family. This additive gene–environment model has its limitations (see Turkheimer & Gottesman, 1996). However, by documenting within-family and between-family differences, and by estimating the extent to which genes and environments matter, longitudinal twin studies provide unique information about the nature of developmental processes (Rutter, 2007).

When specific environments are directly measured, twin studies may also signal possible gene–environment interplay in developmental trajectories. Indeed, the twin method is usually applied to the study of individual phenotypes, but its rationale can be extended to measured environments, such as peer relationships, to estimate the extent to which measured features of peer relationships are shared or uniquely experienced by twin siblings, and whether they are associated with genetic factors in the child. Finding genetically mediated "child effects" on specific features of peer relationships is the first step in assessing how genetic and environmental factors may work together through a process of gene–environment correlation (rGE) in the development of adjustment problems.

An rGE is established when genetic variation is associated with variation in exposure to a specific environment (Jaffee & Price, 2007). This rGE can be (a) *passive*, such as when parents provide a child with an environment consistent with the parents' genetic makeup, which is inherited by the child; (b) *evocative*, such as when a child makes others react to his or her genetically correlated characteristics; or (c) *selective*, such as when a child chooses an environment on the basis of genetically correlated characteristics (Plomin, DeFries, & Loehlin, 1977; Scarr & McCartney, 1983). Cognitive and physical limitations, such as speech problems and physical clumsiness, have been associated with peer difficulties. However, it is children's disruptive behaviors, in particular aggressive and hyperactive or impulsive behaviors, that have been systematically identified as the main sources of these difficulties in the early grades of school (Coie, 1990). This evidence stems from a variety of cross-sectional, longitudinal, and play-group studies (Boivin, Vitaro, et al., 2005; Coie & Kupersmidt, 1983; Dodge, 1983; Newcomb, Bukowski, & Pattee, 1993; Rubin et al., 2006). However, we are still not sure about the gene–environment processes linking these putative correlates and peer difficulties over time. Given what is known about the behavioral predictors of peer relationship difficulties, finding that these difficulties are associated to genetic factors in the child would suggest an evocative rGE whereby some child characteristics (e.g., disruptive behaviors), known to be associated with genetic factors (Rhee & Waldman, 2002), could lead to peer difficulties.

Evidence of rGE has been provided for various environmental measures, such as parental harsh discipline (Boivin, Pérusse, et al., 2005; Jaffee et al., 2004; Plomin & Bergeman, 1991), social support (Spotts, Prescott, & Kendler, 2006), and marital status and quality (McGue & Lykken, 1992; Spotts et al., 2004). As indicated previously, such genetically mediated "person effects" are also likely for peer difficulties. However, only a handful of studies have examined peer relationship difficulties within a genetic informed design. A study of 10-year-old twins found that 73% of the variance in mother-rated peer victimization was explained by genetic factors (Ball et al., 2008), but results of other studies with younger children were mixed (Brendgen et al., 2008; Brendgen et al., 2009).

These initial findings suggest that genetic factors are associated with peer difficulties. However, they bear important limitations. First, these studies relied on single informants, typically the participant or a member of the entourage such as the teacher, the mother, or the peers, with each of these methods presenting unique weaknesses. A potential shortcoming of self-reports is that they partly reflect the self-system (Boivin & Hymel, 1997; Boivin, Vitaro, & Gagnon, 1992) and may thus yield biased estimates of genetic and environmental contributions to actual peer difficulties. Mothers and teachers may only have limited information regarding their child's peer relationships (Fekkes, Pijpers, & Verloove-Vanhorick, 2005; Houndoumadi & Pateraki, 2001). They may also reveal biased estimates when the mother or the teacher rates both twins of the same family. Peer assessments are often seen as the gold standard when it comes to assessing peer relationship difficulties (Cillessen & Rose, 2005; Kupersmidt & Dodge, 2004; Rubin et al., 2006). Peers are indeed the privileged witnesses and actors of the social scene and as such, may provide unique information on peer experiences. Peer assessments are more reliable in principle because they typically combine information from multiple informants. However, this may not be the case among young children. Peer assessments may also be biased by social reputations and group dynamics. Thus, each measurement approach has its biases and limitations. One way to overcome these limitations is to use multiple informants to establish more reliable "latent" appraisal of the phenomenon, which, in turn, would help clarify the presence of rGE with respect to peer difficulties in young children.

Second, in addition to peer victimization, another type of peer difficulties, peer rejection, has been extensively examined as a potential determinant of children's adjustment problems (Boivin et al., 1995; Dodge et al., 2003; Rubin et al., 2006). Peer rejection and peer victimization map related but distinct instances of adverse peer experiences: Whereas peer victimization refers to actual negative behavior manifested repeatedly by one or more peers toward specific children, peer rejection reflects negative feelings of the peer group toward a child, feelings that may not always be manifested in the child (Boivin, Hymel, & Hodges, 2001). Thus, taken together these assessments provide a more comprehensive coverage of various forms of peer difficulties. However, their origins remain mostly unknown and they have never been examined jointly within a genetically informed design.

Third, previous research has provided a limited view of developmental processes, as peer relationships were assessed at a single point in time without any longitudinal information on the early school years. Peer difficulties are established early in grade school and tend to persist over time (Boulton & Smith, 1994; Coie & Dodge, 1983). However, as suggested by previous cross-sectional reports, there could be developmental changes in the relative strength of genetic contributions to peer difficulties. For instance, Ball et al. (2008) found a strong association between peer victimization and genetic factors in middle childhood, but this finding was not replicated among kindergarten children (Brendgen et al., 2008). This differing pattern could be due to the use of different methods for assessing peer victimization (i.e., mother vs. peer evaluations). It could also reflect a growing association with age between genetic factors and peer difficulties driven by the progressive establishment of an evocative rGE as described earlier. Accordingly, not only is it important to start documenting these difficulties from school entry but we also need to document them longitudinally using the same (multiple) assessment tools over time.

The goal of the present study was to examine the genetic and environmental contributions to peer relationship difficulties, and thus possible rGE, during the first years of school. To this end, we adopted a multiple assessment approach to peer difficulties using a combination of peer-assessed peer rejection and peer, teacher and self-assessed peer victimization from kindergarten to Grade 4.

Method

Participants

Participants were families of twins from the ongoing Quebec Newborn Twin Study, recruited between April 1995 and December 1998 in the greater Montreal area, Canada. Of the 989 families contacted, 662 (67%) agreed to participate. This sample was followed longitudinally at 5, 20, 32, 50, 63 months, and assessed on various child and family characteristics. This article describes findings from the school follow-up in kindergarten, Grade 1, and Grade 4.

Zygosity was ascertained through the Zygosity Questionnaire for Young Twins (Goldsmith, 1991) when the twins were 5 and 20 months of age. Results obtained with this method were 91.9% and 93.8% concordant, respectively, with those derived from DNA samples of 123 twin pairs (Forget-Dubois et al., 2003).

Attrition in the sample averaged approximately 6% per year. Twins for whom peer nominations, teacher ratings, or self-ratings were available were 796 in kindergarten (400 pairs, 164 pairs of MZ twins and 236 pairs of DZ twins; age: $M = 72.7$ months, $SD = 3.6$), 948 in Grade 1 (474 pairs, 198 pairs of MZ twins and 276 pairs of DZ twins; age: $M = 84.9$, $SD = 3.2$), and 868 in Grade 4 (439 pairs, 182 pairs of MZ twins and 257 pairs of DZ twins; age: $M = 120.0$, $SD = 3.4$), although numbers may vary slightly across measures (see Table 1). The lower participation in kindergarten compared to the subsequent

Table 1
Descriptive Data for Peer Relation Difficulties in Kindergarten, Grade 1, and Grade 4

	N twins		*M* (*SD*)		*M* (*SD*)	
Measures	MZ	DZ	MZ	DZ	Males	Females
Kindergarten						
Peer rejection	323	463	$-.26_c$ (.94)	$-.06_c$ (.93)	$.09_b$ (.95)	$-.23_b$ (.92)
Victimization peers	323	463	−.13 (.88)	−.08 (.88)	$.09_c$ (.96)	$-.28_c$ (.91)
Victimization teacher	322	461	$.15_b$ (.38)	$.25_b$ (.45)	$.27_c$ (.47)	$.15_c$ (.38)
Victimization self	248	375	1.06 (.74)	1.02 (.68)	1.07 (.70)	1.01 (.72)
Grade 1						
Peer rejection	341	467	$-.17_b$ (.93)	$.02_b$ (1.02)	$.11_c$ (1.04)	$-.23_c$ (.90)
Victimization peers	341	467	−.09 (.89)	.02 (1.00)	$.20_c$ (1.02)	$-.25_c$ (.83)
Victimization teacher	356	480	.20 (.41)	.27 (.46)	$.31_c$ (.48)	$.17_c$ (.37)
Victimization self	393	544	.87 (.66)	.87 (.69)	$.92_a$ (.69)	$.81_a$ (.66)
Grade 4						
Peer rejection	309	414	−.13 (1.02)	−.10 (.93)	$.03_c$ (1.04)	$-.25_c$ (.86)
Victimization peers	309	414	.00 (.93)	−.02 (.97)	$.26_c$ (1.08)	$-.28_c$ (.73)
Victimization teacher	324	448	.24 (.46)	.27 (.47)	$.34_c$ (.52)	$.17_c$ (.41)
Victimization self	352	484	1.72 (.56)	1.73 (.55)	1.80_c (.57)	1.66_c (.53)

Note. The same subscript letters in this table indicate a significant difference between MZ and DZ twins or between males and females. MZ = monozygotic; DZ = dizygotic.

assessment waves was likely due to a lower participation rate from teachers owing to a teacher union–government disagreement that year, and the positive perception of the data collection in kindergarten resulting in an increased teacher participation the following years. For the sociometry assessments, a total of 636 classes were visited in kindergarten, 681 classes in Grade 1, and 584 classes in Grade 4; on average, 14.02 children per class participated in kindergarten for a participation rate of 92.34%, 14.61 children per class in Grade 1 for a participation rate of 94.94%, and 19.45 children per class in Grade 4 for a participation rate of 96.09%. Seventy percent of the twin pairs were in different classrooms in kindergarten, 77% in Grade 1, and 72% in Grade 4.

Participating twins in kindergarten did not differ from those lost to attrition with regard to zygosity, parent-rated temperament at 5 months of age, or to any sociodemographic background measure, except for slightly higher education levels of the fathers in the remaining sample. Variation in yearly participation from kindergarten to Grade 4 was not associated with any of the peer difficulty measures.

Procedure

Prior to data collection, 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. The sociometric procedure took approximately 45 min per class, during which teachers completed questionnaires for the twin(s) in their class in a separate room. The instruments were approved by the Institutional Review Board, as well as by the School Board administrators.

Measures

Peer rejection. In kindergarten, Grade 1, and Grade 4, booklets of photographs of all children in a given class were handed out to all participating children in the class. The children were asked to circle the photos of three classmates they most liked to play with (positive nominations) and of three children they least liked to play with (negative nominations). The total number of positive nominations received from classmates was calculated for each participant and *z*-standardized within classroom to create a total Liked-Most (LM) score. Similarly, the total number of negative nominations received was calculated for each participant and *z*-standardized within classroom to create a total Liked-Least (LL) score. Following criteria outlined by Coie, Dodge, and Coppetelli (1982), the LL score was then subtracted from the LM score to create a social preference score, which was again *z*-standardized within classroom. This procedure has been used extensively over the past 30 years and was shown to be a valid assessment of peer relation quality in childhood (Ladd & Kochenderfer-Ladd, 2002; Rubin et al., 2006). The resulting score was then inverted to indicate peer relationship difficulties: High levels on this scale indicate peer rejection, whereas low levels indicate greater social preference. The label peer rejection is used throughout for the sake of clarity.

Peer victimization was assessed through peer, teacher, and self-ratings, the last via structured interviews. Because peer victimization is often more obvious to classmates than to adults, peers are seen as a valid source for identifying the victims of peer abuse (Juvonen, Nishina, & Graham, 2000; Pellegrini & Bartini, 2000). Accordingly, as part of the sociometric assessments, children were asked to circle the photos of two classmates who ". . . get called names most often by other children," and ". . . are often pushed and hit by other children, who get the hits." These two items were slightly adapted from the Victimization subscale of the modified Peer Nomination Inventory, which was shown to have good predictive validity and test–retest reliability (Perry et al., 1988). Although only two items were used due to the young age of the children, peer nominations based on a single item tend to be highly reliable because they are based on multiple respondents (Hodges et al., 1997; Perry et al., 1988). The total number of received nominations from classmates on each item was calculated for each participant and then *z*-standardized within classroom. At all grade levels, the two item scores were correlated (kindergarten: $r = .39$, $p < .001$; Grade 1: $r = .47$, $p < .001$; Grade 4: $r = .61$, $p < .001$). Thus, they were averaged to create a total peer-assessed victimization score in kindergarten, Grade 1, and Grade 4, respectively. kindergarten and Grade 4 scores were transformed via square root to conform to normality assumptions.

The teacher was asked to rate on a 3-point scale (0 = *never*, 1 = *sometimes*, 2 = *often*) the extent to which in the past 6 months, the child was "made fun of by other children," ". . . was hit or pushed by other children," and ". . . was called names by other children." These items reflect overt forms of victimization, which are more likely to be noticed by the teacher than indirect and more covert forms of victimization. The same scale was successfully used with mothers to assess the developmental trajectories of peer difficulties in preschool, and was found to predict early school-based victimization (Barker et al., 2008). Individual scores were averaged to yield a teacher-rated peer victimization score in kindergarten (Cronbach's $\alpha = .62$), in Grade 1 ($\alpha = .68$), and in Grade 4 ($\alpha = .77$). Despite these low reliability figures, the scale was significantly associated with peer rejection and peer-assessed victimization at all grades (rs = .23 to .42, all ps < .0001; see Table 2 later), thus supporting its convergent validity. Using the same 3-point response scale, each participating twin also answered the following five items based on the Self-report Victimization Scale developed by Ladd and Kochenderfer-Ladd (2002): "Does it ever happen that: . . . some children at school call you names or say bad things to you? . . . some children at school say bad things in your back to other children? . . . a child at school won't let you play with his or her group? . . . a child at school pushes, hits or kicks you? and . . . a child at school teases you in a mean way?" This scale has shown good internal consistency and significant convergent validity with peer-rated social adjustment difficulties, from kindergarten through Grade 4 (Ladd & Kochenderfer-Ladd, 2002). Item scores were averaged to yield a self-perceived peer victimization score in kindergarten ($\alpha = .75$), Grade 1 ($\alpha = .71$), and Grade 4 ($\alpha = .79$).

Analyses

Missing data were handled with full information maximum likelihood, which uses maximum likelihood to estimate model parameters using all available raw data (Arbuckle, 1996; Wothke, 2000). We first documented gender and zygosity differences, as well as phenotypic stability and associations among peer difficulty scores through analyses of variance and Pearson correlations. Scores were standardized within gender, as well as within zygosity when appropriate, and then pooled across gender to maximize statistical power (Arseneault et al., 2003; Brendgen et al., 2009; Van den Oord, Boomsma, & Verhulst, 2000). Twin intraclass correlations (ICC) were computed for each of the four peer difficulty scores, and full univariate ACE models were tested to derive estimates of genetic and environmental influences. In an ACE model, the phenotypic variance is typically decomposed into three latent sources of variance: (a) additive genetic variance, which can be approximated mathematically as $A = 2 \times (r\text{MZ}-r\text{DZ})$ and where r represents correlation; (b) shared environmental variance, which can be estimated as $C = r\text{M}-A$; and (c) unique environment variance, which can be derived as $E = 1-A-C$ and which includes random measurement error (Roisman & Fraley, 2008). Specifically, we estimated these ACE univariate parameters using Mplus (Muthén & Muthén, 2009): A two-group model was fitted to the data where within-twin pair correlations of the latent additive genetic factor (A) were fixed to 1.0 for MZ twins and to 0.5

for DZ twins. Within-twin pair correlations of the latent shared environmental factor (C) were fixed to 1.0 for both MZ and DZ twins, and within-twin pair correlations of the latent nonshared environmental factor (E) were fixed to 0.0 for both MZ and DZ twins. The estimated coefficients a, c, and e, which were fixed to be equal across the two members of a twin pair and across MZ and DZ twins, are the factor loadings that provide information about the relative contribution of the latent factors A, C, and E to the total variance V_T, with $V_T = a^2 + c^2 + e^2$, with measurement error included in e^2. Given the limited power to detect small estimates, only when the *p* value of an estimate was above .1, was the parameter fixed to zero and the corresponding (nested) submodel (i.e., AE, CE or E) estimated.

To account for a possible inflation due to the same persons rating the two twins, the same analyses were also performed for twins that were in different classrooms only. The resulting ICCs only slightly differed from those for all twins. Disparities were stronger in kindergarten, resulting in different "best fitting" ACE models (see the Appendix). However, this was not the case in later grades.

Then, the different sources of information of peer difficulties were examined simultaneously across time within an extension of a SEM common-pathway model. This model assumes that genetic and environmental factors influence peer difficulties mainly through a time-specific latent factor. Here, this basic common-pathway model was extended to examine genetic–environmental contributions to the phenotypic longitudinal associations (i.e., the stability) linking peer difficulties (a) from kindergarten to Grade 1, and (b) from Grade 1 to Grade 4. This two-step approach was used to maximize power (i.e., given the high number of parameters to estimate for the number of twin pairs, we did not have enough power to reliably assess an integrated model across the three time points), to separate school entry from the later school grades, and because the time intervals differed. Specifically, each longitudinal common-pathway model assumed two time-specific latent "peer difficulties" factors, each resulting from the covariance between the four assessments of peer difficulties at each time point (see Figure 1). The model estimates the phenotypic factor loading of each assessment on the time-specific latent peer difficulties factor. It decomposes the variance of each time-specific latent peer difficulties factor and of the residual-specific components (i.e., information unique to a source) into genetic (A and a parameters, respectively), shared environmental (C and c) and nonshared environmental (E and e) parts. Finally, the model also decomposes the covariance (i.e., the stability) between the two time-specific latent peer difficulties factors into its genetic, shared environment, and unique environment components. Accordingly, the genetic–environmental structure of this longitudinal overlap is estimated by the genetic correlation (R_G), the shared environment correlation (R_C) and the nonshared environment correlation (R_E). These parameters are derived from comparing within-twin stability correlations (e.g., Twin A's peer difficulties at T1 and T2) and cross-twin stability correlations (e.g., Twin A's peer difficulties at T1 and Twin B's peer difficulties at T2) to the expected values of the general multivariate model (Neale & Cardon, 1992). They also allow estimating the relative importance of each component (i.e., additive genetic, shared environment, and unique environment) in the stability in peer difficulties (Loehlin, 1998). To illustrate, the proportion of total stability accounted for by shared additive genetic factors would be calculated by multiplying the genetic path for peer difficulties at T1 (a or square root of A), the genetic correlation (R_G), and the genetic path for peer difficulties at T2, divided by total stability of peer difficulties. Similar calculations can be performed to estimate similar parts of shared and non-shared environments.

Results

Preliminary Analyses

Table 1 presents sample sizes, means, and standard deviations for the four peer relationship assessments, for the total sample and subgroups. According to both peers and teachers, boys were more victimized and more rejected than girls at all grade levels. With respect to self-assessment, boys did not differ from girls in kindergarten, but progressively perceived themselves as more victimized than girls in Grade 1 and Grade 4. MZ twins were less rejected by peers than DZ twins in kindergarten, but this difference progressively faded away in Grade 1 (still significant at $p < .05$) and in Grade 4 (not significant). According to teachers, MZ twins were less victimized than DZ twins in kindergarten, but not in Grade 1 or in Grade 4. MZ and DZ twins did not differ with respect to peer-assessed and self-assessed victimization.

Phenotypic Correlations

Table 2 displays the phenotypic associations among peer difficulty scores in kindergarten,

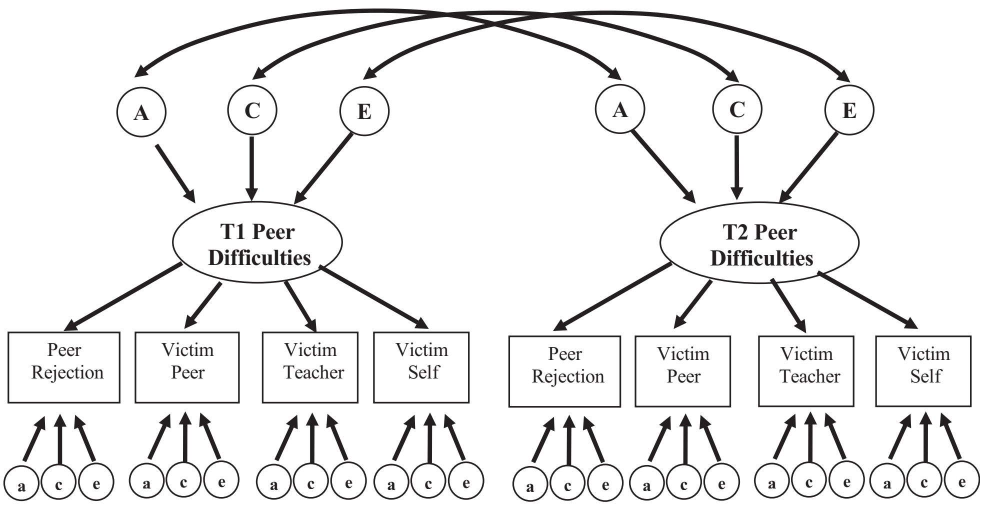

Figure 1. Longitudinal common-pathway model linking peer difficulties across time.
Note. A = additive genetic variance in the general-latent peer difficulties factor; C = shared environment variance in the general-latent peer difficulties factor; E = unique environment variance in the general-latent peer difficulties factor; a = additive genetic variance in the residual-specific components; c = shared environment variance in the residual-specific components; e = unique environment variance in the residual-specific components; Rg = genetic correlation linking T1–T2 peer difficulties; Rc = shared environment correlation linking T1–T2 peer difficulties; Re = nonshared environment correlation linking T1–T2 peer difficulties.

Table 2
Phenotypic Associations Between Peer Difficulties Measures in Kindergarten, in Grade 1, and in Grade 4

	Peer rejection	Victimization peers	Victimization teacher	Victimization self
1. Kindergarten				
Peer rejection	—	.18***	.26***	.10*
Victimization peers		—	.23***	.10*
Victimization teacher			—	.11*
Victimization self				—
2. Grade 1				
Peer rejection		.22***	.31***	.11**
Victimization peers			.29***	.25***
Victimization teacher				.16**
Victimization self				
3. Grade 4				
Peer rejection	—	.46***	.33***	.15***
Victimization peers		—	.42***	.22***
Victimization teacher			—	.22**
Victimization self				—

Note. N varies from 315 to 400 pairs in kindergarten, from 415 to 470 pairs in Grade 1, and from 380 to 427 pairs in Grade 4.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Grade 1, and Grade 4. All correlations were significant and in the expected direction. The size of these correlations was generally low in kindergarten, but increased steadily through Grade 4, thus indicating a growing convergence in the different assessments of peer difficulties. Correlations ranged from .10 to .26 in kindergarten, from .11 to .31 in Grade 1, and from .15 to .46 in Grade 4. Self-ratings of victimization were systematically less associated with other sources of information on peer difficulties but gained in convergence over time.

In the case of peer rejection, the phenotypic stability was .48 from kindergarten to Grade 1, and .37 from Grade 1 to Grade 4, whereas it was .28 and .29 for peer-assessed victimization, .14, and .31 for teacher-assessed victimization, and .30 and .21 for self-assessed victimization, respectively (all *p*s < .001).

Genetic Analyses

Univariate analyses. Table 3 presents the twin ICC for each of the four peer difficulty scores, and their associated univariate A, C, and E estimates and fit indices. A chi-square with a *p* value above .15 reflects a good model fit.

In kindergarten, with the exception of peer rejection, the overall magnitude of the correlations indicated low familial aggregation for both MZ and DZ twins, and only a modest MZ-DZ difference in ICC. The model-fitting results indicated modest heritability (A) for peer rejection, peer-assessed victimization, and teacher-assessed victimization. A modest shared environment contribution (C) was also found for peer rejection and self-assessed victimization.

However, these patterns were not maintained when only twins in different classrooms were considered (see the Appendix): Heritability estimates were no longer significant for both peer rejection and peer-assessed victimization, whereas the A estimate became significant for self-assessed victimization. Shared environment became significant for peer-assessed victimization but was no longer significant for self-assessed victimization. Thus, many of the A and C estimates were low and unstable; they became nonsignificant when only twins in different classrooms were considered. In all cases, unique environment (E), which included measurement error, had an important contribution.

A more consistent picture emerged in Grade 1. For peer rejection, there was a substantial MZ–DZ difference in ICC, resulting in high heritability and no shared environment contribution. Significant moderate heritability, and no shared environment contribution, was also found for both peer-assessed victimization and self-assessed victimization. Only teacher-assessed victimization painted a different picture, with low family aggregation for both MZ and DZ twins resulting in a small shared environment contribution and no heritability. Again, unique environment (E) had important contributions overall. Similar results were found when only twins in different classrooms were considered (see the Appendix).

These patterns were globally maintained in Grade 4. Peer rejection, peer-assessed victimization, and self-assessed victimization were all characterized by significant genetic and unique environment contributions, but no shared environment contributions. Family aggregation remained equally low for MZ and DZ twins in the case of teacher ratings of victimization, yielding a low shared environment contribution, and no heritability. The pattern of results did not change when only twins in different classrooms were considered (see the Appendix).

Table 3
Intraclass Correlations and ACE Estimates for the Different Peer Difficulties Measures

	Intraclass correlation									
	MZ	DZ	Model	χ^2	*p*	AIC	RMSEA	A	C	E
Kindergarten										
Peer rejection	.43	.34	ACE	.03	.985	2174.21	.00	.19	.25*	.56***
Victim peers	.22	.10	AE	.11	.991	2224.21	.03	.21***	—	.79***
Victim teacher	.20	−.01	AE	1.29	.732	2218.92	.08	.16***	—	.84***
Victim self	.24	.23	CE	1.70	.637	1752.94	.00	—	.23***	.77***
Grade 1										
Peer rejection	.56	.22	AE	.40	.940	2209.43	.00	.57***	—	.43***
Victim peers	.30	.11	AE	.33	.954	2275.81	.01	.29***	—	.71***
Victim teacher	.14	.16	CE	1.25	.741	2364.14	.00	—	.15**	.85***
Victim self	.40	.17	AE	.40	.940	2623.36	.00	.39***	—	.61***
Grade 4										
Peer rejection	.46	.21	AE	1.65	.648	1998.89	.04	.43***	—	.57***
Victim peers	.65	.28	AE	2.24	.524	1964.25	.06	.66***	—	.34***
Victim teacher	.25	.26	CE	2.66	.447	2170.00	.00	—	.26***	.74***
Victim self	.20	.04	AE	.86	.835	2369.62	.00	.17**	—	.83***

Note. The fit statistics are computed from the difference between the constrained model and the saturated model. A = additive genetic variance in the general-latent peer difficulties factor; C = shared environment variance in the general-latent peer difficulties factor; E = unique environment variance in the general-latent peer difficulties factor.
**p* < .05. ***p* < .01. ****p* < .001.

Multivariate Longitudinal Analyses

Longitudinal analyses between kindergarten and Grade 1. The initial model estimated the two time-specific peer difficulties factor structures, as well as the correlation between these time-specific peer difficulties latent factors. This initial factor model did not fit the data well, $\chi^2(240) = 361.19$, compared to $\chi^2(144) = 156.92$ for the saturated model; delta $\chi^2(96) = 204.3$, $p < .0005$, comparative fit index (CFI) = .81, root mean square error of approximiation (RMSEA) = .05. The addition of the longitudinal correlations between the residual-specific peer difficulty measures across time in the second model significantly improved the model, $\chi^2(232) = 251.21$, compared to the saturated model, delta $\chi^2(88) = 94.3$, $p = .30$; CFI = .97, RMSEA = .02. In the third model, the longitudinal genetic model was tested. This model, which is presented in Figure 2, revealed an adequate fit when three longitudinal associations between measure-specific residuals were also estimated, $\chi^2(277) = 273.14$, compared to the saturated model, delta $\chi^2(133) = 116.23$, $p = .849$; CFI = 1.00, RMSEA = .00. Thus, over and above the stability of the latent construct and its ACE decomposition, there was also some unique information at the measurement level that also showed significant stability over time. Given their low relevance and for clarity sake, these three residual associations are not shown in Figure 2.

In both kindergarten and Grade 1, all four assessments contributed significantly to a time-specific latent peer difficulties factor (all factor loadings, $p < .001$). The loadings were moderate at both times, although slightly higher in Grade 1 than in kindergarten. Self-assessed victimization had the smallest loadings. At both times, genetic factors accounted for the major part of the variance in the peer difficulties construct (73%), leaving 27% to nonshared environmental factors. Shared environment had no contribution at both times. Stability in peer difficulties, that is, the phenotypic association between the latent constructs at both times, was $r = .73$. When decomposed into its A, C, and E components, this stability was essentially accounted for by the perfect overlap in genetic factors, as indicated by a genetic correlation of $R_G = 1.00$, with no contribution of shared and unique environments, as indicated by the absence of correlation. As per the rules of path analysis described earlier, this phenotypic association is calculated as .85 (i.e., square root of .73) × 1.00 × .85. Inspection of the measure-specific residuals indicated that the unique environment component (e) accounted for most of the residual variance (standardized e estimates varied from .59 to 1.0 in kindergarten and from .48 to 1.0 in Grade 1). With the exception of the shared environment component for peer rejection in kindergarten (.27), and the genetic components of peer rejection (.42) and self-assessed victimization (.35)

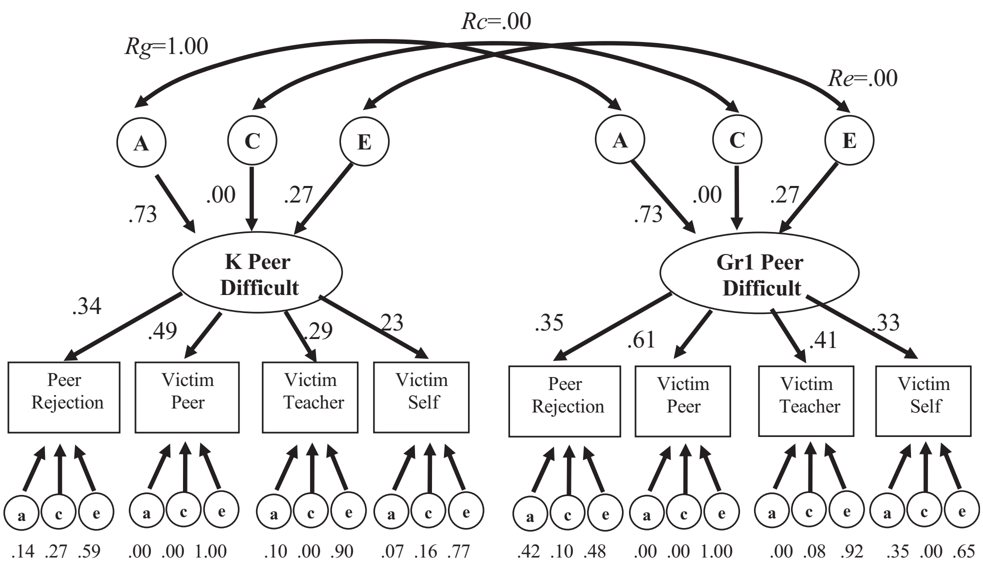

Figure 2. Longitudinal common-pathway model linking peer difficulties in kindergarten and in Grade 1.
Note. A = additive genetic variance in the general-latent peer difficulties factor; C = shared environment variance in the general-latent peer difficulties factor; E = unique environment variance in the general-latent peer difficulties factor; a = additive genetic variance in the residual-specific components; c = shared environment variance in the residual-specific components; e = unique environment variance in the residual-specific components; Rg = genetic correlation linking kindergarten–Grade 1 peer difficulties; Rc = shared environment correlation linking kindergarten–Grade 1 peer difficulties; Re = nonshared environment correlation linking kindergarten–Grade 1 peer difficulties.

in Grade 1, all other measure-specific residuals were marginal. The three significant stability paths among components of measure-specific residuals (all *r*s = 1.0) were those between the genetic and shared environment components of peer rejection over time and that linking the genetic components of self-assessed victimization.

Longitudinal analyses between Grade 1 and Grade 4. The initial model did not fit the data well, $\chi^2(240) = 477.21$, compared to $\chi^2(144) = 146.10$ for the saturated model, delta $\chi^2(96) = 331.1$, $p < .0005$; CFI = .78, RMSEA = .06. However, when the longitudinal associations between the measure-specific residuals were added in the second model, adequate fit was achieved, $\chi^2(224) = 233.87$, compared to the saturated model, delta $\chi^2(80) = 87.8$, $p = .26$; CFI = .99, RMSEA = .01. The longitudinal genetic model, which is presented in Figure 3, also revealed an adequate fit, $\chi^2(274) = 280.92$, compared to the saturated model, delta $\chi^2(130) = 132.91$, $p = .43$; CFI = .99, RMSEA = .01, when specific longitudinal associations between residuals were estimated.

In Grade 4, the factor loadings were again all significant and, in the case of the two peer assessment measures, higher than those in Grade 1. Self-assessed victimization had the smallest loading of the four assessments. Again, genetic factors accounted for the major part of the variance in the latent peer difficulties construct in Grade 4 (94%), leaving 6% to nonshared environmental factors, with shared environment having no contribution. Stability in peer difficulties from Grade 1 to Grade 4, as assessed by the phenotypic association between the two latent constructs, was $r = .69$. This stability was mainly accounted for by the strong overlap of genetic factors at the two time points ($R_G = .83$). The measure-specific residuals in Grade 4 were essentially associated with unique environment (standardized e estimates varied from .69 to .89). Interestingly, there were significant genetic contributions for the residuals of peer rejection (.25), peer-assessed victimization (.31), and self-assessed victimization (.17). Again, four longitudinal associations linking Grade 1 and Grade 4 residuals (i.e., variance not accounted for by the latent factors) were significant in the model: that between the genetic components of peer rejection ($r = .61$), those linking the genetic components ($r = .57$) and the unique environment components ($r = .26$) of self-assessed victimization, and that connecting the unique environment components of teacher-assessed victimization (.55; results not shown in Figure 3).

As indicated previously, given the number of participating twin pairs we could not reliably test and estimate all the parameters of an integrated model covering kindergarten to Grade 4. However, an analog, simplified longitudinal model including the three time points could be adequately tested if

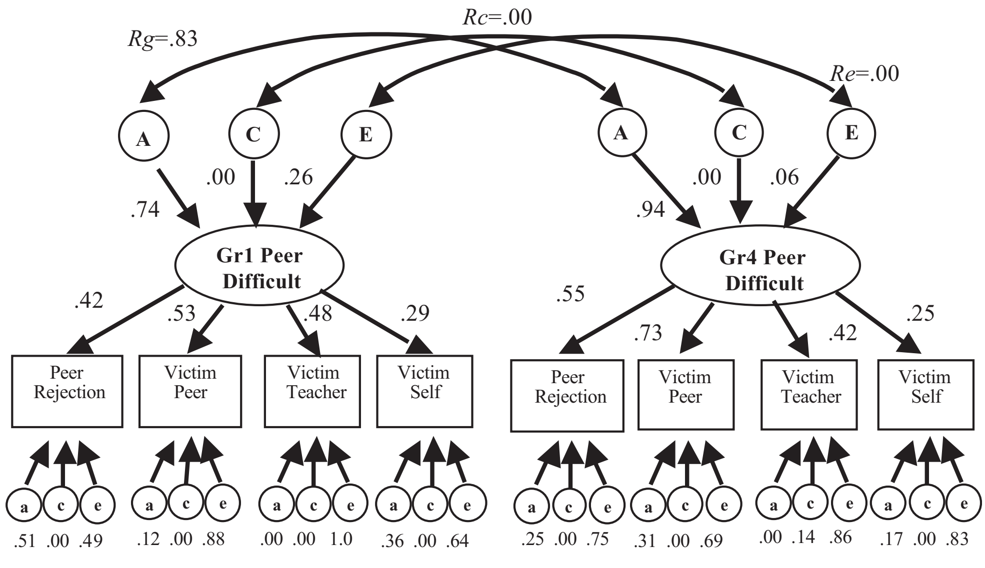

Figure 3. Longitudinal common-pathway model linking peer difficulties in Grade 1 and in Grade 4.
Note. A = additive genetic variance in the general-latent peer difficulties factor; C = shared environment variance in the general-latent peer difficulties factor; E = unique environment variance in the general-latent peer difficulties factor; a = additive genetic variance in the residual-specific components; c = shared environment variance in the residual-specific components; e = unique environment variance in the residual-specific components; Rg = genetic correlation linking kindergarten–Grade 1 peer difficulties; Rc = shared environment correlation linking Grades 1 and 4 peer difficulties; Re = nonshared environment correlation linking Grades 1 and 4 peer difficulties.

the factor structure part of the model was excluded. Accordingly, we performed the following series of analyses. For each time point, we submitted the four peer difficulty scores to a principal component factor analysis. Each factor analysis revealed a one-factor solution accounting for 39% (kindergarten), 45% (Grade 1), and 52% (Grade 4) of the variance, respectively. The corresponding factor scores were computed and found to be almost perfectly correlated to the latent scores derived from the previous analyses (*r*s = .98, .99, and .99, respectively). They could thus be seen as analogs to these previous latent scores, and accordingly, they were used as such in a longitudinal independent pathway ACE model. The full model fitted the data well, $\chi^2(42) = 47.65$, $p = .253$; CFI = .99, RMSEA = .02, and the resulting estimates are presented in the online supporting information Appendix S1. All three peer difficulty composite scores had highly significant loadings on the same genetic factors (.77 in kindergarten, .99 in Grade 1, and .83 in Grade 4), suggesting a high longitudinal overlap in the genetic factor underlying peer difficulty from kindergarten to Grade 4. Both shared and unique environment components were nonsignificant at all grade levels. Residual variance, that is, variance unique to each time, was essentially accounted for by unique environment factors in kindergarten (.93) and in Grade 1 (1.0). However, this was not the case in Grade 4, where new genetic factors accounted for 62% of the residual variance.

Discussion

The goal of the present study was to assess the genetic and environmental contributions to peer difficulties in the early school years. Using a multivariate assessment approach, the study revealed that genetic factors account for a substantial part of both initial and stable peer difficulties from kindergarten to Grade 4. The univariate results were less conclusive and suggested the emergence of a growing consensus among informants regarding the identification of children who experience peer difficulties. There have been some indications in previous work that genetic factors were involved in peer relation difficulties (Ball et al., 2008; Brendgen et al., 2011). The present findings extend the previous reports in several ways and have important implications for preventive intervention.

First, this study is the first to use a multi-informant approach to show that genetic factors are significantly associated with peer difficulties at school entry and in the first years of school. Starting in kindergarten, and then in later grades, genetic factors accounted for most of the variance in peer difficulties, as indexed by a latent factor combining peer, teacher, and self-ratings. In plain words, twins of the same family were highly similar in terms of their peer difficulties, and this similarity was mainly explained by their genetic relatedness. Given that peer difficulties are an experience rather than a child phenotype, a genetic risk associated with peer difficulties could mean that heritable characteristics in the child evoke these negative experiences. Indeed, children's aggressive behaviors, especially of the impulsive or reactive type, have been documented as one of the main behavioral correlates and possible determinants of peer relationship difficulties in the early school years, as well as in preschool (Boivin, Pérusse, et al., 2005; Coie & Kupersmidt, 1983; Dodge, 1983; Dodge, Coie, Pettit, & Price, 1990; Ladd & Troop-Gordon, 2003; Newcomb et al., 1993; Rubin et al., 2006). More recently, physical aggression as early as 17 months was shown to predict high chronic levels of peer victimization in preschool and forecast similar negative experiences at school entry (Barker et al., 2008). As these forms of behavior problems are significantly heritable (Rhee & Waldman, 2002; Van Lier et al., 2007), genetic factors associated with aggressive behavior may partly account for the significant genetic contribution to peer difficulties in the first years of school. Other heritable disruptive behaviors, such as hyperactive behaviors, and deficiencies, such as speech problems, may also be involved. There is a need to further document the presence and nature of these possible associations in the early years of life, as their confirmation would clearly signal the relevance of an early prevention approach that targets these personal risk factors, as well as the ensuing peer difficulties.

Second, this study is also the first to show that genetic factors account for the stability in peer difficulties in the early school years. Specifically, stability of the peer difficulty latent factor was high (*r*s = .73 and .69, respectively), and when these stability coefficients were decomposed, they were mainly accounted for by shared genetic factors between the different time points. Furthermore, this strong genetic association was also found for the diachronic association between the three peer difficulty composite scores when these were integrated in the same model. Finally, genetic factors also accounted for a significant part of the residual variance in peer difficulties that is variance not accounted for by the latent factors, and thus reflecting unique information provided at the measure level (i.e., peer rejection across the three time points and self-assessed victimization between kindergarten and Grade 1). Thus, the genetic factors underlying peer difficulties appeared to be enduring: As the negative experiences crystallize, the same children with the same genetic vulnerabilities tend to become chronically embroiled in a cycle of negative peer experiences. These negative peer experiences have been shown to increase reactive aggression in children, who are initially predisposed to react aggressively (Dodge et al., 2003; Lamarche et al., 2007). Further confirmation of these gene–behavior-environment associations over time would suggest that some developmental trajectories are affected by a cumulative burden of risk, the negative peer experiences, a "correlated" environmental risk, adding to the personal liabilities underlying the behaviors that led to these difficulties. Accordingly, not only should prevention start early but it should also persist over time to alleviate the establishment of this negative cycle.

Over and above the contribution of genetic factors to the stability of peer difficulties (on both latent and residual scores), there was also some evidence for the role of environmental factors in stability. However, this contribution was only found at the level of the residual scores. Specifically, shared environment partly accounted for the stability of (residual) Peer rejection from kindergarten to Grade 1, whereas unique environment accounted for the stability of self and teachers' assessments of victimization from Grade 1 to Grade 4. In other words, at school entry twins of the same family tended to be similarly disliked (or liked) by peers irrespective of their genetic similarity, and later, to stably differ according to self and teachers. The meaning of these contributions is not clear, but as they do not converge with other assessments, they could partly reflect short-term idiosyncratic perceptions, such as persistent biases in self-assessments and teacher assessments (i.e., negative reputations) of peer difficulties over time.

Third, this study is unique in its use of multiple informants, including peer assessments, to evaluate peer difficulties in a large sample of twins. This multi-informant approach provides for an unparalleled control of measurement error, and thus an increased degree of construct validity in the assessment of peer difficulties. The usefulness of the multiple-informant approach was clearly illustrated when the multivariate and univariate results were contrasted. Whereas the multivariate results indicated strong genetic contributions to initial and stable peer difficulties, those stemming from the univariate approach were qualified by age. Specifically for most measures, the pattern of familial aggregation in kindergarten was generally low and unstable (i.e., many of the univariate findings lost their significance when only twins from different classrooms were examined). The results for the later grades were clearer, and the univariate findings pointed toward the progressive establishment of a G–E correlation regarding peer difficulties in the later grade school years.

This initial lack of family aggregation at the measurement level likely relates to measurement and social process issues. On the one hand, it could reflect measurement error due to the young age of the respondents and to the progressive emergence of peer networks and reputations in grade school. Because social relationships and reputations develop over time, they may be more difficult to assess in kindergarten than later in grade school. Kindergarten children and their teacher may have a more idiosyncratic view of emerging social relationships, and thus yield a less consensual and valid assessment of peer difficulties. The fact that the teacher ratings were marginally reliable in kindergarten, but gained in reliability in the later grades, is consistent with this view. The same could be said about the growing associations of peer-nominated victimization items, and more generally, about the lower cross-measure convergence found in kindergarten versus the later grades. This limited, but growing convergence with age is consistent with previous report (Ladd & Kochenderfer-Ladd, 2002) and points to kindergarten as a possible window of opportunity for preventing the establishment of a mutually reinforcing cycle of child–peer antisocial behaviors (Boisjoli, Vitaro, Lacourse, Barker, & Tremblay, 2007), that is, at a time when reputations and social experiences are not yet established and entrenched.

On the other hand, the lower cross-measure convergence in kindergarten did not preclude the reliable estimation of peer difficulties through a latent construct approach. Already in kindergarten, the loadings defining the peer difficulty factor were all significant and showed a degree of convergence supporting the construct validity of our multi-informant approach to peer difficulty.

It is important to note, however, that this lower convergence may have resulted in a latent factor that centers on peer difficulties at the high end of the population distribution, that is, a factor that defines more extreme and salient cases perhaps characterized by severe behavior problems for which genetic influences may be strongest. Indeed, across all ages, the heritability estimates were especially high at the construct level where agreement among assessments is the governing principle. In other words, genetic factors seemed to be most (and highly) important when children cumulated many indications of peer difficulties (see Arseneault et al., 2003, for similar results on antisocial behavior). Those identified by many sources (including self-evaluation), especially if these sources are only moderately associated, may be a unique type of victim, more at risk for a variety of reasons, including genetic factors (see Crick & Bigbee, 1998, on the significance of multivariate assessment of victims). These cases could be of higher clinical significance than those reported by one source only, and should be investigated further.

On that note and with respect to the assessment of peer difficulties more generally, our findings suggest that the information provided by the various informants did not equally converge, and thus may not be uniformly valid. It is noteworthy that self-assessment showed the poorest associations with other measures, and these associations were especially low in kindergarten and in Grade 1. Clearly, each source of information brings a unique perspective to the construct, but significant convergence is expected. A combination of factors may explain why self-report was less associated with the other measures of peer difficulties. First, self-reports partly differed in content and wording from the peer and teacher assessments. For instance, two of the five self-report items referred to indirect and relational forms of victimization, whereas teacher and peer assessments focused on direct forms of victimization. Second, teacher and peer assessments were likely based on the same context, that is, the classroom and school settings, whereas the self-reports could refer to peer difficulties more generally. Finally, peer reports of victimization and rejection likely shared method (i.e., informant) variance, which may have slightly biased the latent construct toward the peer perspective to the detriment of the self-perspective. However that may be, we should be cautious in relying only on self-assessment to document peer difficulties at school entry. More generally, we should always keep in mind that results derived from only one source of information is more likely to carry biased or limited views of peer difficulties, especially in the early years of school. This speaks to the importance of considering multiple viewpoints to reliably assess peer difficulties among young children (see also Ladd & Kochenderfer-Ladd, 2002, for a detailed discussion of the merit of a multi-informant approach to early peer difficulties).

These findings should be interpreted within the limitations of the present study. First, twins may differ from singletons in their peer relationships and generalization could be limited. Having a cotwin, as having a friend (Hodges, Boivin, Vitaro, & Bukowski, 1999), may provide unique experiences of socialization and protection from victimization (Lamarche et al., 2006). In the present study, the peer nomination scores were standardized within class and thus, the resulting z scores provided an indication of where MZ and DZ twins stood in terms of peer difficulties compared to the other children in their class (presumably a majority of singletons). In kindergarten, being an identical (MZ) twin was associated with a more positive status (as indicated by an average peer rejection z score of $-.26$), and with less victimization (an average z score of $-.13$). However, these differences in peer experiences tended to wane over time and did not characterize fraternal (DZ) twins (see Table 1). Most importantly, despite these small initial mean differences, there was substantial variation in peer experiences within the actual sample. This is reflected by the standard deviations of the various peer assessment z scores (peer rejection and peer-assessed victimization). As shown in Table 1, only a few standard deviations were slightly below the expected 1.00. Thus, compared to typical classrooms, our sample of twins had only a limited restriction of the variance in peer difficulties, with a significant number of twins experiencing peer relation difficulties at all ages.

A related question concerns the impact of these difficulties on the child over time. Given that twins may have built-in peer support (i.e., by having a cotwin), one may question whether peer difficulties will affect them similarly as nontwins. Having a cotwin, as a having friend, may protect from the negative impact of these negative experiences (Hodges et al., 1999). This question is obviously beyond the scope of the present study. In previous reports, we found the behavioral and emotional correlates of peer difficulties in twins to be similar to those of singletons (Brendgen et al., 2008, 2009). However, there is a lack of longitudinal data on this question, and future studies should examine the extent to which having a twin moderates or not the relation between peer problems and later poor developmental outcomes.

Second, given the limited sample size, we did not formally test for possible sex differences in G–E contributions to peer difficulties. However, mean sex differences were controlled for, and we found no difference in heritability estimates, thus in rGE, between boys and girls. Third, in relation to possible gender differences, peer difficulties were mainly assessed through direct and overt behaviors by peers (with the exception of peer rejection, which reflected the feelings of peers toward the child), thus limiting the investigating of other, more indirect forms of victimization, often used among girls (Crick & Bigbee, 1998; Paquette & Underwood, 1999; Smith, Cowie, Olafsson, & Liefooghe, 2002).

Fourth, the measures of peer difficulties should also be qualified with respect to the nature of the intended constructs. As is often the case in peer victimization research, we did not specify the power imbalance implicit to the definition of victimization. Instead, the power imbalance was inferred from the questions and, in the case of peer nominations, from the number of nominations received. Scores obtained from peer nominations only provide indirect information about the severity and the frequency of peer victimization. A related and more fundamental question concerns the nature of these early peer experiences as they relate to later negative peer experiences in late childhood and early adolescence where the correlates of peer difficulties, and thus the genetic association, may differ. There is a documented shift in the behavioral correlates of peer difficulties with age, with withdrawn behaviors becoming more associated, and aggressive behavior less correlated, with these negative experiences (Boivin, Petitclerc, Feng, & Barker, 2010; Hanish & Guerra, 2004). It is interesting to note that new genetic factors seemed to partly account for new emerging peer relationship difficulties in Grade 4 (see last analysis). This emerging source of variance could be a sign of such a developmental shift. Future studies should examine the extent to which the pattern of findings holds up for older children, when the severity, nature, and correlates of peer difficulties may change.

These limitations notwithstanding, this is the first large-scale, multiple-informant, longitudinal twin study to provide evidence for a strong genetic "child effect" on persistent peer difficulties in the early school years. However, this strong association with genetic factors in the child should not be interpreted in an overly deterministic way, that is, as a sign that peer difficulties are irremediable and that intervention efforts are useless. Rather, it points to the importance of child characteristics in the process, and to the need to intervene early to prevent these negative experiences from becoming embedded within developmental trajectories and further maladjustment. At the same time, this association signals caution when interpreting heritability estimates assessed at a single point in time. As environmental features, such as peer difficulties, become nested within developmental trajectories associated with genetic factors, they should be taken into account when interpreting the developmental process leading to maladjustment. The same could be said of the early determinants of behavior problems leading to peer difficulties where epigenetic processes could be involved. In the end, these results emphasize the need to adopt an early and persistent prevention framework targeting both the child and the peer context to alleviate the establishment of a negative coercive process and its long-term consequences.

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Appendix

Intraclass Correlations and ACE Estimates for the Different Peer Difficulty Measures for all Twins and for Twins in Different Classes Only

	Intraclass correlation									
	MZ	DZ	Model	$\chi^2(3)$	*p*	AIC	RMSEA	A	C	E
Kindergarten										
Peer rej. (all)	.43	.34	ACE	.30	.999	2172.21	.000	.19	.25*	.56***
Peer rej. (dc)	.30	.24	CE	.41	.938	1545.63	.000	—	.27***	.73***
Vict. peers (all)	.22	.10	AE	.11	.999	2222.21	.030	.21***	—	.79***
Vict. peers (dc)	.15	.21	CE	.88	.830	1546.29	.040	—	.18***	.82***
Vict. teacher (all)	.20	−.01	AE	1.29	.864	2216.92	.085	.16***	—	.84***
Vict. teacher (dc)	.15	−.02	AE	.52	.915	1540.96	.042	.12	—	.88***
Vict. self (all)	.24	.23	CE	1.70	.790	1752.94	.000	—	.23***	.77***
Vict. self (dc)	.31	.14	AE	2.82	.420	1495.62	.000	.35***	—	.65***
Grade 1										
Peer rej. (all)	.56	.22	AE	.40	.982	2207.43	.000	.57***	—	.43***
Peer rej. (dc)	.48	.28	AE	.33	.954	1700.75	.000	.49***	—	.51***
Vict. peers (all)	.30	.11	AE	.33	.988	2273.81	.009	.29***	—	.71***
Vict. peers (dc)	.24	.12	AE	1.25	.741	1744.17	.000	.23***	—	.77***
Vict. teacher (all)	.14	.16	CE	1.25	.869	2362.14	.000	—	.15**	.85***
Vict. teacher (dc)	.04	.14	CE	2.26	.520	1761.53	.000	—	.11*	.89***
Vict. self (all)	.40	.17	AE	.40	.982	2621.36	.000	.39***	—	.61***
Vict. self (dc)	.36	.12	AE	2.90	.407	1734.37	.000	.33***	—	.67***
Grade 4										
Peer rej. (all)	.46	.21	AE	1.65	.800	1996.89	.036	.43***	—	.57***
Peer rej. (dc)	.35	.21	AE	1.55	.671	1411.38	.000	.35***	—	.65***
Vict. peers (all)	.65	.28	AE	2.24	.692	1962.25	.062	.66***	—	.34***
Vict. peers (dc)	.56	.25	AE	.13	.988	1426.63	.000	.55***	—	.45***
Vict. teacher (all)	.25	.26	CE	2.66	.616	2168.00	.000	—	.26***	.74***
Vict. teacher (dc)	.21	.20	CE	2.21	.530	1447.67	.000	—	.20***	.80***
Vict. self (all)	.20	.04	AE	.86	.930	2367.62	.000	.17**	—	.83***
Vict. self (dc)	.28	.04	AE	1.60	.659	1490.46	.003	.24**	—	.74***

Note. Intraclass correlations were computed for all twins (all), and for twins who were in different classes only (dc). The fit statistics are computed from the difference between the constrained model and the saturated model. A = additive genetic variance in the general-latent peer difficulties factor; C = shared environment variance in the general-latent peer difficulties factor; E = unique environment variance in the general-latent peer difficulties factor.
*$p < .05$. **$p < .01$. ***$p < .001$.

Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's website:

Appendix S1. Longitudinal Independent Pathway ACE Model Linking Peer Difficulties from Kindergarten to Grade 4.