The Challenging Pupil in the Classroom : The Effect of the Child on the Teacher

Renate M. Houts, Avshalom Caspi, Robert C. Pianta, Louise Arseneault and Terrie E. Moffitt

Psychological Science 2010 21: 1802 originally published online 15 November 2010
DOI: 10.1177/0956797610388047

Research Article

Psychological Science
21(12) 1802–1810

DOI: 10.1177/0956797610388047
http://pss.sagepub.com

The Challenging Pupil in the Classroom: The Effect of the Child on the Teacher

Renate M. Houts[1], Avshalom Caspi[1,2], Robert C. Pianta[3], Louise Arseneault[2], and Terrie E. Moffitt[1,2]
[1]Duke University, [2]King's College London, and [3]University of Virginia

Abstract

Teaching children requires effort, and some children naturally require more effort than others. In this study, we tested whether teacher effort devoted to individual children varies as a function of each child's personal characteristics. In a nationwide longitudinal study of 1,102 pairs of twins followed for 7 years, between the ages of 5 and 12 years, we asked teachers about the effort they invested in each child in our study. We found that teacher effort was a function of heritable child characteristics, that a child's challenging behavior assessed at 5 years of age predicted teacher effort toward the same child at 12 years of age, and that challenging child behavior and teacher effort share a common etiology with respect to children's genes. We found that child effects accounted for a significant proportion of variance in teacher effort, but also observed variation in effort exerted by teachers that could not be attributed to children's behavior. Treating children who exhibit challenging behavior and enhancing teachers' skills in managing such behavior could increase the time and energy teachers have to deliver their curriculum in class.

Keywords

behavior genetics, teaching, childhood development, educational psychology

Received 2/4/10; Revision accepted 4/22/10

Relationships between children and adults have a lasting influence on the children's development. Such relationships reflect both the socialization efforts made by adults and the specific characteristics that children bring to these relationships. Forty years ago, developmental and clinical psychologists began investigating how children's characteristics (e.g., gender, developmental delays, sociability, conduct disorder, antisocial behavior) influence interactions with adults (Bell, 1968; Lytton, 1977). In order to disentangle the effects of parenting on children from the effects of children on parenting, the research approach must be carefully designed. Three designs in particular have proven useful (Moffitt, 2005). First, laboratory experiments in which boys were paired with their own mothers and other children's mothers show that conduct-disordered boys elicit more negativity than boys who are not conduct disordered (Anderson, Lytton, & Romney, 1986). Second, adoption studies show that adolescents whose biological mothers have a history of antisocial behavior elicit more negativity from their adoptive parents than adolescents whose biological mothers do not have a history of antisocial behavior (O'Connor, Deater-Deckard, Fulker, Rutter, & Plomin, 1998). Third, studies of twins show that children's heritable characteristics partially explain the amount of punishment children receive (Jaffee et al., 2004). Thus, child-effects research has shown that children who exhibit more difficult behavior also elicit greater negativity and harsher treatment from parents interacting with them.

Although child effects on parents are now known to be ubiquitous, there are fewer studies of child effects on teachers. This is surprising, as children spend approximately 15,000 hr of their young lives at school, and their school performance has a profound effect on their opportunities later in life (Rutter, Maughan, Mortimore, & Ouston, 1979). Studies show that children whose relationships with their teachers are characterized by low levels of conflict and dependency, as well as high levels of closeness and warmth, have more positive academic and social outcomes (Baker, 2006; Birch & Ladd, 1997; Hamre & Pianta, 2001; Pianta, Steinberg, & Rollins, 1995; Rudasill & Rimm-Kaufman, 2009). Moreover, teachers' interactions with children—particularly the regulatory aspects of those behaviors (i.e., timing, contingency, feedback) and their emotional valence—are strongly linked to how much children learn in the classroom (Hamre & Pianta, 2005;

Corresponding Author:
Renate M. Houts, Duke University, Department of Psychology & Neuroscience, 2020 West Main St., Suite 201, Box 104410, Durham, NC 27708
E-mail: rh93@duke.edu

Mashburn et al., 2008). Positive teacher-child interactions can also mitigate aspects of a child's developmental history that increase that child's risk of poor classroom performance (Rimm-Kaufman, La Paro, Downer, & Pianta, 2005). One question that remains, however, is the extent to which estimates of teacher influence or classroom influence are a function of child effects. In other words, how much do children influence their teachers' behavior? In the present study, we examined this question by studying the effort teachers reported when interacting with particular children in their classroom.

Establishing and maintaining positive, productive relationships with children requires significant effort on the part of teachers. This effort involves behaviors similar to those exhibited by effective parents (Wentzel, 2002), such as control, maturity demands, democratic communication, and nurturance (Baumrind, 1971, 1991). More important, one-on-one teacher effort is a precious commodity—although extra attention may be helpful to an individual child, the time spent giving this extra time to one child may detract from the teacher's instruction time or availability to the class as a whole. Given the already limited opportunities to learn in classrooms (Pianta, Belsky, Houts, Morrison, & the Eunice Kennedy Shriver National Institute of Child Health and Human Development Early Child Care Research Network, 2007), and given that "teacher quality is the most important schooling factor affecting student achievement" (Goldhaber & Hannaway, 2009, pp. 3–4), it is important to better understand the factors that shape teachers' behavior. Correlational studies provide suggestive evidence that children's cognitive, emotional, and behavioral difficulties are linked to conflicted relationships with their teachers (Birch & Ladd, 1998; Doumen, Verschueren, Buyse, Germeijs, Luyckx, & Soenens, 2008; Rudasill & Rimm-Kaufman, 2009; Sutherland & Oswald, 2005). To date, however, research designs employed in this field have not enabled researchers to disentangle the direction of effects in the classroom, as they have in the home (Plomin, 1994).

In our study, we tested hypotheses about variation in teacher effort as a function of variation in children's personal characteristics, using a design that has not previously been applied to investigate child effects on teachers. Using the Environmental Risk Study (Moffitt & the E-Risk Study Team, 2002), we directly asked teachers about the effort required to teach each of the 12-year-old children enrolled in our longitudinal twin study as they entered secondary school. In the United Kingdom, children progress from primary school to secondary school between the ages of 11 and 12. We therefore measured teacher effort as children were making a fresh start in a new school and were establishing a new academic and behavioral reputation that could potentially persist through secondary school.

In our analysis, we focused on teacher effort, a measure reflecting the effort teachers say they allocate to a particular pupil. This effort is separate from that required by the class as a whole. Using teacher effort as the outcome, we examined child effects on the environment in two ways. First, by relying on the different levels of relatedness between monozygotic (MZ) and dizygotic (DZ) twin children, we tested the relative contribution of genetic and environmental factors to variation in teacher effort. Finding that the measure of teacher effort was influenced by children's genes would indicate that teacher effort toward a particular child is elicited at least in part by the personal characteristics of the child. Furthermore, we aimed to rule out alternative methodological explanations for such an association by comparing twins rated by the same teacher (in the same classroom) with twins rated by different teachers (in different classrooms). Second, relying on our multimethod/multi-informant longitudinal design, we tested whether cognitive abilities (i.e., low IQ) and behavioral styles (i.e., challenging behavior) of children at 5 years of age contribute to the effort required to teach them 7 years later, at 12 years of age. Finding that teacher effort was influenced by these early characteristics would indicate that teacher effort toward a particular child is elicited at least in part by qualities that predate that child's schooling history.

Method

Sample

Participants were members of the E-Risk Longitudinal Twin Study, which tracks the development of a nationally representative birth cohort of 2,232 British children. The sample was drawn from a larger birth register of twins born in England and Wales between 1994 and 1995 (Trouton, Spinath, & Plomin, 2002). Details about the sample have been reported previously (Moffitt & the E-Risk Study Team, 2002). Briefly, the E-Risk sample was constructed between 1999 and 2000, when 1,116 families with same-sex 5-year-old twins (93% of all eligible families) participated in home-visit assessments. Families were recruited to represent the United Kingdom population of families with newborns in the 1990s, on the basis of residential location (throughout England and Wales) and mother's age (i.e., older mothers having twins via assisted reproduction were underselected, and teenage mothers with twins were overselected). We used this sampling method to replace families who were selectively lost to the register via nonresponse, and to ensure that children growing up in high-risk environments were adequately represented in our study. Follow-up home visits were conducted when the children were 7 years old (98% participation), 10 years old (96% participation), and 12 years old (96% participation). At each home visit, parents were asked for permission to send a written questionnaire to the twins' teachers. Parents were given an opportunity to view this questionnaire before giving their consent.

Zygosity was determined using a standard zygosity questionnaire, which has been shown to be 95% accurate (Price et al., 2000). Ambiguous cases were zygosity-typed using DNA. The sample consisted of 55% MZ twins and 45% DZ twins. Sex was evenly distributed within zygosity (49% male, 51% female). Parents gave informed consent, and children gave

assent to participate in our study. Ethical approval was granted by the Joint South London and Maudsley and the Institute of Psychiatry Research Ethics Committee.

Measures

Teacher effort required by individual children. When the children in the study were 12 years old, questionnaires were mailed to their teachers. Completed questionnaires were obtained for 80% of the original 2,232 E-Risk Study twins (83% of those taking part in the follow-up). The majority of co-twins were in different classrooms and evaluated by different teachers (n = 622 pairs, 70%; 340 MZ pairs, 55%; 282 DZ pairs, 45%), but a substantial minority were in the same classrooms and evaluated by the same teacher (n = 268 pairs, 30%; 147 MZ pairs, 55%; 121 DZ pairs, 45%).

To rate the amount of effort each child required (Table 1), we asked teachers to indicate the frequency with which they needed to intervene with the child in the classroom, using a 7-point scale from 0 (*much less* than typical pupils of the same age) to 6 (*much more* than typical pupils of the same age). All items loaded on one factor, accounting for 64% of the total variance. Cronbach's alpha was .88. The mean of the items served as the final score used in our analyses.

To evaluate interrater agreement, we obtained two teacher reports for 300 children in our sample. Agreement between different teachers was acceptable, r = .61, and comparable to that found in other studies examining cross-teacher consistency (e.g., r = .64 in Achenbach, McConaughy, & Howell, 1987). In subsequent analyses, for children with more than one teacher questionnaire, we included the questionnaire data from the teacher who reported knowing the child best.

Children's IQ. At age 5, children's IQ was individually tested using a short form of the Wechsler Preschool and Primary Scale of Intelligence, Revised (Wechsler, 1990). Using only the Vocabulary and Block Design subtests, we prorated children's IQs following procedures described by Sattler (1992, pp. 998−1004). Scores ranged from 52 to 145 (M = 95.8, SD = 14.5).

Children's challenging behavior. At age 5, children's challenging behavior was assessed via mother and teacher report and observer ratings. Mothers and teachers each reported on 18 symptoms of hyperactivity-impulsivity and inattention included in the *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition (DSM–IV; American Psychiatric Association, 1994). After the home visit, observers-examiners rated each twin on behavioral characteristics assessing style of approach, response to the testing session, and general response to the home visit. In our study, we focused on two scales (Caspi, Henry, McGee, Moffitt, & Silva, 1995): Irritability/negative affect included ratings of lability, low frustration tolerance, hostility, roughness, and resistance; impulsivity/distractibility included ratings of restlessness, impulsivity, fleeting attention, and lacking persistence. See the Supplemental Material (Table S1) available online for individual scale items and reliability coefficients.

We created a composite score to combine the ratings from mothers, teachers, and observers. This score represented psychometrically "true" challenging child behavior that reflected only the part of the ratings by multiple informants in different settings that was due to challenging child behavior. This was accomplished by using principal-component analysis to remove extraneous variance associated with the perspective and context of the different raters (Kraemer et al., 2003). The first component extracted consisted of moderate to strong loadings (range = .58–.67) for all variables. This component accounted for approximately 40% of the total variance (see Table S2 in the Supplemental Material). Standardized scoring

Table 1. Descriptive Statistics for the Teacher-Effort Scale

Question	Number of twins	*M*	*SD*
How frequently must you give this child extra encouragement to get him/her to take part?	1,761	2.30	1.76
How frequently must you act to keep this child's attention on a task?	1,759	2.09	1.81
How frequently must you act to curb disruptive behavior by this child?	1,758	1.36	1.76
How frequently does this child's behavior make it rewarding to work with him/her?[a]	1,761	3.95	1.46
How frequently does this child's behavior make it frustrating to work with him/her?	1,759	1.46	1.70
How frequently does this child need one-to-one interaction from you?	1,760	2.40	1.73
Total score (α = .88)	1,740	1.94	1.36

Note: Available response categories ranged from *much less* than typical pupils of the same age to *much more* than typical pupils of the same age: 0 = *much less*, 1 = *somewhat less*, 2 = *slightly less*, 3 = *about average*, 4 = *slightly more*, 5 = *somewhat more*, 6 = *much more*.

[a]Responses to this question were reverse-scored prior to creating a total teacher-effort score.

coefficients were used to create scores representing challenging child behavior.

Results

Is the effort required to teach a child influenced by that child's genetic makeup?

Table 2 documents substantial twin resemblance in the effort required to teach a child. The within-pair MZ correlation was .64, and the within-pair DZ correlation was .40. The higher correlation between MZ twins (who share their entire DNA sequence) than between DZ twins (who, on average, share half of their segregating DNA sequence) suggests that a child's genetic information influences required teacher effort. To test this hypothesis, we conducted univariate behavior-genetic model fitting using MPlus software, Version 5.21 (Muthén & Muthén, 1998−2009). In behavior-genetic model fitting, variation in phenotype (e.g., required teacher effort) is assumed to be influenced by latent additive genetic (*A*), common environmental (*C*), and nonshared environmental (*E*) factors. We fit different nested models (*ACE* vs. *CE* and *ACE* vs. *AE*) to account for the observed covariance structure using the most parsimonious number of parameters.

Table 2 shows that the model in which children's genetic factors were constrained to have no influence on teacher effort

Table 2. Results of Behavior-Genetic Modeling and Within-Pair Correlations

Sample and model	Variance components			Model fit statistics			
	A	*C*	*E*	χ^2	*df*	RMSEA	$\Delta\chi^2$
Teacher effort (child age = 12)							
Full sample (MZ *r* = .64; DZ *r* = .40)							
ACE	**.45 (.28−.66)**	**.18 (.05−.40)**	**.37 (.32−.42)**	**5.72**	**6**	**0.000**	—
CE	—	.53 (.48−.58)	.47 (.42−.52)	29.86**	7	0.083	24.14**
AE	.64 (.59−.69)	—	.36 (.31−.41)	9.47	7	0.027	3.75†
Co-twins in same classroom (MZ *r* = .80; DZ *r* = .55)							
ACE	**.51 (.31−.80)**	**.27 (.09−.57)**	**.19 (.15−.25)**	**3.24**	**6**	**0.000**	—
CE	—	.68 (.62−.75)	.32 (.26−.39)	27.04**	7	0.146	23.80**
AE	.81 (.76−.86)	—	.19 (.15−.25)	7.23	7	0.016	3.99*
Co-twins in different classrooms (MZ *r* = .56; DZ *r* = .32)							
ACE	.43 (.21−.73)	.12 (.00−.46)	.45 (.38−.53)	6.86	6	0.022	—
CE	—	.46 (.40−.53)	.54 (.48−.61)	18.36*	7	0.073	11.50**
AE	**.56 (.49−.63)**	—	**.44 (.37−.51)**	**7.81**	**7**	**0.019**	**0.95**
Challenging child (child age = 5)							
Full sample (MZ *r* = .68; DZ *r* = .21)							
ACE	.67 (.62−.71)	.00 (.00−.05)	.33 (.29−.38)	15.73*	6	0.056	—
CE	—	.47 (.42−.52)	.53 (.48−.58)	121.50**	7	0.176	105.77**
AE	**.67 (.62−.71)**	—	**.33 (.29−.38)**	**15.73***	**7**	**0.049**	**0.00**

Note: Models in boldface are the best-fitting models. Numbers in parentheses are 95% confidence intervals. Models of teacher effort and challenging child behavior were tested for the full sample; in addition, models of teacher effort were tested separately for twin pairs in which co-twins were in the same classroom and twin pairs in which co-twins were in different classrooms. MZ = monozygotic; DZ = dizygotic; *A* = additive genetic effect; *C* = common-environmental effect; *E* = unique-environmental effect; RMSEA = root-mean-square error of approximation; χ^2 = chi-square model fit statistic; $\Delta\chi^2$ = chi-square test of the difference in fit between the full *ACE* model and the reduced model (*CE* or *AE*).
†$p < .10$. *$p < .05$. **$p < 01$.

(i.e., the *CE* model) fit significantly worse than the model that included genetic factors (i.e., the *ACE* model), $\Delta\chi^2(1, N = 953) = 24.14$, $p < .001$. The model that constrained the common-environmental effect to have no influence on teacher effort (i.e., the *AE* model) had a marginally worse fit than the *ACE* model, $\Delta\chi^2(1, N = 953) = 3.75$, $p = .053$. We chose to accept the more complex *ACE* model because the 95% confidence interval for the *C* term did not include zero. Thus, the best-fitting *ACE* model (highlighted in bold in Table 2) indicated that children's genetic factors accounted for 45% of the variance in teacher effort; common environmental factors accounted for 18% of the variance, and unique, child-specific environmental factors accounted for the remaining 37% of the variance in teacher effort.

Before accepting this interpretation, it is important to consider the possibility that teachers might rate effort required to teach MZ twins more similarly than they would rate effort required to teach DZ twins, simply because MZ twins are more similar in appearance and are therefore more easily taken for one another. That is, it may be that genetic factors did not contribute to MZ twins' greater similarity, but rather that MZ twins appeared to require more similar teacher effort than DZ twins because of rater bias on the part of teachers. To evaluate this possibility, we compared the within-pair MZ correlations and within-pair DZ correlations among twins who were in the same classroom (and evaluated by the same teacher) with the same correlations among twins who were in different classrooms (and evaluated by different teachers; see Table 2).

For twins in the same classroom, the within-pair MZ correlation was .80, and the within-pair DZ correlation was .55. The best-fitting model was the *ACE* model, a result suggesting that genetic factors accounted for 51% of the variance in teacher effort, common environmental factors accounted for 27% of the variance, and unique, child-specific environmental factors accounted for the remaining 19% of variance in teacher effort. For twins in different classrooms, the within-pair MZ correlation was .56, and the within-pair DZ correlation was .32. The best-fitting model was the *AE* model, which indicated that children's genetic factors accounted for 56% of the variance in teacher effort, and unique, child-specific environmental factors accounted for the remaining 44% of variance in teacher effort, with no influence of common environmental factors. The increased shared-environmental effect in same classrooms compared with different classrooms suggests that, in addition to children's characteristics, teacher characteristics or classroom climate influences teacher effort.

We also tested a multigroup model that allowed separate estimates of *A*, *C*, and *E* for twins in the same versus different classrooms, in contrast to a reduced model that constrained the estimates of *A* to be equal for twins in the same and different classrooms. The constrained model did not significantly decrease model fit, $\Delta\chi^2(1, N = 885) = 0.13$, $p = .72$, which indicates that children's genetic factors exerted an equal influence (56%) on required teacher effort regardless of whether children were in the same classroom and evaluated by the same teacher or in different classrooms and evaluated by different teachers.

Is the effort required to teach a child influenced by the child's cognitive ability and challenging behavior?

Table 3 documents whether a child's cognitive and behavioral characteristics at 5 years of age predicted required teacher effort expended on the child at 12 years of age. Irrespective of the source of the behavioral report—mother, teacher, or home visitor—children whose reported behavior was more irritable, impulsive, hyperactive, and inattentive at 5 years of age required more teacher effort at 12 years of age than children with lower levels of these behaviors at age 5. The challenging-child-behavior composite at age 5 correlated positively with required teacher effort at age 12 years, $r = .33$. Children's IQ at age 5 correlated negatively with required teacher effort 7 years later, $r = -.20$. Partialing out the effect of IQ only slightly attenuated the correlation between children's challenging behavior and required teacher effort ($pr = .28$). Partialing out the effect of children's challenging behavior, however, reduced the correlation between IQ and teacher effort by half ($pr = -.10$). Thus, it appears that much of the relationship between low IQ and required teacher effort is accounted for by challenging child behavior, but the relationship between challenging child behavior and teacher effort is less susceptible to variations in children's IQ. Given the statistically weak independent effect of child IQ on teacher effort, we focused our remaining analyses on etiological factors that could influence both challenging child behavior and required teacher effort.

Do genetic factors that influence children's challenging behavior also influence how much teacher effort they require?

Table 2 presents the univariate model-fitting results for challenging child behavior. The *AE* model provided the best fit to the data, with genetic factors accounting for 67% of children's challenging behavior and child-specific environmental factors accounting for the remaining 33% of the variance. We then examined the genetic and environmental influences on the covariation between children's challenging behavior and required teacher effort. In multivariate twin analysis, we compared MZ and DZ correlations across phenotypes—for example, one twin's challenging-behavior score was correlated with the co-twin's teacher-effort score. A finding that the cross-phenotype twin correlations are greater for MZ twins than for DZ twins would imply that genetic factors contribute to the correlation between the two phenotypes. We found that the cross-twin cross-phenotype correlations for challenging behavior and teacher effort were higher for MZ twins than for

Table 3. Correlations Between Children's Characteristics at 5 Years of Age and Teacher Effort When the Children Were 12 Years of Age

	Correlation with teacher effort	
Variable	*r*	*pr*
Mother ratings		
Inattentive	.24	.19
Hyperactive/impulsive	.21	.17
Teacher ratings		
Inattentive	.21	.17
Hyperactive/impulsive	.21	.19
Observer ratings		
Irritability/negative affect	.18	.14
Impulsivity/distractibility	.21	.17
Challenging-child composite	.33	.28
Child IQ	−.20	−.10

Note: All correlations are significant at $p < .01$ (adjusted for clustering of twins within families). *pr* = partial correlation between age-5 risk factor and age-12 teacher effort, removing the effect of challenging child behavior (for IQ) or child IQ (for all others).

DZ twins (MZ: .32 and .33; DZ: .18 and .20). This result suggests that children's genetic background influences the association between challenging behavior and required teacher effort (Table 4).

To formally test this hypothesis, we constructed a bivariate Cholesky model from the most parsimonious univariate models for challenging child behavior (i.e., the *AE* model) and required teacher effort (i.e., the *ACE* model). A significant path from additive genetic influences on challenging child behavior to teacher effort would indicate the degree to which genetic influences on challenging child behavior also influence variation in required teacher effort. Similarly, a significant path from nonshared environmental influences on challenging child behavior to teacher effort would indicate the extent to which child-specific environmental influences on challenging child behavior also influence teacher effort. Since our univariate model for challenging child behavior did not include shared environmental influences, this component could not contribute to the explanation of required teacher effort.

Model fit did not deteriorate significantly when the path from nonshared environmental influences on challenging child behavior to teacher effort was set to zero, $\Delta\chi^2(1, N = 1{,}102) = 0.12$, $p = .73$. However, when additive genetic influences on challenging child behavior were hypothesized to have no effect on teacher effort, the model fit declined significantly, $\Delta\chi^2(1, N = 1{,}102) = 156.39$, $p < .001$. Thus, the final model with the best fit consisted of an *AE* model for challenging child behavior at age 5, an *ACE* model for required teacher effort at age 12, and a significant genetic pathway from challenging child behavior to teacher effort. This model fit our data well, $\chi^2(20, N = 1{,}102) = 29.84$, $p = .07$, root-mean-square error of approximation = .030.

Figure 1 shows that in the model with the best fit, the only significant path between challenging child behavior and required teacher effort is that from genetic influences on challenging child behavior at age 5 to required teacher effort when the child is 12 years of age. This result indicates that 100% of the relationship between challenging child behavior and required teacher effort can be explained by the child's genes that influence both phenotypes ($\beta = 0.40$, $p < .001$). When we estimated parameters as proportions of variance (by squaring the standardized parameter estimates), genetic influences on challenging child behavior accounted for 16% of variance in

Table 4. Within-Twin and Across-Twin Correlations Between Challenging Child Behavior at 5 Years of Age and Required Teacher Effort When the Child Was 12 Years Old

	Twin 1		Twin 2	
Twin and measure	Challenging child, age 5	Teacher effort, age 12	Challenging child, age 5	Teacher effort, age 12
Monozygotic twins				
Twin 1				
Challenging child, age 5	—			
Teacher effort, age 12	.34	—		
Twin 2				
Challenging child, age 5	.68	.32	—	
Teacher effort, age 12	.33	.64	.35	—
Dizygotic twins				
Twin 1				
Challenging child, age 5	—			
Teacher effort, age 12	.26	—		
Twin 2				
Challenging child, age 5	.21	.18	—	
Teacher effort, age 12	.20	.40	.37	—

Note: All correlations are significant at $p < .01$; monozygotic n = 421−599 pairs, dizygotic n = 335−498 pairs.

teacher effort. The remaining variance in teacher effort was accounted for by other genetic influences on the child (35%), shared environmental influences (12%), and nonshared environmental influences (37%) unique to required teacher effort. This means that although we found heritable child effects on teacher effort, teacher effort also may arise from sources beyond the child.

Discussion

Our findings indicate that there are substantial child effects on the effort required to teach individual children. This was demonstrated in three ways. First, variation in teacher effort was shown to be a function of variation among heritable child characteristics. Second, children's challenging behavior, assessed when entering primary school, significantly predicted the effort required to teach the same children in secondary school. Third, such challenging child behavior and the effort required to teach a child appear to share a common genetic etiology. We ruled out two potential methodological artifacts: First, significant child effects remained even when we examined twins rated by different teachers. Second, the measure of challenging child behavior represented a composite of several raters (early teachers, parents, and researchers), which suggests that this composite likely represents stable aspects of the child's behavior, rather than context-specific behavior.

It is interesting to note that child effects on teacher effort were significantly influenced by children's challenging behavior (irritability, negative affect, impulsivity, distractibility, and hyperactivity), and less influenced by children's IQ scores. We found that, consistent with previous research findings, connections between children's cognitive ability and teacher-child relationships appeared to be a function of children's self-regulation and behavioral difficulties (Eisenhower, Baker, & Blacher, 2007). This finding is likely because children with low IQ tend to have co-occurring challenging behaviors, but children exhibiting challenging behavior do not necessarily have low IQ.

Although child effects accounted for a significant proportion of the variance in teacher effort that we observed, we also found considerable variation in teacher effort toward individual children that could not be attributed to a child effect. Common environmental factors influenced required teacher effort among children in the same classroom, but not among children in different classrooms. The common-environment variance component in behavior-genetic models is usually thought to index environmental experiences in children's families that have made the children similar. In our study, shared environmental factors created similarities in teacher's effort between children in the same classroom, but not between children in different classrooms. There are three possible explanations for this finding: First, a shared classroom climate may result in pupils who require similar teaching effort, irrespective of their genetic backgrounds. Second, teachers' individual styles may lead them to invest similar amounts of effort in all pupils in their classrooms. Third, ratings provided by the same teacher may contain bias and create artificial similarities among pupils. Further work examining possible connections among classroom climate, teachers, and teacher effort is

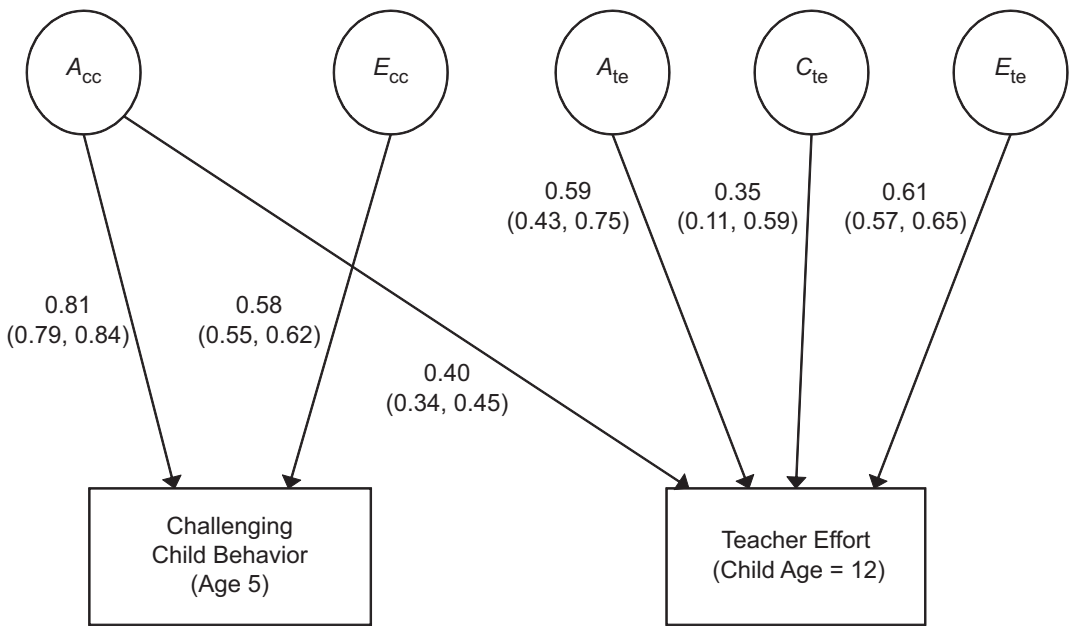

Fig. 1. Standardized parameter estimates (with 95% confidence intervals) for the bivariate Cholesky model of the association between challenging child behavior ("cc") at age 5 and required teacher effort ("te") at age 12. *A* refers to additive genetic influences, *C* to shared environmental influences, and *E* to nonshared environmental influences. The model is displayed for Twin 1 only, but the model for Twin 2 would look identical. The variances of the latent variables are fixed at 1. All parameter estimates are statistically significant at $p < .01$.

needed to determine which of these factors is the most likely explanation for our finding.

Our study has several limitations. First, the findings are limited to one birth cohort growing up in England and Wales; future research will need to establish whether our findings generalize to school settings in other nations. Second, we studied a cohort of twins, and the findings need to be replicated in singletons. Third, we studied only one age group, and factors influencing teacher effort may be different at different ages and stages of school. Fourth, because this was a nationwide cohort, each pair of twins attended a different school, and we were unable to estimate school-level effects on teacher effort. Fifth, our self-report measure of teacher effort was developed for this study and showed very good psychometric properties. However, this measure should be validated against observational measures of teachers in classrooms.

Teaching children requires effort, and some children naturally require more effort than others. The goal of our study was not to blame children (or teachers) for difficulties in the classroom. Rather, our goal was to test the scope of children's effects on adults outside the family in order to better understand the factors that shape teachers' behavior in the classroom, which is emerging as one of the most important schooling factors affecting student learning (Goldhaber & Hannaway, 2009).

Our findings about child effects on teachers have four implications. First, targeted interventions directed at curbing early emerging, challenging child behaviors, particularly those associated with inattention and hyperactivity/impulsivity, may improve children's later teaching environments and thereby contribute to their learning; that is, cumulative continuities in children's difficulties may be stalled by actively breaking up gene-environment correlations. Indeed, treatment for hyperactivity and attentional problems has been shown to improve parenting (Barkley, 1981; Schachar, Taylor, Wieselberg, Thorley, & Rutter, 1987) and may have similar effects on teachers' behavior. Second, children's levels of challenging behavior could be used to determine classroom placement. Minimizing the number of children in each classroom who are extremely challenging would assist teachers in managing difficult behaviors that inevitably arise. Third, the fact that challenging students require more individual effort from teachers is important to consider when developing educational policies such as pay for performance, especially in schools with disproportionate numbers of challenging children. Finally, given the powerful role of children in shaping their teachers' behavior, teachers may benefit from learning and mastering cognitive and behavioral management skills for dealing with challenging child behaviors. Teachers will then be better able to prevent future problems before they arise—particularly problems that consume teachers' efforts and interfere with other students' learning.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Funding

The E-Risk Study is funded by the Medical Research Council (G9806489). Additional support was provided by the Economic and Social Research Council (RES-177-25-0013), Eunice Kennedy Shriver National Institute of Child Health and Human Development (HD061298), National Institute of Mental Health (MH077874), and National Institute on Drug Abuse (DA023026). Louise Arseneault is supported by the U.K. Department of Health. Avshalom Caspi is a Royal Society Wolfson Research Merit Award holder.

Supplemental Material

Additional supporting information may be found at http://pss.sagepub.com/content/by/supplemental-data

References

Achenbach, T.M., McConaughy, S.H., & Howell, C.T. (1987). Child/adolescent behavioral and emotional problems: Implications of cross-informant correlations for situational specificity. *Psychological Bulletin*, *101*, 213–232.

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: Author.

Anderson, K.E., Lytton, H., & Romney, D.M. (1986). Mothers' interactions with normal and conduct disordered boys: Who affects whom? *Developmental Psychology*, *22*, 604–609.

Baker, J.A. (2006). Contributions of teacher-child relationships to positive school adjustment during elementary school. *Journal of School Psychology*, *44*, 211–229.

Barkley, R.A. (1981). The use of psychopharmacology to study reciprocal influences on parent-child interaction. *Journal of Abnormal Child Psychology*, *9*, 303–310.

Baumrind, D. (1971). Current patterns of parental authority. *Developmental Psychology Monographs*, *4*, 1–103.

Baumrind, D. (1991). Effective parenting during the early adolescent transition. In P.A. Cowan & M. Hetherington (Eds.), *Family transitions* (pp. 111–164). Hillsdale, NJ: Erlbaum.

Bell, R.Q. (1968). A reinterpretation of the direction of effects of studies of socialization. *Psychological Review*, *75*, 81–95.

Birch, S.H., & Ladd, G.W. (1997). The teacher-child relationship and children's early school adjustment. *Journal of School Psychology*, *35*, 61–79.

Birch, S.H., & Ladd, G.W. (1998). Children's interpersonal behaviors and the teacher-child relationship. *Developmental Psychology*, *34*, 934–946.

Caspi, A., Henry, B., McGee, R., Moffitt, T.E., & Silva, P.A. (1995). Temperamental origins of child and adolescent behavior problems: From 3 to age 15. *Child Development*, *66*, 55–68.

Doumen, S., Verschueren, K., Buyse, E., Germeijs, V., Luyckx, K., & Soenens, B. (2008). Reciprocal relations between teacher-child conflict and aggressive behavior in kindergarten: A three-wave longitudinal study. *Journal of Clinical Child and Adolescent Psychology*, *37*, 588–599.

Eisenhower, A.S., Baker, B.L., & Blacher, J. (2007). Early student-teacher relationships of children with and without intellectual

disability: Contributions of behavioral, social, and self-regulatory competence. *Journal of School Psychology*, *45*, 363–383.

Goldhaber, D., & Hannaway, J. (2009). Overview. In D. Goldhaber & J. Hannaway (Eds.), *Creating a new teaching profession* (pp. 3–14). Washington, DC: Urban Institute Press.

Hamre, B.K., & Pianta, R.C. (2001). Early teacher-child relationships and the trajectory of children's school outcomes through eighth grade. *Child Development*, *72*, 625–638.

Hamre, B.K., & Pianta, R.C. (2005). Can instructional and emotional support in the first grade classroom make a difference for children at risk of school failure? *Child Development*, *76*, 949–967.

Jaffee, S.R., Caspi, A., Moffitt, T.E., Polo-Tomas, M., Price, T., & Taylor, A. (2004). The limits of child effects: Evidence for genetically mediated child effects on corporal punishment but not physical maltreatment. *Developmental Psychology*, *40*, 1047–1058.

Kraemer, H.C., Measelle, J.R., Ablow, J.C., Essex, M.J., Boyce, W.T., & Kupfer, D.J. (2003). A new approach to integrating data from multiple informants in psychiatric assessment and research: Mixing and matching contexts and perspectives. *American Journal of Psychiatry*, *160*, 1566–1577.

Lytton, H. (1977). Do parents create, or respond to, differences in twins? *Developmental Psychology*, *13*, 456–459.

Mashburn, A., Pianta, R., Hamre, B.K., Downer, J., Barbarin, O., Bryant, D., et al. (2008). Measures of classroom quality in prekindergarten and children's development of academic, language and social skills. *Child Development*, *79*, 732–749.

Moffitt, T.E. (2005). The new look of behavioral genetics in developmental psychopathology: Gene-environment interplay in antisocial behavior. *Psychological Bulletin*, *131*, 533–554.

Moffitt, T.E., & the E-Risk Study Team. (2002). Teen-aged mothers in contemporary Britain. *Journal of Child Psychology and Psychiatry*, *43*, 727–742.

Muthén, L.K., & Muthén, B.O. (1998–2009). *MPlus user's guide* (5th ed.). Los Angeles, CA: Muthén & Muthén.

O'Connor, T.G., Deater-Deckard, K., Fulker, D., Rutter, M., & Plomin, R. (1998). Genotype-environment correlations in late childhood and early adolescence: Antisocial behavior problems and coercive parenting. *Developmental Psychology*, *34*, 970–981.

Pianta, R.C., Belsky, J., Houts, R., Morrison, F., & the Eunice Kennedy Shriver National Institute of Child Health and Human Development Early Child Care Research Network. (2007). Opportunities to learn in America's elementary classrooms. *Science*, *315*, 1795–1796.

Pianta, R.C., Steinberg, M.S., & Rollins, K.B. (1995). The first two years of school: Teacher-child relationships and deflections in children's classroom adjustment. *Development and Psychopathology*, *7*, 295–312.

Plomin, R. (1994). *Genetics and experience: The interplay between nature and nurture*. Thousand Oaks, CA: Sage.

Price, T.S., Freeman, B., Craig, I., Petrill, S.A., Ebersole, L., & Plomin, R. (2000). Infant zygosity can be assigned by parental report questionnaire data. *Twin Research*, *3*, 129–133.

Rimm-Kaufman, S.E., La Paro, K., Downer, J., & Pianta, R. (2005). The contribution of classroom setting and quality of instruction to children's behavior in the kindergarten classroom. *Elementary School Journal*, *105*, 377–394.

Rudasill, K.M., & Rimm-Kaufman, S.E. (2009). Teacher-child relationship quality: The roles of child temperament and teacher-child interactions. *Early Childhood Research Quarterly*, *24*, 107–120.

Rutter, M., Maughan, B., Mortimore, P., & Ouston, J. (1979). *Fifteen thousand hours*. Cambridge, MA: Harvard University Press.

Sattler, J.M. (1992). *Assessment of children: WISC-III and WPPSI-R supplement*. San Diego, CA: Sattler.

Schachar, R., Taylor, E., Wieselberg, M., Thorley, G., & Rutter, M. (1987). Changes in family function and relationships in children who respond to methylphenidate. *Journal of the American Academy of Child & Adolescent Psychiatry*, *26*, 728–732.

Sutherland, K.S., & Oswald, D.P. (2005). The relationship between teacher and student behavior in classrooms for children with emotional and behavioral disorders: Transactional processes. *Journal of Child and Family Studies*, *14*, 1–14.

Trouton, A., Spinath, F.M., & Plomin, R. (2002). Twins Early Development Study (TEDS): A multivariate, longitudinal genetic investigation of language, cognition and behavior problems in childhood. *Behavior Genetics*, *5*, 444–448.

Wechsler, D. (1990). *Wechsler Preschool and Primary Scale of Intelligence-Revised*. London, England: Psychological Corp./ Harcourt Brace and Co.

Wentzel, K.R. (2002). Are effective teachers like good parents? Teaching styles and student adjustment in early adolescence. *Child Development*, *73*, 287–301.