Published in final edited form as:
J Child Psychol Psychiatry. 2008 June ; 49(6): 646–653. doi:10.1111/j.1469-7610.2008.01891.x.

Nonshared environmental influences on teacher-reported behaviour problems: Monozygotic twin differences in perceptions of the classroom

Bonamy R. Oliver[1], **Alison Pike**[2], and **Robert Plomin**[1]

[1]Social, Genetic and Developmental Psychiatry Centre, King's College London, UK

[2]Psychology Department, University of Sussex, UK

Abstract

Background—The identification of specific nonshared environments responsible for the variance in behaviour problems is a key challenge.

Methods—Nonshared environmental influences on teacher-reported behaviour problems were explored independently of genetics using the monozygotic (MZ) twin differences design. Six aspects of classroom environment were rated by a representative sample of 570 nine-year-old MZ twins in the UK in different classrooms and were related to their different teachers' reports of prosocial behaviour, hyperactivity, conduct problems, peer problems and emotional symptoms.

Results—Within-pair differences in perceptions of the classroom were significantly correlated with teacher-reported behaviour problems, indicating children with less favourable perceptions of their classroom environment were reported by their teachers as less prosocial, more hyperactive, and to have more conduct and peer problems. Socioeconomic status did not significantly moderate any of these relationships. However, parent-reported household chaos was a significant moderator.

Conclusions—The classroom environment is related to behaviour problems even when genetic factors are held constant. Classroom environment is more strongly associated with behaviour problems when the home environment is more chaotic.

Keywords

Nonshared environment; monozygotic twins; behaviour problems; classroom environment

---

Of concern to parents and professionals alike, behaviour problems have extensive long-term implications for academic achievement, delinquency and premature school departure as well as social functioning (e.g., Ferdinand, Stijnen, Verhulst, & Van der Reijden, 1999; McGee, Prior, Williams, Smart & Sanson, 2002). Concern over their far-reaching effects as well as high prevalence rates (Achenbach, Dumenci, & Rescorla, 2003) has motivated a search for the sources of individual variability in behaviour problems.

Address for correspondence: Dr Bonamy Oliver, Box P083, Social, Genetic and Developmental Psychiatry Centre, Institute of Psychiatry, De Crespigny Park, London SE5 8AF, U.K. Tel: +44 (0) 20 7848 0748, b.oliver@iop.kcl.ac.uk.

Although the results are somewhat mixed, behavioural genetic studies of behaviour problems converge in their indication of significant genetic influences, negligible to modest shared and moderate nonshared environmental influences (for review, see Saudino, Ronald & Plomin, 2005). While such studies are informative, the identification of specific genes and environments responsible for the variance remains a challenge for molecular and behavioural genetic researchers.

Classroom Environment & Child Behaviour

For school-age children, it is clear that the classroom setting is a potential source of child-specific environment, not least because the pupil-teacher relationship plays an important role in creating the right conditions for motivating children (Turner, Midgley, Meyer, Gheen, Anderman et al., 2003). For example, a recent study indicated associations between poor classroom environment and an increase in emotional and behavioural problems (Somersalo, Solantaus, Almqvist, 2002).

Despite the seemingly obvious relationship between classroom environment and classroom behaviour, relatively little research has sought to explain it. Furthermore, extant research has not accounted for the fact that such associations may be due to gene-environment correlations, that is, individuals may have ‘genetic control’ of exposure to the environment (Kendler & Eaves, 1986). This can take one of three forms: passive, reactive, or evocative gene-environment correlations (Plomin, DeFries, & Loehlin, 1977); the latter two are most likely to be involved in relationships between classroom environments and behaviour problems. Reactive gene-environment correlation refers to the evocation of reactions from others on the basis of an individual’s genetic propensities; for example, teachers may respond less supportively to a behaviourally difficult child. Active gene-environment correlation occurs when individuals select and modify their environments on the basis of their genetic propensities; for example, a behaviourally difficult child may seek out less well-behaved peers.

MZ Differences Method

Plomin & Daniels (1987) identified three challenges for researchers seeking to unravel the role of nonshared environment in psychology: identify environments that are specific to children in the same family, relate these differential environments to differential outcomes, and disentangle the direction of causality. Limited to a cross-sectional design, the current study does not attempt to tackle the third of these challenges, which remains an important focus for future research. However, our study of monozygotic (MZ) twins addresses the first two of these challenges using a simple and elegant method for identifying effective nonshared environments: the MZ differences method. This method exploits the fact that MZ twins share 100% of their genes, and thus any differences between their environments is purely nonshared (Pike, Reiss, Hetherington, & Plomin, 1996). For MZ twins, such differences cannot be due to differing genes eliciting differential environmental experiences, as is possible in the case of typical siblings who share (on average) only 50% of their segregating genes. Several studies using the methodology have now been published (e.g., Asbury, Dunn, Pike, & Plomin, 2003; Caspi, Moffitt, Morgan, Rutter, Taylor et al., 2004;

Lehn, Derks, Hudziak, Heutink, van Beijsterveldt, & Boomsma, 2007; Sharp, Gottesman, Greenstein, Ebens, Rapoport, & Castellanos, 2003).

Many of these studies have had children's behaviour problems as their focus, typically testing parental differential treatment as the nonshared environmental candidate. For example, differential maternal expressed emotion has been identified as a risk factor for antisocial behaviour (Caspi et al., 2004) and differences in harsh discipline and negative parental feelings have been linked to twins' prosocial behaviour, hyperactivity, and conduct problems (Asbury et al., 2003). Extra-familial environmental factors have received little attention; the current study is the first to examine the classroom environment as a potential nonshared environmental factor.

In the current study, we assess children's perceptions of their classroom as a candidate for explaining MZ twin differences in problem behaviour. Children's own perceptions of their classroom environment were used because of their critical importance - over and above objective measures - for individual and academic outcomes (for review see Dorman, 2002; also, Anderman, 2002).

Moderation by Shared Environmental Factors

Although traditional quantitative genetic theory makes the assumption that genes, shared and nonshared environments work in an additive fashion to influence outcomes, methodological and statistical advances have documented G-E correlations and GXE interactions (Rutter, 2006). Additionally, shared environmental risk factors such as low socio-economic status have been associated with increased parental differential treatment (Jenkins, Rasbash, & O'Connor, 2003), again indicating that simplistic additive models may mask important interactive processes. The current study examined whether shared environmental factors moderated links between differential classroom environment (the nonshared environmental candidate) and children's problem behaviour. We chose one distal shared environmental factor, socio-economic status, and one proximal factor, household chaos (an environment that is high in noise and crowding, and low in regularity and routines (Wachs, 2005)), as the prospective moderators.

Previous research indicates a small but consistent link between socio-economic status (SES) and children's problem behaviour (e.g., Huston, McLoyd, & Coll, 1994). Further, SES has been shown to moderate the relationship between child temperament and parental warmth, with stronger relationships found in lower SES families (Jenkins et al., 2003). Far less research has been conducted concerning household chaos, although links have been found with children's behaviour problems (e.g., Dumas, Nissley, Nordstrom, Smith, Prinz et al., 2005). More importantly, chaos has been shown to moderate the association between parenting and behaviour problems, such that children in highly chaotic homes who also experienced poorer quality parenting were at particular risk for behaviour problems (Coldwell, Pike, & Dunn, 2006). Based on these findings, SES and household chaos were deemed appropriate shared environmental factors that could moderate associations between differential classroom environment and behaviour problems.

Current Study

Sampled from a large population-based sample of twins, our study used a multi-informant approach to avoid rater bias – a limitation of previous MZ difference research described by Rutter (2006). The over-arching goal was to explore the relationship between aspects of the classroom environment and MZ differences in behaviour problems. Specifically, we aimed to: (i) identify the extent to which MZ twins in middle childhood perceive their classrooms differently, (ii) examine the links between differential classroom environments and twin differences in behaviour problems and (iii) assess potential moderation of the associations by SES and household chaos.

Method

Sample

The Twins' Early Development Study (TEDS), a longitudinal study of U.K. twins born in 1994, 1995 and 1996, formed the sampling frame for the current study. TEDS has been in contact with the twins and their families since infancy, and continues to follow them through childhood and into adolescence. TEDS has been shown to be reasonably representative of the U.K. population, and is described elsewhere (Trouton, Spinath & Plomin, 2002; Oliver & Plomin, 2007).

When the 1994 and 1995 cohorts were nine years old, data were collected from children, parents and teachers. Full data - that is data from parent, teacher and from both twins in the pair were available for 2,325 families (4,650 children). After medical and missing data exclusions, we selected only MZ twins for the present analyses. We further selected twins - approximately one third of the remaining sample - in different classrooms (with different teachers), for three main reasons. First, restricting the sample in this way ensures that every co-twin was rated by a different teacher, second, the classroom environment experienced by the twins was unique, providing a more generalisable measured nonshared candidate, and third, this scenario mimics that for most non-twin children who do not attend classes with their siblings. Single teacher ratings for both members of MZ twin pairs are likely to be more similar than those from different teachers; while it is possible that this is a reflection of greater similarity between twins sharing their classroom environment, it can also be due to rater bias. This issue is considered further later (see Results). Zygosity was assigned using DNA testing. The current sample consisted of 285 twin pairs (570 children), 123 boy, and 162 girl pairs. The mean age was 9.03 years (range = 8.46 – 10.27 years) when teacher questionnaires were received and 9.01 years (range = 8.44 – 10.34) when parent and child questionnaires were returned. Informed consent was obtained.

Measures

Behaviour—Teacher assessments of the children's behaviour at school were collected using the 25-item Strengths and Difficulties Questionnaire (SDQ: Goodman, 1997), designed to measure behaviour problems and competencies in children aged 3–16 years. The rater is asked to indicate whether attributes are "not true" (score=0), "somewhat true" (score=1) or "certainly true" (score=2) for the child. The SDQ provides scores (derived by summing five items for each scale) assessing prosocial behaviour, hyperactivity-inattention, conduct problems, peer problems, and emotional symptoms. The SDQ's validity and reliability is well established (Goodman, 2001).

Classroom Environment—Children's perceptions of the classroom (CEQ) were assessed using a modified version of the *School Life Questionnaire* (Ainley & Bourke, 1992), adapted TEDS by a) selecting the four highest-loading items for six domains (General Satisfaction, Negative Affect, Social Integration, Opportunity, Pupil-Teacher Relationship, and Adventure), a total of 24 items; and b) modifying all items to make them appropriate for nine year-olds. Child responses to items within each domain were summed, creating six individual scale scores. Reliabilities for all domains were high and comparable to published reports (mean alpha = .72 (.61–.80)).

Socio-Economic Status—Using information provided by parents, an index of socio-economic status (SES) was created based on a factor analysis of fathers' and mothers' highest educational qualification, fathers' and mothers' occupation, and mother's age at birth of eldest child. Each variable was standardised, and summed using unit weights.

Chaos in the Home—Household disorganization was examined using a short version of the Confusion, Hubbub and Order Scale (CHAOS; Matheny, Wachs, Ludwig, & Phillips, 1995), and comprises six items such as 'We are usually able to stay on top of things', 'You can't hear yourself think in our home', and, 'It's a real zoo in our home' (1 = definitely untrue; 5 = definitely true). Higher scores indicate greater disorganization. Items were summed to produce a total household disorganization score. Internal reliability of this measure in TEDS is adequate (alpha = .52).

With the exception of prosocial behaviour, where a high score indicates more prosocial behaviour, all teacher, child and parent scales were coded in the direction of risk, such that a high score indicated more problem behaviour (SDQ) and less favourable perceptions of the classroom environment (CEQ).

As expected, significant sex differences were found for both SDQ and CEQ scales, with SDQ correlations with sex greater in magnitude (mean r = 0.21; range r = 0.01 (emotional symptoms) − 0.38 (hyperactivity-inattention)) than those for CEQ scales (mean r = 0.11; range r = 0.01 (Social Integration) − .17 (Pupil-Teacher Relationship)). Thus, SDQ and CEQ scales were adjusted for sex. The scales were also adjusted for age, and standardized to a mean of zero and standard deviation of 1 on the basis of the entire TEDS sample, after excluding twins with major perinatal and/or medical problems. These residuals were used in the analysis because the age and sex of twins in this same-sex sample are perfectly correlated across pairs, and variation in age and sex could contribute to the correlation between twins, which may be misrepresented as shared environmental influence (McGue & Bouchard, 1984).

Results

In order to assess the extent to which MZ twins in middle childhood perceive their classrooms differently, MZ twin correlations of their perceptions of their classroom environments were calculated. These were moderate in magnitude: r = .38, .32, .36, .22, .36, and .40 for General Satisfaction, Negative Affect, Social Integration, Opportunity, Adventure, and the Total score respectively. These associations thus indicated substantial *dis*similarity in MZ twin classroom environment. Twin correlations for SDQ (.33 – .52) also indicated considerable non-shared environmental influences for teacher-reported behaviour, thus allowing for the possibility that MZ twin differences in perceived classroom environment could account, at least in part, for MZ twin differences in teacher-observed behaviour problems.

Table 1 presents phenotypic correlations between children's perceptions of the classroom environment and teacher-reported SDQ subscales, half of which were significant (.01 – .33; average significant correlation, .21).

Within pair relative difference scores were calculated for the CEQ and SDQ scales by randomly assigning one of the twins of each pair as Twin1 and the other as Twin2 and subtracting the Twin2 score from the Twin1 score. We correlated MZ differences in classroom environment with MZ differences in behaviour (see Table 2). Nine of the 30 correlations were significant, and modest in magnitude. Negative Affect, Social Integration, Opportunity, and Adventure subscales all yielded links across more than one domain of behaviour. All significant correlations were in the expected direction, indicating that twins who reported less satisfaction with their classroom environment than did their co-twin displayed more problematic behaviour than did their co-twin. It should be noted, however, that the correlations presented were not corrected for multiple tests of significance, and that just two of the associations were significant at $p < .01$. We chose a liberal strategy for this study due to this being the first investigation of classroom environment as a nonshared environmental candidate. Caution, pending replication, is of course warranted.

For interest, we reran our analyses for twins in the same classroom. As expected, MZ twin similarity for both teacher-rated behaviour and twins' perceptions of the classroom were higher than for those twins in different classrooms. Importantly, correlating behaviour differences with CEQ differences indicated that correlations for twins in the same classroom were remarkably similar to, though slightly smaller in magnitude than, those in different classrooms (same teacher: average correlation = .06 (.01 – .13); different teacher: average correlation = .08 (.01 – .19).

Multiple regression analyses were conducted to assess the total and relative contributions of differential CEQ to the prediction of the SDQ subscales. Table 3 shows that the multiple Rs ranged from .11 to .23, suggesting that MZ CEQ differences account for 1–5% of the variance of the SDQ scales. There were few independent predictions, however: Social Integration independently predicted prosocial behaviour and conduct problems, and Negative Affect independently predicted peer problems. One reason why the CEQ scales did not independently predict SDQ is that the CEQ scales are correlated (.04 – .58; average correlation, .32). A factor analysis of the CEQ scales indicated that a principal component accounted for 48% of the variance. For this reason, a total CEQ score was calculated (CEQt) to provide a more global index of differences in MZ twins' perceptions of the classroom. Phenotypic correlations between CEQt and SDQ scales were all significant (see Table 2), bar that with emotional symptoms: −.22, .23, .22, .21 and .03 for prosocial behaviour, hyperactivity-inattention, conduct problems, peer problems and emotional symptoms respectively.

As well as assessing the relationships between MZ differences in perceptions of the classroom and teacher-reported behaviour problems, the effects of potential shared environmental moderators – reported by parents – of these relationships were assessed. We examined the moderating effects of SES and household chaos. To determine whether SES moderated the link between differences in CEQ and behaviour problems, a hierarchical multiple regression predicting SDQ behaviour problems was conducted in which CEQt and SES were added in Step 1. In Step 2, the interaction term (CEQt*SES) was entered which provides the test for moderation. A significant R^2 change from Step 1 to Step 2 indicates significant moderation by SES of the association between classroom environment and behaviour problems. SES did not significantly moderate any of the relationships between MZ differences in CEQt and the SDQ scales. Next, we tested for moderation by household chaos using the same hierarchical regression approach. Parent-reported household chaos significantly moderated the relationships between MZ differences in CEQt and MZ differences in conduct problems and emotional symptoms. Correlations were calculated separately for twins living in high chaos homes and low chaos homes. For conduct problems, these correlations were .06 (*ns*) and .21 ($p < .05$), for the low and high chaos groups, respectively. For emotional symptoms, these correlations were .15 and −.02, for the low and high chaos groups, respectively, however neither association was significant.

Discussion

We conducted an MZ twin differences study of nine-year olds attending different classrooms to investigate children's perceptions of their classroom environment in relation to teacher-reported behaviour problems. The MZ differences approach linked twin differences in environment with twin differences in outcome. In this way, we have identified a critical – and specific – aspect of nonshared environmental influence linked to behaviour. We also found a moderating effect by household chaos for conduct problems, such that the effect of the classroom environment was exacerbated in the context of more chaotic home environments. These two main findings are discussed in turn, followed by a discussion of the limitations of the study and future directions for research.

Classroom Environment and Behaviour Problems

The present study indicated that MZ differences in child-reported classroom environment were significantly associated with teacher-reported problem behaviours. We investigated six aspects of the classroom in relation to five behaviour problem subscales. Nine of the correlations between differences in classroom environment and differences in behaviour problems were significant. All of these correlations indicated that twins with less favourable perceptions of the classroom environments had more behaviour problems.

The amount of variation in children's behaviour problems accounted for was small (2 – 3%). Previously, such effects have been interpreted rather negatively by some researchers:

> "…we believe that the appropriate conclusion is the causal mechanisms underlying nonshared environmental variability in outcome remain unknown. The first candidate to receive serious consideration – objectively nonshared environmental events – does not appear likely to provide such an explanation"
>
> (Turkheimer & Waldron, 2000, p. 91).

We hold a more optimistic, and we believe realistic view. Genetically sensitive analyses like those reported here are conservative. Unlike typical phenotypic analyses, the MZ differences approach does not capitalize on genetically or shared environmentally mediated links between the environment and children's behaviour. Just as molecular genetic research pinpoints specific genes linked to individual differences in behaviour, our analysis pinpoints the degree to which a specific nonshared environmental candidate (classroom environment) is linked to problem behaviour. Geneticists do not expect to find that single genes explain more than 1% of the phenotypic variance of common disorders (Plomin, 2005) and we argue that specifying environmental influences is a similar pursuit. Thus, we hypothesize that children's behaviour problems are explained by many genetic factors, as well as by many environmental factors.

Moderation by Specific Shared Environmental Factors

A striking finding in the current study came in the assessment of two potential shared environmental moderators of associations between classroom environment and behaviour problems. SES was not a significant moderator; this result may at first sight be surprising given that SES has been found to influence behaviour problems. However, moderation is independent of individual associations between the measures, so the extent to which SES (and chaos) are related to classroom environment and behaviour problems is irrelevant to moderation results. Furthermore, like other distal processes, effect sizes for the influence of SES are usually small, and previous research suggests that more potent influences on behaviour problems are in the form of proximal processes. For example, poor parenting style has a greater influence on behaviour problems than being raised in a single-parent family (Amato, 2001).

The moderating influence of household chaos found elsewhere (Coldwell et al., 2006) was replicated in our study: associations between differential classroom environment and conduct problems were greater for children in more chaotic households. Previous research (e.g., Jenkins et al, 2003) has shown that shared environmental factors can exacerbate differential treatment; we go a step further showing that shared environment can affect the process by which the nonshared environment links to conduct problems.

Two theoretical ideas assist in interpreting these findings. Our results are an example of Rutter's "cumulative risk" phenomenon; Rutter (1979) and others (e.g., Deater-Deckard, Dodge, Bates, & Pettit, 1998) have found that whilst children may withstand a single environmental risk (e.g., parental divorce) unscathed, each successive risk factor works in an exponential fashion, increasing risks of mental health problems more dramatically than an additive model would predict. In our study, the significant interaction effect (CEQt*Chaos) indicates that the children most at risk were those with *both* a disorganized home environment, *and* a classroom environment that they deemed less satisfactory than their twin. This finding also provides a reminder that considering the multiple contexts of children's lives, and the inter-relation among them is essential for fully understanding children's development. In his conceptualisation of children's developmental contexts, Bronfenbrenner (1994) includes microsystems -- those contexts that children are directly in contact with, such as home and classroom environments -- as well as the mesosystem – interaction effects among different microsystems. The moderation effects found here are just such effects, and suggest that the influences of the home and the school environment cannot be fully understood unless both are considered simultaneously.

Limitations and Future Directions

The primary limitation of the study is that measurement was limited to postal questionnaires, a 'cost' of the large TEDS sampling frame; in-depth investigations with a focus on multi-method assessments (e.g., observations) of environmental processes are needed to complement our findings. However, our use of questionnaire measures has advantages, not least the assessment of differential perceptions of the classroom by questionnaire, which may encourage more candid responses, for example in children's descriptions of the pupil-teacher relationship.

The cross-sectional nature of the associations reported mean that the direction of effects cannot be established. For example, it is plausible that a twin displaying more behaviour problems would elicit more negative reactions from their teacher, and, equally, that a twin experiencing a more negative classroom environment would exhibit more problem behaviour. Moreover, it is feasible that another nonshared environmental factor – one causing MZ twins to differ in their classroom experience, and correlated with behaviour – may be accounting for the associations observed in the current analyses. Future longitudinal analyses (although not ruling out third variable explanations) are planned and will allow specification of the chronology of nonshared environment–behaviour links.

Previous studies have indicated that boys and girls experience classroom environments rather differently (e.g., Gentry, Gable, & Rizza, 2002). Therefore, although also beyond the remit of the current study, future research to explore the relationship between perceptions of the classroom and behaviour problems separately for boy-boy and girl-girl pairs is likely to be of interest and value.

The moderation effect shown in this report is provocative, and demonstrates that simple additive models cannot capture all of the relevant processes in development. As well as testing additional nonshared environmental candidates in the traditional manner, large samples of MZ twins will be required to identify possible interactions with both shared and nonshared environmental factors. Furthermore, improving and supplementing the analytical tools available will help tackle the daunting but critical task of identifying specific environmental factors responsible for the considerable nonshared environmental variance found for most complex behaviours.

Acknowledgments

We thank TEDS families for their continuing support and candidness. TEDS has been funded since 1995 by a programme grant from the U.K. Medical Research Council (G9424799, now G050079); TEDS' research on school environment is funded by the U.S. National Institute of Child Health and Human Development (HD44454) and of mathematics (HD46167).

References

Achenbach TM, Dumenci L, Rescorla LA. Are American Children's Problems Still Getting Worse? A 23-Year Comparison. Journal of Abnormal Child Psychology. 2003; 31:1–11. [PubMed: 12597695]

Ainley J, Bourke S. Student views of primary schooling. Research Papers in Education. 1992; 7:107–128.

Amato PR. Children of divorce in the 1990s: An update of the Amato and Keith (1991) meta-analysis. Journal of Family Psychology. 2001; 15:355–370. [PubMed: 11584788]

Anderman EM. School effects on psychological outcomes during adolescence. Journal of Educational Psychology. 2002; 94:795–809.

Asbury K, Dunn JF, Pike A, Plomin R. Nonshared environmental influences on individual differences in early behavioral development: A monozygotic twin differences study. Child Development. 2003; 74:933–943. [PubMed: 12795399]

Bronfenbrenner U, Ceci SJ. Natureuture reconceptualized in developmental perspective: A bioecological model. Psychological Review. 1994; 101:568–586. [PubMed: 7984707]

Caspi A, Moffitt TE, Morgan J, Rutter M, Taylor A, Arseneault L, Tully L, Jacobs C, Kim-Cohen J, Polo-Tomas M. Maternal Expressed Emotion Predicts Children's Antisocial Behavior Problems: Using Monozygotic-Twin Differences to Identify Environmental Effects on Behavioral Development. Developmental Psychology. 2004; 40:149–161. [PubMed: 14979757]

Coldwell J, Pike A, Dunn J. Household chaos – Links with parenting and child behaviour. Journal of Child Psychology and Psychiatry. 2006; 47:1116–1122. [PubMed: 17076750]

Deater-Deckard K, Dodge KA, Bates JE, Pettit GS. Multiple risk factors in the development of externalizing behavior problems: Group and individual differences. Development and Psychopathology. 1998; 10:469–493. [PubMed: 9741678]

Dorman J. Classroom environment research: Progress and possibilities. Queensland Journal of Educational Research. 2002; 18:112–140.

Dumas JE, Nissley J, Nordstrom A, Smith EP, Prinz RJ, Levine DW. Home Chaos: Sociodemographic, Parenting, Interactional, and Child Correlates. Journal of Clinical Child and Adolescent Psychology. 2005; 34:93–104. [PubMed: 15677284]

Dunn J, Stocker C, Plomin R. Nonshared experiences within the family: Correlates of behavioral problems in middle childhood. Development and Psychopathology. 1990; 2:113–126.

Ferdinand RF, Stijnen T, Verhulst FC, Van Der Reijden M. Associations between behavioural and emotional problems in adolescence and maladjustment in young adulthood. Journal of Adolescence. 1999; 22:123–136. [PubMed: 10066336]

Gentry M, Gable RK, Rizza MG. Students' perceptions of classroom activities: Are there grade-level and gender differences? Journal of Educational Psychology. 2002; 94(3):539–544.

Goodman R. The Strengths and Difficulties Questionnaire: A research note. Journal of Child Psychology and Psychiatry. 1997; 38:581–586. [PubMed: 9255702]

Goodman R. Psychometric properties of the Strengths and Difficulties Questionnaire. Journal of the American Academy of Child & Adolescent Psychiatry. 2001; 40:1337–1345. [PubMed: 11699809]

Huston AC, McLoyd VC, Coll CG. Children and poverty: issues in contemporary research. Child Development. 1994; 65:275–282. [PubMed: 7516847]

Jenkins JM, Rasbash J, O'Connor TG. The role of the shared family context in differential parenting. Developmental Psychology. 2003; 39:99–113. [PubMed: 12518812]

Kendler KS, Eaves LJ. Models for the joint effect of genotype and environment on liability to psychiatric illness. American Journal of Psychiatry. 1986; 143:279–289. [PubMed: 3953861]

Lehn H, Derks EM, Hudziak JJ, Heutink P, van Beijsterveldt TCEM, Boomsma DI. Attention problems and attention-deficit/hyperactivity disorder in discordant and concordant monozygotic twins: Evidence of environmental mediators. Journal of the American Academy of Child and Adolescent Psychiatry. 2007; 46(1):83–91. [PubMed: 17195733]

Matheny AP, Wachs TD, Ludwig JL, Phillips K. Bringing order out of chaos: Psychometric characteristics of the confusion, hubbub, and order scale. Journal of Applied Developmental Psychology. 1995; 16:429–444.

McGee R, Prior M, Williams S, Smart D, Sanson A. The long-term significance of teacher-rated hyperactivity and reading ability in childhood: Findings from two longitudinal studies. Journal of Child Psychology and Psychiatry. 2002; 43:1004–1016. [PubMed: 12455922]

McGue M, Bouchard TJ. Adjustment of twin data for the effects of age and sex. Behavior Genetics. 1984; 14:325–343. [PubMed: 6542356]

Oliver BR, Plomin R. Twins' Early Development Study (TEDS): A multivariate, longitudinal genetic investigation of language, cognition and behavior problems from childhood through adolescence. Twin Research & Human Genetics. 2007; 10(1):96–105. [PubMed: 17539369]

Pike A, Reiss D, Hetherington EM, Plomin R. Using MZ differences in the search for nonshared environmental effects. Journal of Child Psychology and Psychiatry. 1996; 37:695–704. [PubMed: 8894950]

Plomin R. Finding genes in child psychology and psychiatry: When are we going to be there? Journal of Child Psychology and Psychiatry. 2005; 46:1030–1038. [PubMed: 16178925]

Plomin R, Daniels D. Why are children in the same family so different from one another? Behavioral and Brain Sciences. 1987; 10:1–16.

Plomin R, DeFries JC, Loehlin JC. Genotype-environment interaction and correlation in the analysis of human behavior. Psychological Bulletin. 1977; 84:309–322. [PubMed: 557211]

Rutter M. Maternal deprivation, 1972–1978: New findings, new concepts, new approaches. Child Development. 1979; 50:283–305. [PubMed: 114367]

Rutter, M. Genes and behavior: Nature-nurture interplay explained. Malden, MA, US: Blackwell Publishing; 2006.

Saudino KJ, Ronald A, Plomin R. 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. 2005; 33:113–130. [PubMed: 15759595]

Sharp WS, Gottesman RF, Greenstein DK, Ebens CL, Rapoport JL, Castellanos FX. Monozygotic twins discordant for attention-deficit/hyperactivity disorder: Ascertainment and clinical characteristics. Journal of the American Academy of Child and Adolescent Psychiatry. 2003; 42(1):93–97. [PubMed: 12500081]

Somersalo H, Solantaus T, Almqvist F. Classroom climate and the mental health of primary school children. Nordic Journal of Psychiatry. 2002; 56:285–290. [PubMed: 12470320]

Trouton A, Spinath FM, Plomin R. Twins Early Development Study (TEDS): A Multivariate, Longitudinal Genetic Investigation of Language, Cognition and Behavior Problems in Childhood. Twin Research. 2002; 5:444–448. [PubMed: 12537874]

Turkheimer E, Waldron M. Nonshared environment: A theoretical, methodological, and quantitative review. Psychological Bulletin. 2000; 126:78–108. [PubMed: 10668351]

Turner JC, Midgley C, Meyer DK, Gheen M, Anderman EM, Kang Y, Patrick H. The classroom environment and students' reports of avoidance strategies in mathematics: A multimethod study. Journal of Educational Psychology. 2002; 94:88–106.

Wachs, TD. Environmental chaos and children's development: Expanding the boundaries of chaos. Paper presented at the Society for Research in Child Development; Atlanta, Georgia. 2005 Apr.

Table 1

Phenotypic correlations between child-reported CEQ and teacher-reported SDQ

	Teacher SDQ				
	Prosocial	**Hyperactivity**	**Conduct Problems**	**Peer Problems**	**Emotional Symptoms**
Child CEQ					
General Satisfaction	−.15*	.07	.07	.14*	−.03
Negative Affect	−.19**	.30**	.23**	.33**	.22**
Social Integration	−.16**	.21**	.24**	.23**	.09
Opportunity	−.07	.05	.06	−.08	−.07
Pupil-Teacher Relationship	−.17**	.16**	.19**	.17**	−.02
Adventure	−.09	.10	.04	.01	−.09
Total Score	−.22**	.23**	.22**	.21**	.03

Note.

* $p < .05$;

** $p < .01$

NIH-PA Author Manuscript

NIH-PA Author Manuscript

Table 2

MZ differences in CEQ correlated with individual SDQ outcome and MZ differences in SDQ

	Teacher SDQ				
Child CEQ	**Prosocial**	**Hyperactivity**	**Conduct Problems**	**Peer Problems**	**Emotional Symptoms**
General Satisfaction	−.10	.06	.03	.09	−.02
Negative Affect	−.03	.08	.14*	.13*	.06
Social Integration	−.17**	.06	.19**	.04	.01
Opportunity	−.14*	.03	.06	.12*	.04
Pupil-Teacher Rel.	−.13*	.06	.04	.10	−.00
Adventure	−.10	.15*	.04	.15*	.07
Total Score	−.18**	.12	.14*	.16**	.05

Note.

* $p < .05$;

** $p < .01$

NIH-PA Author Manuscript
NIH-PA Author Manuscript

Table 3

Multiple regression analyses predicting MZ differences in SDQ from MZ differences in CEQ

	Prosocial		Hyperactivity		Conduct Problems		Peer Problems		Emotional Symptoms	
	β	*t*	*β*	*t*	*β*	*t*	*β*	*t*	*β*	*t*
General Satis.	.01	.13	−.03	−.36	−.07	−.85	−.00	−.03	−.05	−.64
Negative Affect	−.01	−.17	.10	1.45	.12	1.91	.15	2.25*	.06	.84
Social Integration	−.15	−2.14*	.01	.11	.18	2.64**	−.04	.59	−.01	−.11
Opportunity	−.07	−.98	−.01	−.09	.03	.39	.07	1.08	.05	.74
Pupil-Teacher Rel.	−.05	−.72	−.01	−.12	−.04	−.48	.02	.24	−.05	−.61
Adventure	−.02	−.27	.16	2.20*	.04	.55	.10	1.36	.10	1.39
	Total R =.20		Total R =.18		Total R =.23		Total R =.21		Total R =.11	
	F(6,250) =1.82		F(6,247) =1.31		F(6,247) =2.25*		F(6,250) =1.85		F(6,249) =.55	

Note.

* $p < .05$;

** $p < .01$