



ELSEVIER

Journal of School Psychology xx (2007) xxx–xxx

Journal of
School
Psychology

The effect of classroom environment on problem behaviors: A twin study

Lisabeth Fisher DiLalla*, Paula Y. Mullineaux

*Southern Illinois University School of Medicine, Department of Family and Community Medicine,
 Mail Code 6503, Carbondale, IL 62901, USA*

Received 16 June 2006; received in revised form 27 January 2007; accepted 12 February 2007

Abstract

Children's behavior problems, both internalizing and externalizing, are a function of both genetic and environmental influences. One potentially important environmental influence is the classroom environment. This study of 1941 monozygotic twin pairs examined whether children whose parents rated them as similarly high or low on a number of problem behaviors were rated in the same way by teachers when they were together versus separated in their classrooms at school. Results showed that twins in the same classrooms were rated by their teachers more similarly on each dimension of problem behavior than were twins who were separated into different classrooms, suggesting that the classroom environment is important in predicting differences between twins in terms of problem behaviors at school. In addition, parents' ratings of problem behaviors were lower for twins placed in the same classroom versus twins in different classrooms. Thus, there is reason to consider whether, at least during the early school years, parents should be allowed to make the decision to not separate twins at school.

© 2007 Society for the Study of School Psychology. Published by Elsevier Ltd. All rights reserved.

Keywords: Twins; Classroom environment; Anxiety; Conduct problems; Peer problems

The interaction between child and environment is at the heart of child development. Children's interactions with others in their environment are part of a two-way street, with children's biological make-up influencing their own behaviors as well as influencing how others perceive them (Scarr & McCartney, 1983). This two-way interaction was first

* Corresponding author. Tel.: +1 618 453 1855; fax: +1 618 453 5861.

E-mail addresses: ldilalla@siu.edu (L.F. DiLalla), pmullin@vt.edu (P.Y. Mullineaux).

0022-4405/\$ - see front matter © 2007 Society for the Study of School Psychology. Published by Elsevier Ltd. All rights reserved.

doi:[10.1016/j.jsp.2007.02.001](https://doi.org/10.1016/j.jsp.2007.02.001)

Please cite this article as: DiLalla, L. F., & Mullineaux, P. Y. The effect of classroom environment on problem behaviors: A twin study. *Journal of School Psychology* (2007), doi:[10.1016/j.jsp.2007.02.001](https://doi.org/10.1016/j.jsp.2007.02.001)

described by the Transactional Model (Sameroff & Chandler, 1975), which highlights the importance of both child and parent influencing each other during interactions. The same model can be applied to the relationships between children and teachers, with children's genetic make-up and subsequent behaviors influencing the ways in which teachers respond to them, and simultaneously teachers' behaviors affecting children's responses. Thus, it is essential to understand both the classroom environment as well as the biological and historical influences that children bring to the classroom situation for creating a complete picture of the importance of the classroom environment in affecting children's development and their school achievement.

In addition, the processes that occur as a result of transactional interactions may be especially relevant for co-twins. Not only do parent/child and teacher/child pairs affect each other, but it also is true that siblings affect each other. Twins may have a greater effect on each other than other sibling pairs by virtue of being the same age and of sharing a special attachment bond. This transactional process has implications for the ways in which twins interact with each other and with others, and these interactions are likely to be important influences on children's behaviors in the classroom.

Children's behavior problems, both internalizing and externalizing, are a function of both genetic and environmental influences. A number of studies have examined genetic influence on early behavior problems, and many studies have been conducted on the impact of certain home environments on children's problem behaviors, but the classroom environment itself as an influence on such behavior problems has rarely been examined using a genetic paradigm. Examination of twins in same versus different classrooms allows consideration of two important questions. First, it provides an estimate of the importance of the actual classroom environment on behavior problems, controlling for genetic influence. Second, it permits examination of the appropriateness of separating twins or keeping twins in the same classrooms in school. This is an important issue currently; legislation in Oklahoma, Quebec, and Minnesota recently has addressed whether parents should have a say in whether twins are kept together or are separated, whereas other states leave this decision up to individual schools or districts. Specifically, we can ask whether separating twins increases or decreases the incidence of behavior problems in these children.

The issue of keeping twins together in a classroom can be considered in light of attachment theory (Bowlby, 1969/1982, 1973, 1980; Cassidy & Shaver, 1999). Twins, especially monozygotic twins, are especially attached to each other. They are more likely to nominate each other as their own best friend (Rose, 2002) and their relationship to each other has been characterized as intimate and as one that falls within the definitions of an attachment relationship (Tancredy & Fraley, 2006). Thus, it is reasonable to expect that when twins are in a stressful situation, they would look to their co-twin as a secure base. In a new school classroom, when they are separated from their mothers, having their co-twin with them might provide a protective factor for children who are especially anxious.

On the other hand, in terms of externalizing behaviors, it is likely that twins who are genetically similar also interact in such a way as to increase problem behaviors in each other. According to the transactional model, monozygotic twins who are genetically prone to exhibiting externalizing problems may elicit increased problem behaviors from their co-twin, who also has a genetic proclivity for these behaviors. Thus, these externalizing behaviors may increase in the presence of a monozygotic co-twin. If this is the case, then

separating twins who show these behavior problems in the classroom might help to alleviate the problems.

A study examining the genetic and environmental influences on behavior problems in 7-year-old twins recently compared twins in same versus different classrooms using twins from the Twins Early Development Study (TEDS; Saudino, Ronald, & Plomin, 2005). The researchers studied children's internalizing and externalizing problem behaviors based on both parent and teacher ratings. They found that shared environment (aspects of the environment that make family members more similar) did not differ for children in same versus different classrooms. However, they also found that the influences of nonshared environment (aspects of the environment that make family members dissimilar) increased if twins were separated at school. This suggests that different classrooms exert significant differential effects on children, making the twins different from each other. Other studies also have found that nonshared environment is significant when teachers rate children on various problem behaviors (Towers et al., 2000). Part of this may be a result of teacher rating biases because twins in different classrooms were rated by different teachers rather than by the same teachers, but part of this may reflect real differences in child behavior as a function of the influences of different teachers and different classrooms. One way to address the question of the importance of classroom environment on child behavior is through the use of monozygotic (MZ) twins. By examining differences between MZ twins, who are genetically the same, any differences that emerge must be a result of nonshared environmental influences (Pike, Reiss, Hetherington, & Plomin, 1996). Thus, if we begin with children who are genetically the same (MZ twins) and who are behaviorally similar according to parent reports, then the direct impact of the classroom can be assessed. If the classroom environment affects the children's behaviors, these twins in different classrooms should be rated as more different from each other than should twins placed in the same classrooms.

This method was applied to TEDS twins when they were 4 years old (Asbury, Dunn, Pike, & Plomin, 2003). Examination of the relation between parenting behaviors and behavioral problems for MZ twins suggested that differences between twins in parenting were related to differences in behavior problems, all of which were rated by parents, usually the mothers, who rated their own parenting behaviors toward the children. By examining only MZ twins, the authors were able to identify the relative importance of nonshared environmental influences on children's behaviors. This study demonstrated that differential parenting behaviors explained a small but significant portion of the nonshared environmental variance that influences young children's problem behaviors. The present study will use this MZ differences method to examine the relative importance of classroom environment as a critical measure of nonshared environment for school-aged children.

Effects of classroom environment on children's behavior problems at school

The classroom environment is one of multiple contexts within which children develop (Bronfenbrenner, 1979), and it must be considered along with the home environment as a predictor of child behaviors. Both the class environment and early behaviors learned in the home prior to the advent of school are important predictors of children's school behaviors (NICHD Early Child Care Research Network, 2003), and these work in conjunction with

the child's biological bases to form a system within which the child develops. Thus, the transactional model can also be applied to teacher–child relationships. Teachers may have an effect on child behaviors, and also children affect teacher responses to them based in part on the children's biologically based behaviors as well as behaviors learned outside of the school.

Much research has shown that aspects of the mother–child interaction are important correlates of classroom behaviors. Overall, mother–child relationships that are characterized as warm and sensitive are related to better school outcomes during the preschool and kindergarten period (Connell & Prinz, 2002; Hess, Holloway, Dickson, & Price, 1984; Pianta, Nimetz, & Bennett, 1997). It is sensible, therefore, to assume that the teacher–child relationship that is more warm and sensitive also should be related to better behavioral outcomes of children. In fact, the classroom environment and the teacher–child relationship have been found to be related to school adjustment (Birch & Ladd, 1997), and the direction of effects can go both ways. Child problem behaviors appear to impact the quality of the teacher–child relationship (Henricsson & Rydell, 2004). Children with externalizing problem behaviors have more negative interactions with their teachers and their teachers report a more negative relationship with these children. Likewise, teachers' behaviors and attitudes toward their students have been linked to children's reported behavioral problems in the classroom. For example, teachers' rejection of their students has been related to externalizing behavior problems reported by the children's parents (Pace, Mullins, Beesley, Hill, & Carson, 1999). Conflictual teacher–child interactions predicted negative teacher–child relationships beyond reported child behavioral problems (Henricsson & Rydell, 2004) whereas a close positive teacher–child relationship has a compensatory effect for children with extreme problem behaviors (Baker, 2006).

The classroom environment more generally has been found to impact child problem behaviors. Higher quality classrooms in kindergarten are related to higher levels of child engagement, fewer child compliance problems, and greater cooperation with peers (Rimm-Kaufman, La Paro, Downer, & Pianta, 2005). Likewise, fourth graders' problem behaviors have been shown to increase if they were placed in a poorer classroom environment in fifth grade (Barth, Dunlap, Dane, Lochman, & Wells, 2004). The ways in which teachers manage behavior problems in the classroom also are related to children's behaviors, or at least to how teachers rate those behaviors (Vitaro, Tremblay, & Gagnon, 1995). In a large community sample of children rated first during kindergarten and then in first grade, Vitaro et al. (1995) found that teachers with different management styles rated the same children very differently across grades on aggression and hyperactivity, although parents and peers rated the children similarly over time. This could be a result of children behaving differently at school (but not outside of school) in response to different teacher styles, or it could reflect teacher rater biases. This underlines the importance of including teacher style as a critical component of understanding child behavior at school.

Given that we know that there are important effects of teachers and classrooms on problem behaviors, it is reasonable to assume that children who are genetically the same and who are similar in terms of particular behavior problems as preschoolers should continue to be similar if they are in the same classroom when they go to school. However, they should begin to show behavioral differences if they are placed in different classrooms if the classroom environment is an important nonshared environmental influence on these

behaviors. This study was designed to assess the degree to which classroom environment predicts behavioral differences between MZ twins.

Separating twins in the classroom

In 2006, bill H.F. No. 130 was passed in Minnesota to require that twins and multiples be kept in the same classroom if parents request this. However, there have been few systematic studies of the benefits or disadvantages of putting twins in the same or different classrooms (Hay, 2004; Segal, 2003). Whether or not they are separated is usually mandated by the individual school, and schools vary widely on their perspective. Research guiding these choices is needed. Specifically, the question must be asked whether twins who are already anxious or having peer problems may show an increase in behavior problems as a function of being separated from their co-twins. If the emotional resource of their co-twin is important for helping them deal with the stress of being in school, then an increase in such behavior problems can be expected for twins who are already showing these particular problems.

Currently, two studies have yielded different results examining this issue. Tully, Moffitt, Caspi, Taylor, Kiernan, and Andreou (2004) showed that twins separated in school at 7 years of age had more internalizing problems, but Van Leeuwen, van den Berg, van Beijsterveldt, and Boomsma (2005) did not find this. The Tully et al. (2004) UK study utilized the E-Risk subsample of the Twins Early Development Study (TEDS) twins, which included twins from a particular 2-year assessment period with an oversampling of high-risk mothers who were 20 years or younger when they had their first child. In this study, the researchers examined behavior problems using the Teacher Report Form (TRF; Achenbach & Rescorla, 2001) in twins who were either together or separated in school. They found in their sample of 7-year-old twins that twins who were separated, especially MZ twins, had more internalizing problems, and that this could be attributed to the actual separation and not to the existence of problems prior to separation. On the other hand, Van Leeuwen et al. (2005) studied a Netherlands twin sample and found that more internalizing and externalizing problems were reported for 7-year-old twins who had been separated, but these problems appeared to be evident prior to the separation. Only maternal ratings of internalizing problems seemed to be a direct result of the twins being separated at school. Interestingly, Tully et al. (2004) only used teacher ratings, which may account at least in part for the different findings.

The present project further examined the TEDS sample of twins in same or different classrooms at age 7, utilizing the full sample of TEDS twins rather than only the E-Risk subsample. We assessed children's behavioral problems based on parent ratings at age 4 and then examined whether classroom environment tends to exacerbate or decrease the classroom behavior problems at age 7, using both teacher and parent reports. We also examined whether prior parent reported problem behaviors and classroom environment interacted to affect classroom behavior. Only monozygotic (MZ) twins were included in these analyses because MZ twins share 100% of their genetic make-up and shared environment. Therefore, any differences between the twins must be a result of nonshared environmental influences. This provided a more direct estimate of the influence of classroom environment on the children's behaviors. Thus, rather than conducting standard behavior-

genetic analyses on this sample, as reported by [Saudino et al. \(2005\)](#), this study provides an in-depth examination of environmental influences on children's problem behaviors by holding genetic influence constant via utilization of an only-MZ sample.

Specifically, we hypothesized that MZ twins who were rated similarly by their parents on behavior problems at age 4 and who were in the same classroom at age 7 would be rated similarly for behavior problems at school. Conversely, MZ twins who were rated similarly for behavior problems based on parent ratings at age 4 and who were in different classrooms would be rated more differently for behavior problems at school if the classroom environment affects behavior problems. If there is no behavioral difference, then it can be assumed that classroom environment does not have a significant impact on behavior problems.

In addition, we examined whether twins should be separated or kept in the same classrooms at school. Specifically, we hypothesized that twins with internalizing behavior problems prior to beginning school would have fewer behavior problems at school if they were kept in the same classroom as their co-twin, but twins with more externalizing behavior problems would have fewer problems at school if they were put in separate classrooms.

Methods

Participants

The sample was derived from twins who have participated in the Twins Early Development Study (TEDS), an on-going population-based study that includes all twins born in England and Wales in 1994–1996 ([Trouton, Spinath, & Plomin, 2002](#)). When the twins were 18 months old, background information was collected on pregnancy, birth, and family demographics. Twins were then assessed at 2, 3, 4, and 7 years of age. The current analyses were based only on monozygotic (MZ) twins from the 1994–1996 cohorts tested at ages 4 and 7 with data from parents at ages 4 and 7 and from teachers at age 7. Of the 3659 original MZ families, 2022 (55%) families had complete data for the current analyses. Although this was a fairly high level of attrition, the families continue to be representative of the UK population in terms of parental occupation, education, and ethnicity ([Spinath, Ronald, Harlaar, Price, & Plomin, 2002](#)). Additionally, these twins were not significantly different from the larger set of twins tested at 2 years of age on various behavior problems, including hyperactivity, prosocial behavior, conduct problems, emotional problems, and total behavior problems ([Saudino et al., 2005](#)).

Parent responses to a physical similarity questionnaire were used to assess zygosity. The questionnaire has been shown to be more than 95% accurate when compared to DNA markers ([Price et al., 2000](#)). Same-sex twin pairs were assigned zygosity in 95% of the cases. If zygosity could not be ascertained with certainty, DNA analyses were used. Twin pairs were excluded if zygosity could not be assigned or if one or both twins had a hearing problem, had a specific medical or genetic condition (e.g., cerebral palsy, Down syndrome), or were an outlier for birth weight, time spent in hospital, special care after birth, gestational age, or maternal alcohol consumption during pregnancy. Following these exclusions, the final sample size for the present analyses was 1935 families (53% of the original MZ families). The mean ages at assessment were 4.04 years ($SD = .11$) at age 4, 7.06 ($SD = .25$) for parent ratings at age 7, and 7.20 ($SD = .28$) for teacher ratings at age 7.

Procedure

For both age 4 and age 7 assessments, booklets were sent to the twin families and were returned via mail. In addition, permission was requested from parents to contact children's current teachers. 91% agreed and provided information about teachers' names and contact information. For the present sample of MZ twins, 1237 twin pairs were assessed by the same teacher and 692 were assessed by different teachers (this information was missing for 6 pairs). School policies determined whether twins were placed in same or different classrooms. These policies are highly variable and appear to result in twins being placed in same or different classrooms more or less randomly (Saudino et al., 2005). Socioeconomic status was higher for twins placed in different classrooms ($t=3.66$, $p<.001$), but this accounted for less than .05% of the variance (Saudino et al., 2005).

Measures

The Strengths and Difficulties Questionnaire (SDQ; Goodman, 2001) is a one-page questionnaire that assesses prosocial behaviors and both internalizing and externalizing problem behaviors. There are parent and teacher versions so that parents and teachers can complete comparable assessments of the same children. A 3-point Likert-type scale is used to assess children on 25 items, from Not True to Sometimes True to Always True. Five items load on each of five scales: Prosocial Behaviors, Emotional Symptoms or Anxiety, Conduct Problems, Hyperactivity–Inattention, and Peer Problems. Emotional Symptoms/Anxiety includes items such as “Nervous or clingy in new situations.” Conduct Problems includes items such as “Often fights with other children or bullies them.” Hyperactivity–Inattention includes items such as “Restless, overactive, cannot stay still for long.” Peer Problems includes items such as “Picked on or bullied by other children.” Because the focus of this paper was on behavior problems, the Prosocial Behaviors scale was not used. The SDQ was completed by parents at ages 4 and 7 and by teachers at age 7. Table 1 presents the means and standard deviations for children's SDQ scores for both parent and teacher ratings. Although the SDQ is intended for children as young as four years of age, the norms for a British sample exist only for children aged 5–16 years. Thus, our sample means were compared to norms at age 7 but not at age 4. At age 7, compared to a large British normed sample, the present sample was significantly less disordered on all scales except Hyperactivity. However, the differences between this sample and the normed sample were very small, as can be seen in Table 1. Significant differences appear to be a result of the extremely large sample.

Results

Correlations among the SDQ variables for parent ratings at ages 4 and 7 and for teacher ratings are presented in Table 2. Pairwise deletion was used for this analysis but not for analyses described below. Therefore, sample size differs slightly across analyses for one of two reasons: either because some parents completed questionnaires at one age but not the other, or because parents and teachers occasionally omitted items from the questionnaires, making subscale scores impossible to compute for less than 1% of the children (0.1% for parents at both ages, 0.5% for teachers at age 7).

Table 1
Descriptive statistics for SDQ variables

SDQ variable	Parent norm		Teacher norm		
	Parent age 4	Parent age 7	Age 5–10 ^a	Teacher age 7	Age 5–10 ^a
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Anxiety	1.33 (1.40)	2.21 (1.81)**	1.9 (2.0)	1.29 (1.81)**	1.5 (1.9)
Hyperactivity	4.03 (2.17)	3.61 (2.49)	3.6 (2.7)	2.93 (2.65)	3.0 (2.8)
Conduct Problems	2.08 (1.52)	1.68 (1.60)	1.6 (1.7)	0.75 (1.39)**	0.9 (1.6)
Peer Problems	1.32 (1.38)	0.85 (1.29)**	1.4 (1.7)	1.06 (1.48)**	1.4 (1.8)
Total Behavior Problems	8.85 (4.46)	8.34 (4.93)*	8.6 (5.7)	6.04 (5.17)**	6.7 (5.9)

* Significantly different from normed sample, $p < .05$.

** Significantly different from normed sample, $p < .001$.

^a Norms for British sample from Goodman, 2006, <http://www.sdqinfo.com/bba3.pdf>.

Assessment of the influence of the classroom environment

The influence of the classroom environment was examined in several steps. First, regression analyses were used to determine whether the degree to which children were behaviorally different at age 4 according to parent ratings was related to the degree to which teachers rated them as behaviorally different at age 7. Whether twins were in the same or different classrooms was also an independent variable in the regression equation, thereby allowing ascertainment of whether children in same classrooms behaved more similarly than did children placed in different classrooms. The interaction between same versus different classroom and age 4 behavioral rating was added to the regression model in Step 2 in order to determine whether more difficult children in different classrooms were significantly more difficult as rated by teachers at age 7. The idea was that children who were genetically the same (MZ twins) and behaviorally the same (according to parent ratings at age 4) would be behaviorally the same at age 7 if they continued to be in the same environment (same classroom) but would be behaviorally different if they were placed in different environments (different classrooms).

However, it is possible that 4-year-old parent-rated behaviors would not be related to later teacher-rated behaviors simply because parent and teacher ratings typically are not highly correlated with each other (Achenbach & Rescorla, 2000). Therefore, in a second set of analyses, the same regression analyses were repeated, this time using parent ratings of behavioral differences at age 7 as the dependent variable. These analyses were expected to show a stronger effect of early behavior on classroom behavior because parent reports across time tend to be more highly correlated than are parent and teacher reports. This also allowed an assessment of whether classroom environment effects might affect children at home as well as at school. The results of these analyses were expected to yield information about whether the classroom environment was a significant environmental influence on children's behavior problems.

Finally, in order to examine the effects of the classroom environment with a sharper scalpel, twin pairs were dichotomized into either concordant or discordant pairs according to their parental behavioral ratings. Thus, pairs who were genetically the same as well as behaviorally the same could be compared to pairs who were genetically the same but

Table 2
Listwise deletion correlation matrix between SDQ parent and teacher ratings ($N=1601$)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<i>Parent ratings:</i>															
1 Anxiety Age 4	1.0	.20**	.27**	.24**	.59**	.36**	.16**	.15**	.11**	.29**	.06*	-.01	.01	.01	.02
2 Hyperactive Age 4		1.0	.46**	.18**	.78**	.14**	.54**	.31**	.16**	.46**	-.01	.25**	.16**	.10**	.20**
3 Conduct Disorder Age 4			1.0	.18**	.72**	.17**	.37**	.50**	.15**	.45**	.04	.19**	.18**	.09**	.19**
4 Peer Problems Age 4				1.0	.54**	.20**	.13**	.15**	.30**	.27**	.06*	.09**	.08**	.11**	.12**
5 Total Problems Age 4					1.0	.30**	.49**	.42**	.26**	.57**	.05	.22**	.17**	.12**	.21**
6 Anxiety Age 7						1.0	.18**	.23**	.33**	.61**	.25**	.00	.00	.19**	.12**
7 Hyperactive Age 7							1.0	.47**	.23**	.78**	.05*	.38**	.26**	.15**	.33**
8 Conduct Disorder Age 7								1.0	.26**	.72**	.03	.27**	.29**	.15**	.28**
9 Peer Problems Age 7									1.0	.58**	.19**	.14**	.12**	.29**	.26**
10 Total Problems Age 7										1.0	.18**	.32**	.26**	.23**	.36**
<i>Teacher ratings:</i>															
11 Anxiety Age 7											1.0	.15**	.12**	.32**	.56**
12 Hyperactive Age 7												1.0	.54**	.33**	.81**
13 Conduct Disorder Age 7													1.0	.33**	.68**
14 Peer Problems Age 7														1.0	.67**
15 Total Problems Age 7															1.0

Note: Numbers in bold are correlations between same problem behavior at different ages or with different raters.

behaviorally different, and both of these groups could be compared in terms of whether they were in the same environments (same classrooms) or different environments (different classrooms). In order to do this, parent ratings of each twin at age 4 were compared to determine whether parents rated their twins similarly on each problem behavior category. First, each twin was rated as either extremely high (in the top 20%) or low (in the remaining 80%) for each of the behaviors. Twins were considered concordant for a behavior if both members of the twin pair were rated in the top 20% of the sample or if both members of the twin pair were rated in the remaining 80% of the sample for a particular category. Twins were considered discordant when one twin was rated as extremely high (top 20%) for a behavior and the co-twin was rated as low (remaining 80%) for that behavior. In addition, in order to be considered discordant, the pairs must also differ by more than 2 points on the problem behavior ratings so that twins with scores that were quite close were not rated as discordant. This additional criterion was included to ensure that twin pairs were not identified as discordant when one twin was rated just above the 20% cutoff and the co-twin was rated at just below the 20% cutoff. When this occurred the pair was rated as concordant for the behavior category. This provided a measure of similarity of behavior of the twins at home and in venues for which the parents are familiar. This was repeated with parent ratings at age 7 for each behavior problem. Twin pairs who were concordant at both ages were considered “concordant MZ pairs.” All other twins were considered “discordant MZ pairs.”

Regression analyses

In the first set of analyses, differences between teachers' ratings of twins' problem behaviors were regressed onto parents' age 4 difference scores for problem behaviors, the rating of whether children were in the same versus different classrooms, and the interaction between these two variables. The interaction variable that was used was the residual obtained when the cross-product of the two variables was regressed on both variables. The advantage of this method is that the interaction variable was independent of the original variables, thus not violating variable independence for the regression analysis and thereby making final interpretations clearer (Burrill, 2006). For both teachers and parents, the scores used were the absolute difference scores between the two twins. Thus, children who were behaviorally different at age 4 and in different classrooms at age 7 were expected to be the most behaviorally different at age 7, and children who were behaviorally similar at age 4 and in same classrooms at age 7 were expected to have teacher difference scores near zero. Analyses were run separately for each of the problem behavior categories.

Results showed that being in the same versus different classrooms was significantly predictive of teacher similarity scores for all behavior problems (see Table 3). In addition, differences in age 4 behavior significantly predicted teacher difference scores for the Conduct Disorder, Peer Problems, and Total Behavior Problems scales. No interaction terms were significant. Thus, the primary predictor of teacher difference scores for the twin pairs was whether or not the twins were in the same classrooms and, therefore, whether or not the same teachers rated them.

Similar regression analyses were repeated, this time using as outcome scores the differences between parent rather than teacher ratings of the twins at age 7 in order to determine whether the same results were obtained when using a different rater. Results are

Table 3
Multiple regression results predicting teacher difference scores of SDQ measures from same versus different classrooms and parent SDQ difference scores

	Anxiety			Hyperactivity			Conduct disorder			Peer problems			Total problem behaviors		
	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β
Same/different classroom Age 7	.41	.08	.14***	.59	.09	.19***	.31	.05	.16***	.62	.06	.27***	1.27	.18	.20***
Parent rating Age 4	.03	.04	.02	.03	.02	.03	.06	.02	.07**	.06	.03	.06*	.08	.03	.06*
Classroom \times age 4 difference	-.01	.04	-.01	.01	.05	.00	.04	.03	.04	.01	.04	.01	-.03	.11	-.01
Adjusted R^2	.02			.04			.03			.08			.04		
	$F(3,1480)=9.64***$			$F(3,1486)=19.07***$			$F(3,1486)=13.72***$			$F(3,1480)=41.85***$			$F(3,1488)=23.74***$		

* $p < .05$, ** $p < .01$, *** $p < .001$.

presented in Table 4, and are the opposite of what was found when teacher ratings were used. According to parent ratings, twins who were more similar at age 4 were also more similar at age 7 regardless of whether or not they were in the same or different classrooms. This was true for all five problem behavior categories. In addition, twins who were in the same classrooms were rated by their parents as more similar to each other on the Peer Problems scale. Again, no interaction terms were significant.

Comparing dichotomous groups

The issue of classroom environment was further examined by assessing whether MZ twins who were rated at ages 4 and 7 years by their parents as being behaviorally concordant (“concordant MZ pairs”) were rated similarly by teachers whether they were in the same or different classrooms. Difference scores between teachers’ ratings of twins within a pair were the dependent variables. The top half of Table 5 presents the mean difference scores of the teachers for concordant MZ pairs, stratified by twins who were in the same versus different classrooms. Independent sample *t*-tests were used to compare the difference scores for twins in same versus different classrooms. For each comparison, only twins concordant on parent ratings for the outcome SDQ variable were included. As can be seen quite clearly in the top half of the table, for every category, twins in different classrooms were rated as significantly more different from each other than were twins in the same classroom ($p < .001$ for all measures). These results are consistent with the hypothesis that concordant MZ twins differ from each other more when they are in different classrooms. However, it also is possible that different teachers rated them as more different because of teacher rating biases. The next comparison addressed this question.

If the environmental effect was real and not simply a result of teacher bias, then MZ twins in different classrooms who were rated as concordant by their parents should be rated more similarly by different teachers than should MZ twins in different classrooms who were rated by their parents as discordant. Thus, a comparison was made between MZ twins in different classrooms who were rated as concordant by their parents versus those rated as discordant.

Examination of Table 5 shows that concordant twins in different classrooms were rated as more similar than were discordant twins in different classrooms. However, this was only significant for three of the categories: Anxiety ($t(337.26) = 2.92, p < .01$), Hyperactivity ($t(348.33) = 3.63, p < .001$), and Total Behavior Problems ($t(224.87) = 2.53, p < .01$). This suggests that for these behaviors, teachers’ ratings accurately reflected differences between the twins. However, for Conduct Disorder and Peer Problems, there appears to be a teacher rating bias operating. The differences between the twins actually were much smaller for these two behaviors than for the others, demonstrating that teachers rated co-twins more similarly for these behaviors than for the other three. This also was true when the same teachers rated both twins.

Should twins be separated at school?

Five regression analyses were conducted to test the hypothesis that twins with internalizing behavior problems would have fewer problems if kept in the same classroom as their co-twin, whereas the opposite would be true for twins with externalizing problems.

Table 4
Multiple regression results predicting age 7 parent difference scores of SDQ measures from same versus different classrooms and age 4 parent SDQ difference scores

	Anxiety			Hyperactivity			Conduct disorder			Peer problems			Total problem behaviors		
	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β
Same/different classroom Age 7	.05	.07	.02	-.08	.10	-.02	.01	.05	.00	.16	.06	.08**	-.04	.15	-.01
Parent rating Age 4	.24	.03	.20***	.29	.03	.28***	.17	.02	.20***	.23	.03	.22***	.25	.03	.23***
Classroom \times age 4 difference	.02	.04	.01	-.03	.05	-.02	.01	.03	.01	-.02	.03	-.01	-.03	.09	-.01
Adjusted R^2	.04			.07			.04			.05			.05		
	$F(3,1500)=21.94***$			$F(3,1497)=40.83***$			$F(3,1498)=20.17***$			$F(3,1495)=29.15***$			$F(3,1500)=28.88***$		

** $p < .01$, *** $p < .001$.

Table 5

Means (sd's) of difference scores in SDQ teacher ratings between twin 1 and twin 2, broken down by twins concordant versus discordant for parent SDQ ratings and twins in same versus different classrooms

SDQ teacher ratings:					
Same vs different teachers:	Anxiety	Hyperactivity	Conduct disorder	Peer problems	Total problem behaviors
<i>Concordant parent ratings</i>					
Same teacher	0.81 ^a (1.38)	0.95 ^{a,b} (1.32)	0.39 ^a (0.81)	0.39 ^a (0.82)	2.00 ^{a,b} (2.66)
Different teacher	1.22 ^c (1.48)	1.56 ^d (1.57)	0.63 (1.09)	0.97 (1.21)	3.16 ^c (3.11)
<i>Discordant parent ratings</i>					
Same teacher	0.96 ^c (1.57)	1.21 ^d (1.56)	0.55 ^c (0.94)	0.60 ^c (1.03)	2.70 ^d (3.53)
Different teacher	1.44 (1.98)	1.95 (1.85)	1.02 (1.38)	1.20 (1.34)	4.27 (3.62)

Note. For all SDQ categories, there was a significant difference between concordant and discordant twins and between twins in same versus different classrooms.

^a Significantly different from Concordant Parent/Different Teacher rating, $p < .001$.

^b Significantly different from Discordant Parent/Same Teacher rating, $p < .01$.

^c Significantly different from Discordant Parent/Different Teacher rating, $p < .01$.

^d Significantly different from Discordant Parent/Different Teacher rating, $p < .001$.

^e Significantly different from Discordant Parent/Different Teacher rating, $p < .05$.

One twin from each pair was randomly chosen for these analyses. The independent variables were whether or not twins were in the same classroom as their co-twin at age 7, parent ratings of the child at age 4 for each of the problem behaviors on the SDQ, sex of child, and the residual interaction term between parent rating and same versus different classroom, created as noted above by obtaining the residual score after regressing the interaction term on both original variables. The dependent variables were teacher ratings on the SDQ problem behavior scales. A separate analysis was conducted for each problem behavior.

Results (presented in Table 6) showed that for all behavior problems, children rated as having behavior problems by their parents were significantly likely also to be rated by their teachers as having similar behavior problems. Sex was a significant main effect for all behaviors except Anxiety, with boys rated higher by their teachers on all externalizing problem behaviors. There was no significant effect of being in the same or different classroom as the co-twin except for Peer Problems; children who were separated from their co-twins in the classroom had significantly more peer problems as rated by their teachers. In addition, there were small but significant interaction effects for Conduct Disorder and Peer Problems. Children who were rated by their parents as having conduct problems at age 4 were rated by their teachers as having more conduct problems if they were separated at school from their co-twin, whereas children without early problems were more likely to be rated as having conduct problems if they were kept in the same classroom as their co-twin. A different effect was found for Peer Problems. Children who were in different classrooms from their co-twins and also were rated as having peer problems at age 4 were rated by their teachers as having the most peer problems. Children in the same classrooms as their co-twins and rated as not having earlier problems were rated by teachers as having the fewest peer problems.

Table 6
Multiple regression results predicting teacher SDQ measures (one twin randomly chosen from each pair) from same versus different classrooms and parent age 4 SDQ scores

	Anxiety			Hyperactivity			Conduct disorder			Peer problems			Total problem behaviors		
	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β
Same/different classroom Age 7	.03	.09	.01	-.05	.13	-.01	-.04	.07	-.01	.29	.08	.10***	.20	.25	.02
Sex of child (1=boy, 0=girl)	-.08	.09	-.02	1.36	.12	.26***	.40	.06	.15***	.23	.07	.08**	1.89	.24	.19***
Parent rating Age 4	.08	.03	.06*	.26	.03	.22***	.14	.02	.16***	.12	.03	.12***	.22	.03	.19***
Classroom \times age 4 behavior	.05	.05	.03	-.01	.06	-.00	.14	.02	.07**	.08	.04	.05*	.18	.12	.03
Adjusted R^2	.00			.13			.06			.03			.08		
	$F(4,1640)=1.83$			$F(4,1641)=60.77***$			$F(4,1643)=26.27***$			$F(4,1641)=13.19***$			$F(4,1643)=37.43***$		

* $p < .05$, ** $p < .01$, *** $p < .001$.

Because it is possible that teacher ratings may not be sufficient for detecting subtle differences in some of these behaviors, especially anxiety (teacher ratings of internalizing problem behaviors tend to be less accurate; Kolko & Kazdin, 1993), these analyses were repeated using parent ratings at age 7 as the dependent variables and parent ratings at age 4 as the independent variables (see Table 7). For all behavior problems, age 4 ratings were significantly predictive of age 7 ratings. Also, boys showed more Hyperactivity and Conduct Disorder problems, and girls scored higher on Anxiety. There also were significant main effects for being in same versus different classrooms as their co-twin for Conduct Disorder, Peer Problems, and Total Behavior Problems. Children who were separated from their co-twin were more likely to be rated by their parents as having more problem behaviors. In addition, there was a small but significant age 4 rating \times classroom interaction effect for Conduct Disorder. For children who were rated at age 4 as having conduct disorder problems, if they were in a different classroom from their co-twin, they were rated by their parents as having more conduct disorder problems at school than were children who were in classrooms together with their co-twins.

Discussion

Classroom effects

This study used monozygotic (MZ) twins to examine the influence of the classroom environment on several different problem behaviors of 7-year-old children. The results demonstrated that twins in the same classrooms were rated by their teachers more similarly on each dimension of problem behavior than were twins who were separated into different classrooms. This suggests that the classroom environment is an important influence on children's problem behaviors at school. Teacher rating bias does not appear to account for these differences in teacher ratings when MZ twins were placed in separate classrooms. MZ twins who were in the same classroom with each other were especially rated more similarly on measures of anxiety and hyperactivity.

It must be remembered that the classroom environment includes the presence or absence of the co-twin. Therefore, the salient aspect of the classroom that served to make twins in the same classroom more similar to each other may be the presence of the co-twin. If so, then it is not surprising that children would increase each other's already similar behaviors, as predicted by transactional theory (Sameroff & Chandler, 1975). This study did not assess specific aspects of the classroom environment that also would contribute to similar behaviors. This remains to be studied further.

For twins, this classroom influence occurs via shared environmental influences when twins are in the same classroom and via nonshared environmental influences when twins are in different classrooms. The advantage of using MZ twins is that comparing the two co-twins across classrooms allows us to hold genetic influences constant. A number of studies have demonstrated a heritable effect on various problem behaviors in children (Arseneault et al., 2003; Deater-Deckard & Plomin, 1999; DiLalla, 2002; Polderman, Posthuma, De Sonneville, Verhulst, & Boomsma, 2006). Thus, examination of only MZ twins permitted the study of the effect of the classroom environment on problem behaviors without having to consider the effect of genetic effects. By holding genetic influences constant, any

Table 7
Multiple regression results predicting age 7 parent SDQ measures (one twin randomly chosen from each pair) from same versus different classrooms and parent age 4 SDQ scores

	Anxiety			Hyperactivity			Conduct disorder			Peer problems			Total problem behaviors		
	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β
Same/different classroom Age 7	.16	.08	.04	-.03	.10	-.01	.17	.07	.05*	.23	.06	.09***	.45	.19	.05*
Sex of child (1=boy, 0=girl)	-.25	.08	-.07**	.42	.09	.09***	.17	.06	.05**	.07	.05	.03	.31	.19	.03
Parent rating Age 4	.47	.03	.35***	.59	.02	.53***	.50	.02	.47***	.28	.02	.30***	.61	.02	.54***
Classroom \times age 4 behavior	.04	.04	.02	.01	.05	.01	.09	.03	.05**	.02	.03	.02	.07	.10	.01
Adjusted R^2	.13			.29			.23			.10			.30		
	$F(4,1939)=73.35$			$F(4,1937)=202.70***$			$F(4,1937)=148.56***$			$F(4,1937)=52.62$			$F(4,1939)=212.32***$		

* $p < .05$, ** $p < .01$, *** $p < .001$.

reported differences are due to nonshared environmental influences. Thus, the size of effect must be interpreted in reference to the proportion of the nonshared variance explained versus the total variance due to genetic, shared environmental, and nonshared environmental influences which represents 100% of the variance. In general, nonshared environment accounts for roughly 40% of the variance in parents' and same and different teachers' ratings of problem behaviors (Saudino et al., 2005). When genotype and parent-rated problem behaviors were the same for both members of a twin pair, the classroom environment had a significant impact on children's problem behaviors. The magnitude of the effect sizes for prediction of total problem behaviors ranged from small (4%) to large (30%). These effect sizes should be considered out of a total of approximately the 40% expected for nonshared environment rather than out of 100% because genetic influences are held constant in this study of MZ twins.

This study provides evidence for the importance of the classroom environment as a nonshared influence that significantly affects behavior. Other studies have shown that nonshared environment accounts for significant variance in school-aged children's problem behaviors (Saudino et al., 2005; Towers et al., 2000). In this study, we found that concordant MZ twins' behaviors differed more when they were in separate classrooms, and teacher rating biases did not completely account for this difference. This was especially true for ratings of anxiety, hyperactivity, and total problem behaviors. If teacher rating bias were the sole cause of the differences between twins, then co-twins rated by different teachers would be different from each other whether or not they were considered to be concordant for the behavior. However, we found that this difference was significantly larger for discordant than for concordant pairs. In addition, an earlier study (Saudino et al., 2005) on the 7-year-old TEDS twins demonstrated that teacher rater bias does not appear to account for differences in teachers' ratings. Thus, the classroom environment is likely an important aspect of the nonshared environment that is a significant influence on various problem behaviors.

Other researchers have identified aspects of the classroom environment that appear to influence children's behaviors. For example, the quality of the classroom is related to children's school performance (Barth et al., 2004; Rimm-Kaufman et al., 2005), and students' positive relationships with their teachers are related to fewer behavior problems by the children (Birch & Ladd, 1997; DiLalla, Marcus, & Wright-Phillips, 2004; Pianta, Hamre, & Stuhlman, 2003). However, these studies are based on single children in a family and therefore cannot explore whether the important influence is the classroom environment per se or a genetic predisposition on the part of the child. The present study demonstrates that the classroom environment is a significant influence on children's behaviors beyond the influence of genetic factors.

Same versus different classrooms for twins

The analyses on individual children within a twin pair speak to the potential importance of keeping twins together when they attend school. Although we had expected that being separated at school might help children with externalizing problems, results of this study showed that twins who were separated from their co-twin at school were more likely to be reported by their parents and teachers as having peer problems at

school. It is likely that MZ twin pairs serve as important attachment figures for each other (Tancredy & Fraley, 2006). Thus, having their co-twin with them in the same classroom gave twins a safe base from which to make other friends or else it gave them a sufficient friend so that they did not need others. Rose (2002) has reported that MZ twins are more likely than dizygotic (DZ) twins to report their co-twin as being their best friend. Also, 5-year-old MZ twins have shown greater inhibition in play behavior when they were separated from their co-twin and put in a play situation with an unfamiliar child (DiLalla & Caraway, 2004). Thus, having their co-twin in the classroom appears to have provided a support system so that others did not pick on them as much as when they were separated from their co-twin and alone in a classroom.

Having their co-twin with them in class also seems to have led to reduced conduct problems according to parent ratings. Parents reported that their children had fewer conduct problems if they were kept together with their co-twin in the same classroom. Thus, in terms of conduct and peer problems, twins seem to behave better when they share a classroom with their co-twin. Whether the benefit of experiencing the same classroom environment persists through the later school years is not known. It is possible that the co-twin serves as an important source of support only during the early school years. One study of prosocial behaviors suggested that twins may rely more on their co-twin when they are younger and then become more independent during later school years (DiLalla, 2006).

We had expected that being in the same classroom as their co-twin would help twins show fewer anxiety problems at school, as was found by Tully et al. (2004), but this was not the case. Thus, having an attachment figure (their co-twin) in the classroom with them did not reduce anxiety for these twins. It is possible that anxiety problems were not as evident in this full TEDS sample. The Tully et al. sample was composed of children in the E-Risk subsample, and perhaps higher risk children show their anxiety more overtly. Anxiety is one of the more difficult problem behaviors to observe in others because of the internalizing nature of the problem behavior (Kolko & Kazdin, 1993).

It is possible that children who had more behavioral problems prior to the advent of school were purposely separated at school and placed into different classrooms. An earlier report on this sample found that twins appeared to be either separated or kept together at school based on random school policies rather than based on specific child behaviors or parental request (Saudino et al., 2005). However, examination of the group differences between children in the same versus different classrooms showed that there was indeed a greater likelihood of being separated at school if children had higher scores on hyperactivity or conduct disorders at age 4. This is consistent with the study by Van Leeuwen et al. (2005) that showed that twins had more behavior problems when separated at school but also that these twins had more behavioral problems even before they began school. However, this is unlikely to account for the increased age 7 ratings in the present sample. If it were the case that being in the same versus different classrooms was related to age 7 problem behaviors only because of the relation with classroom and age 4 problem behaviors, then both age 4 problem behaviors and classroom separation would not independently account for variation in age 7 problem behavior scores in the regression analyses, but they did. This suggests that although the primary influence on age 7 problem behaviors was age 4 problem behaviors, being separated at school added significantly to the increase in problem behavior ratings for conduct disorders and peer

problems. Therefore, it is unlikely that purposeful separation of difficult twins was responsible for the results found in this study.

Thus, overall, this study indicates that twins exhibit fewer problem behaviors when they are placed in the same classroom. It appears that there is at least some benefit for twins to share their classroom environments and that this is reflected in their reduced problem behaviors both at home and at school. In fact, when difficult twins were separated at school, their problem behavior scores increased. This evidence suggests that legislators and school systems should consider allowing twins to be placed in the same classroom at least during the early school years.

Limitations

This study has several limitations, the primary one being a lack of explicit assessment of the classroom environments. Without such assessment, it is impossible to identify exactly what in the classroom was responsible for the increase in problem behaviors for children who were separated from their co-twins. In addition, the only way to determine with certainty whether teacher rating bias accounts for these results would be to have a second rater in each classroom to rate the children and then to compare these ratings to the teachers' ratings. This was beyond the scope of this project. With a sample size this large, we must rely on more global ratings by parents and teachers rather than having trained, reliable raters attend each child's classroom to provide accurate ratings of the environment. Nonetheless, the advantages of the large data set offset this limitation and provide valuable information on this twin data set.

The longitudinal nature of this study is both a strength and a concern. Of course a longitudinal study is superior to a cross-sectional study when attempting to determine whether early factors are useful in predicting outcome. In the present study, this method also was useful for identifying twins with early behavior problems at age 4 and then using that information to ascertain whether the twins were behaviorally similar to each other prior to beginning formal schooling. However, it must be acknowledged that the 3-year lag between age 4 and 7 may account for part of the differences in reported behaviors between early parent reports and teacher reports.

Conclusions

This genetically informative study has demonstrated that the classroom environment has a significant impact on children's problem behaviors. Separating twins at school impacts their behaviors via nonshared environmental influences. This demonstrates the importance of differences in unique classroom experiences that are impacting development. Thus, the classroom experience should be conceptualized as an important micro-environmental influence rather than simply viewing the larger schooling experience as a more global macro-environmental influence (Bronfenbrenner, 1979).

In addition, this has specific consequences for twins related to whether they are kept together or separated at school. Our results suggest that twins who are placed in separate classrooms from their co-twins may have more conduct disorder and peer problems. We conclude that at least during the early school years it may be valuable for families to have the option of keeping their twins together in the same classroom.

Acknowledgements

The authors gratefully thank Dr. Robert Plomin for access to the TEDS data. The TEDS is supported by a program grant from the UK Medical Research Council.

References

- Achenbach, T. M., & Rescorla, L. A. (2000). *Manual for ASEBA Preschool Forms & Profiles*. Burlington, VT: University of Vermont, Research Center for Children, Youth, & Families.
- Achenbach, T. M., & Rescorla, L. A. (2001). *Manual for the ASEBA School-Age Forms & Profiles*. Burlington, VT: University of Vermont, Research Center for Children, Youth, & Families.
- Arseneault, L., Moffitt, T. E., Caspi, A., Taylor, A., Rijdsdijk, F. V., Jaffee, S. R., et al. (2003). Strong genetic effects on cross-situational antisocial behaviour among 5-year-old children according to mothers, teachers, examiner-observers, and twins' self-reports. *Journal of Child Psychology and Psychiatry*, *44*, 832–848.
- Asbury, K., Dunn, J. F., Pike, A., & Plomin, R. (2003). Nonshared environmental influences on individual differences in early behavioral development: A monozygotic twin differences study. *Child Development*, *74*, 933–943.
- Baker, J. A. (2006). Contributions of teacher–child relationships to positive school adjustment during elementary school. *Journal of School Psychology*, *44*, 211–229.
- Barth, J. M., Dunlap, S. T., Dane, H., Lochman, J. E., & Wells, K. C. (2004). Classroom environment influences on aggression, peer relations, and academic focus. *Journal of School Psychology*, *42*, 115–133.
- Birch, S. H., & Ladd, G. W. (1997). The teacher–child relationship and children's early school adjustment. *Journal of School Psychology*, *35*, 61–79.
- Bowlby, J. (1973). *Attachment and loss. Separation, Vol. 2*. New York: Basic Books.
- Bowlby, J. (1980). *Attachment and loss. Loss, sadness and depression, Vol. 3*. New York: Basic Books.
- Bowlby, J. (1982). *Attachment and loss, (2nd ed.) Attachment, Vol. 1*. New York: Basic Books Original work published 1969.
- Bronfenbrenner, U. (1979). *The ecology of human development*. Cambridge, MA: Harvard University Press.
- Burrill, D. F. (2006). Modeling and interpreting interactions in multiple regression. Accessed 2 June 2006. <http://www.minitab.com/resources/articles/BURRILL2.aspx>
- Cassidy, J., & Shaver, P. R. (Eds.). (1999). *Handbook of attachment: Theory, research, and clinical applications*. New York: Guilford Press.
- Connell, C. M., & Prinz, R. J. (2002). The impact of childcare and parent–child interactions on school readiness and social skills development for low-income African American children. *Journal of School Psychology*, *40*, 177–193.
- Deater-Deckard, K., & Plomin, R. (1999). An adoption study of the etiology of teacher and parent reports of externalizing behavior problems in middle childhood. *Child Development*, *70*, 144–154.
- DiLalla, L. F. (2002). Behavior genetics of aggression in children: Review and future directions. *Developmental Review*, *22*, 593–622.
- DiLalla, L. F. (2006). Social development in twins. *Twin Research and Human Genetics*, *9*, 95–102.
- DiLalla, L. F., & Caraway, R. A. (2004). Behavioral inhibition as a function of relationship in preschool twins and siblings. *Twin Research*, *7*, 449–455.
- DiLalla, L. F., Marcus, J. L., & Wright-Phillips, M. (2004). Longitudinal effects of preschool behavioral styles on early adolescent school performance. *Journal of School Psychology*, *42*(5), 385–401.
- Goodman, R. (2001). Psychometric properties of the Strengths and Difficulties Questionnaire (SDQ). *Journal of the American Academy of Child and Adolescent Psychiatry*, *40*, 1337–1345.
- Goodman, R. (2006). Information for researchers and professionals about the Strengths & Difficulties Questionnaires. Retrieved February 15, 2006, from <http://www.sdqinfo.com>
- Hay, D. A. (2004). Together or apart? *Twin Research*, *7*, iii–iv.
- Henricsson, L., & Rydell, A. M. (2004). Elementary school children with behavior problems: Teacher–child relations and self-perception. A prospective study. *Merrill-Palmer Quarterly*, *50*, 111–138.
- Hess, R. D., Holloway, S. D., Dickson, W. P., & Price, G. G. (1984). Maternal variables as predictors of children's school readiness and later achievement in vocabulary and mathematics in sixth grade. *Child Development*, *55*, 1902–1912.

- Kolko, D. J., & Kazdin, A. E. (1993). Emotional/behavioral problems in clinic and nonclinic children: Correspondence among child, parent and teacher reports. *Journal of Child Psychology, Psychiatry, & Allied Disciplines*, 34, 991–1006.
- NICHD Early Child Care Research Network. (2003). Social functioning in first grade: Associations with earlier home and child care predictors and with current classroom experiences. *Child Development*, 74, 1639–1662.
- Pace, T. M., Mullins, L. L., Beesley, D., Hill, J. S., & Carson, K. (1999). The relationship between children's emotional and behavioral problems and the social responses of elementary school teachers. *Contemporary Educational Psychology*, 24, 140–155.
- Pianta, R. C., Hamre, B., & Stuhlman, M. (2003). Relationships between teachers and children. In W. M. Reynolds & G.E. Miller (Eds.), *Handbook of psychology: Educational psychology, Vol. 7* (pp. 199–234). NY: John Wiley and Sons, Inc.
- Pianta, R. C., Nimetz, S. L., & Bennett, E. (1997). Mother–child relationships, teacher–child relationships, and school outcomes in preschool and kindergarten. *Early Childhood Research Quarterly*, 12, 263–280.
- Pike, A., Reiss, D., Hetherington, E. M., & Plomin, R. (1996). Using MZ differences in the search for nonshared environmental effects. *Journal of Child Psychology and Psychiatry and Allied Sciences*, 37, 695–704.
- Polderman, T. J. C., Posthuma, D., De Sonneville, L. M. J., Verhulst, F. C., & Boomsma, D. I. (2006). Genetic analyses of teacher ratings of problem behaviors in 5-year-old-twins. *Twin Research and Human Genetics*, 9, 122–130.
- Price, T. S., Freeman, B., Craig, I. W., Petrill, S. A., Ebersole, L., & Plomin, R. (2000). Infant zygosity can be assigned by parent report questionnaire data. *Twin Research*, 3, 129–133.
- Rimm-Kaufman, S. E., La Paro, K. M., Downer, J. T., & Pianta, R. C. (2005). The contribution of classroom setting and quality of instruction to children's behavior in kindergarten classrooms. *The Elementary School Journal*, 105, 377–394.
- Rose, R. J. (2002). How do adolescents select their friends? A behavior-genetic perspective. In L. Pulkkinen & A. Caspi (Eds.), *Paths to successful development: Personality in the life course* (pp. 106–125). New York, NY: Cambridge University Press.
- Sameroff, A. J., & Chandler, M. J. (1975). Reproductive risk and the continuum of caretaking casualty. In F. D. Horowitz, E. M. Hetherington, S. Scarr-Salapatek, & G. Siegal (Eds.), *Review of child development research, Vol 4* (pp. 187–244). Chicago: University of Chicago Press.
- Saudino, K. J., Ronald, A., & Plomin, R. (2005). The etiology of behavior problems in 7-year-old twins: Substantial genetic influence and negligible shared environmental influence for parent ratings and ratings by same and different teachers. *Journal of Abnormal Child Psychology*, 33, 113–130.
- Scarr, S., & McCartney, K. (1983). How people make their own environments: A theory of genotype to environment effects. *Child Development*, 54, 424–435.
- Segal, N. (2003). Research summaries: Relationships, chorions and chromosomes. *Twin Research*, 6, 499–501.
- Spinath, F. M., Ronald, A., Harlaar, N., Price, T. S., & Plomin, R. (2002). Phenotypic 'g' early in life: On the etiology of general cognitive ability in a large population sample of twin children aged 2 to 4 years. *Intelligence*, 31, 195–210.
- Tancredy, C. M., & Fraley, R. C. (2006). The nature of adult twin relationships: An attachment-theoretical perspective. *Journal of Personality and Social Psychology*, 90, 78–93.
- Towers, H., Spotts, E., Neiderhiser, J. M., Hetherington, E. M., Plomin, R., & Reiss, D. (2000). Genetic and environmental influences on teacher ratings of the Child Behavior Checklist. *International Journal of Behavioral Development*, 24, 373–381.
- Trouton, A., Spinath, F. M., & Plomin, R. (2002). Twins Early Development Study (TEDS): A multivariate, longitudinal genetic investigation of language, cognition and behaviour problems in childhood. *Twin Research*, 5, 444–448.
- Tully, L. A., Moffitt, T. E., Caspi, A., Taylor, A., Kiernan, H., & Andreou, P. (2004). What effect does classroom separation have on twins' behaviors, progress at school and reading abilities? *Twin Research*, 7, 115–124.
- Van Leeuwen, M., van den Berg, S. M., van Beijsterveldt, T. C. E. M., & Boomsma, D. I. (2005). Effects of twin separation in primary school. *Twin Research*, 8, 384–391.
- Vitaro, F., Tremblay, R. E., & Gagnon, C. (1995). Teacher ratings of children's behaviors and teachers' management styles: A research note. *Journal of Child Psychology and Psychiatry & Allied Disciplines*, 36, 887–898.