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Genetic and Environmental Processes in Young Children's Resilience and Vulnerability to Socioeconomic Deprivation

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Some children exposed to socioeconomic (SES) deprivation are resilient and function better than expected, given the level of deprivation they have experienced. The present study tested genetic and environmental contributions to young children's resilience and vulnerability to SES deprivation. Children's resilience was assessed by the difference between their actual score and the score predicted by their level of SES deprivation in the E-Risk Study, an epidemiological cohort of 1,116 five-year-old twin pairs. Consistent with previous research, results showed that maternal warmth, stimulating activities, and children's outgoing temperament appeared to promote positive adjustment in children exposed to SES deprivation. Findings add new information by demonstrating that resilience is partly heritable and that protective processes operate through both genetic and environmental effects.

Children in poor families are at elevated risk for behavioral and cognitive problems compared with children in nonpoor families (for reviews, see Bradley & Corwyn, 2002; Brooks-Gunn & Duncan, 1997; McLoyd, 1998). However, not all poor children develop problems, and some of these resilient children function better than expected, given the level of deprivation they have experienced (Luthar & Zigler, 1991; Masten, Best, & Garmezy, 1990; Rutter, 1985). Resilience researchers have identified protective factors that predict favorable outcomes despite exposure to adversity (e.g., Cowen, Wyman, Work, & Parker, 1990; Luthar, Doernberger, & Zigler, 1993; Masten et al., 1990; Werner & Smith, 1982, 1992), and have increasingly emphasized that to advance theoretical understanding, studies must investigate the processes that promote resilience (Cicchetti & Garmezy, 1993; Luthar, Cicchetti, & Becker, 2000; Rutter, 1990). Emerging evidence demonstrates that genes play a role in adaptive responses to risk (Caspi et al., 2002; Caspi, Sugden, et al., 2003), but no study has yet explored genetic mechanisms in children's resilience. The aim of the present study was to use a twin design to test the relative genetic and environmental contributions to young children's resilience and vulnerability to socioeconomic (SES) deprivation.

Protective Factors Against SES Deprivation

Researchers have found that economic hardship predicts young children's conduct problems and cognitive abilities, even after controlling for the effects of maternal education, female head of household, and ethnicity (Dodge, Pettit, & Bates, 1994; Duncan, Brooks-Gunn, & Klebanov, 1994; Korenman, Miller, & Sjaastad, 1995; McLeod & Shanahan, 1993; Smith, Brooks-Gunn, & Klebanov, 1997). Poverty is associated with lower levels of warmth and maternal responsiveness, which are linked to children's behavior problems (Bolger, Patterson, & Thompson, 1995; Brooks-Gunn, Klebanov, & Liaw, 1995; Dodge et al., 1994; McLeod & Shanahan, 1993; McLoyd, 1990). Likewise, children from poor families have less access to cognitively stimulating activities than do children from non poor families (Bradley, Corwyn, Burchinal, McAdoo, & Garcia Coll, 2001; Brooks-Gunn et al., 1995; Garrett, Ng'andu, & Ferron, 1994; Smith et al., 1997), and

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cognitive stimulation accounts for the association between family SES level and children's IQ (Duncan et al., 1994; Guo & Harris, 2000; Linver, Brooks-Gunn, & Kohen, 2002; Smith et al., 1997). These models suggest that children's resilience to impoverished life conditions would be promoted by the amount of emotional warmth and cognitively stimulating experiences a child receives.

Three clusters of factors are known to predict resilient adjustment: (a) child characteristics (e.g., temperament), (b) aspects of the parent–child relationship (e.g., cognitive stimulation, emotional warmth), and (c) social support (Masten et al., 1990; Rutter, 1990; Werner & Smith, 1982, 1992). The present study of twins' development focused on child-specific and family-wide factors that buffer young children against SES deprivation. Child-specific variables are those that can be measured separately for each twin but are not necessarily child characteristics. Family-wide variables are those that must be measured for each twin pair and are, therefore, the same for each twin.

Child-specific protective factors. In this study, children's outgoing temperament (a child characteristic) and maternal warmth toward the child (an aspect of the parent–child relationship) were selected as the child-specific protective variables of focus. An outgoing temperament, characterized by the confidence and eagerness with which a child approaches and interacts with novel tasks and with unfamiliar adults, has been shown to be associated with several strengths and competencies (Caspi, Henry, McGee, Moffitt, & Silva, 1995). Moreover, a good-natured, sociable temperament has been observed among young children resilient to SES adversity (Werner & Smith, 1992; Wyman, Cowen, Work, & Parker, 1991) and has been found to help moderate the effects of stress on children's behavioral problems (Rende & Plomin, 1992; Rutter & Quinton, 1984; Wertlieb, Weigel, Springer, & Feldstein, 1987).

Researchers have found that parental warmth is an important aspect of positive parenting that is linked to children's social and emotional well-being. Several studies have found that responsive caregiving and parental warmth in early childhood protects children from the effects of adversity (Egeland, Kalkoske, Gottesman, & Erickson, 1990; Rutter et al., 1975; Werner & Smith, 1982, 1992; Wyman et al., 1999). For example, Wyman et al. (1999) found that in a high-risk, low-income sample, nurturant involvement (e.g., emotional closeness and time spent together) by a primary caregiver was one of the most sensitive predictors of children's resilience to stressful life events.

Family-wide protective factors. In the present study, mothers' social support and stimulating activities for children were examined as family-wide protective factors. Researchers have shown that parental social support predicts resilience in children who are raised in socioeconomically disadvantaged circumstances (Runyan et al., 1998). Social support is positively associated with expressions of parental warmth (Mason, Cauce, Gonzales, Hiraga, & Grove, 1994) and the provision of learning experiences (Klebanov, Brooks-Gunn, & Duncan, 1994). Moreover, social support moderates the effects of stress on parenting, especially in poor families (Hashima & Amato, 1994) and helps maintain mothers' confidence in their own parenting abilities (Cutrona & Troutman, 1986). Conversely, lack of social support has been linked to an increased risk for child maltreatment (Bishop & Leadbeater, 1999; Garbarino & Sherman, 1980).

Cognitively stimulating experiences in the home have been shown to mediate the relationship between family income and young children's cognitive and behavioral development (Linver et al., 2002). In low-income families, children of mothers who engaged in cognitively stimulating parenting practices had better cognitive outcomes (McGroder, 2000), and evidence suggests that parents' participation in stimulating activities with their children in the preschool years significantly predicts later resilience to stressful life events in an economically disadvantaged sample (Cowen et al., 1990).

In sum, the present study hypothesized that each child's unique temperament and the unique emotional treatment the children receive from their mothers would protect them from negative behavioral and cognitive consequences of socioeconomically impoverished conditions. Furthermore, we hypothesized that mothers' social support and the stimulating activities children in the same family experience—factors that are shared by twins—would attenuate the effects of SES deprivation on children's behavioral and cognitive functioning.

Measuring Resilience

Resilience has been conceptualized as a "process encompassing positive adaptation within the context of significant adversity" (Luthar et al., 2000, p. 543). Although investigators have operationally defined resilience in myriad ways, the two central components of the definition are exposure to risk and evidence of good adjustment (Luthar & Cushing, 1999; Masten & Coatsworth, 1995). The diversity of ways in which resilience has been operationally defined has led to concerns about inconsistent findings and about the usefulness of the construct (Luthar, 1993; Masten & Coatsworth, 1998). Luthar et al. (2000) have responded to methodological concerns by providing guidelines for handling the multidimensional nature of the resilience construct. First, they noted that there should be a clear rationale for choosing the outcome domain in defining resilience to a particular risk factor. When the risk confers particularly high risk for an outcome, it should be given priority (Luthar, 1993; Luthar et al., 2000). Although SES deprivation is a stronger predictor of young children's intellectual than behavioral outcomes (Duncan et al., 1994; McLoyd, 1998), it has been shown to influence both. The present study examined both behavioral and intellectual outcomes.

Second, Luthar et al. (2000) stated that consideration must be given to whether multiple or single outcomes should be measured. At-risk children may be resilient in a particular domain of functioning but not in others (Cicchetti & Rogosch, 1997; Kaufman, Cook, Arny, Jones, & Pittinsky, 1994; Luthar et al., 1993). Therefore, investigators have begun to question the utility of global, combined measures of outcomes in studying resilient processes (Luthar & Cushing, 1999; Masten & Coatsworth, 1998). Luthar et al. (2000) proposed that if the outcomes examined represent largely discrete constructs, it is most meaningful to examine them separately. Because young children's behavioral and intellectual functioning represents two distinct areas of development, the present study investigated two different types of resilience: behavioral resilience and cognitive resilience. Doing so allowed for a targeted search for processes at work in resilient development.

A third methodological consideration is whether to classify and compare groups of resilient and vulnerable children or to use the entire continuum on a measure of children's functioning, ranging from resilience on one end to vulnerability on the other (Luthar & Cushing, 1999; Masten & Coatsworth, 1998). Some investigators have classified resilient children based on a cutoff on the positive end of a distribution (e.g., Cicchetti & Rogosch, 1997; Luthar et al., 1993; Wyman et al., 1991). Other investigators have relied on statistical associations between measures of risk, a continuous measure of adjustment, and various protective factors linked to resilience or vulnerability. According to Luthar and Cushing (1999), one caveat of this approach is that resilience is inferred from the pattern of statistical associations rather than measured directly. The present study addressed this concern by measuring a continuum of vulnerability to resilience using the standardized residual from a regression predicting children's antisocial behavior or IQ from SES deprivation (cf. Baldwin et al., 1993). To illustrate, children whose actual IQ score is higher than their predicted score have a positive residual (reflecting resilience), and children whose actual IQ is lower than their predicted score have a negative residual (reflecting vulnerability). Researchers have increasingly cited the need to focus on "off-diagonal" outcomes, that is, to study why some children have better or worse outcomes given the level of risk they experience (Brooks-Gunn et al., 1995; Reiss, 1995). We also estimated the group heritability of resilience and vulnerability at the extreme ends of the continuum.

What Processes Promote Resilience to SES Deprivation?

Identifying the underlying processes by which protective factors promote resilience is essential for advancing developmental theory (Cicchetti & Garmezy, 1993; Luthar, 1993; Luthar et al., 2000; Rutter, 1990). Researchers have made some progress toward this goal. For instance, Wyman et al. (1999) described a process by which competent parenting and parental mental health directly and proximally predicted highly stressed children's resilient status. However, this study could not account for the possibility that competent parenting and children's resilient adjustment may covary as a function of genetic factors (e.g., a passive gene–environment correlation). In other words, it is possible that the genetic factors influencing parents' nurturant caregiving are the same genetic factors in the children that contribute to their healthy adjustment. No study has explored the genetic and environmental processes that contribute to children's resilience.

A growing body of evidence suggests that genes play an important part in children's successful adaptation to SES deprivation. Three findings are notable. First, behavioral genetics research has made clear that measures of the family environment, including SES, and children's characteristics, such as temperament, show substantial genetic influence (Plomin & Bergeman, 1991; Plomin, Reiss, Hetherington, & Howe, 1994). Likewise, researchers have found that genetic factors account for up to 80% of the variance in young children's antisocial behavior (Arseneault et al., 2003) and for up to 40% of the variance in young children's IQ (McGue, Bouchard, Iacono, & Lykken, 1993). If genetic factors are involved in SES as well as in children's behavioral and cognitive development, it is reasonable to expect that genetic influences are present in children's behavioral and cognitive resilience to SES disadvantage.

Second, if genetic factors contribute to measures of the family environment and children's characteristics (Plomin et al., 1993), it is likely that genetic factors are also involved in the link between our hypothesized protective factors and children's resilience. For instance, genetic factors have been shown to mediate the association between the home environment and young children's cognitive development (Braungart, Fulker, & Plomin, 1992). Third, two recent studies found specific genes involved in protecting some maltreated children from developing antisocial behavior and depression throughout adolescence and young adulthood (Caspi et al., 2002; Caspi, Sugden, et al., 2003). These literatures led us to hypothesize that the covariation between children's resilience and protective factors would show significant genetic influences.

Clearly, however, genetic factors do not tell the whole story. Genetically sensitive designs that are able to control for and rule out genetic explanations have also established that putative environmental factors do contribute to individual differences in children's developmental outcomes through processes that are environmental (Jaffee, Caspi, Moffitt, & Taylor, 2004; Koenen, Moffitt, Caspi, Taylor, & Purcell, 2003). Furthermore, experimental intervention studies have demonstrated that when home-based services are provided to low-income families, significant improvements are made in children's academic achievement (see Olds & Kitzman, 1993,for review). Other studies have found that as family income improves over time, so do measures of the home environment (Garrett et al., 1994) and children's behavioral problems (Costello, Compton, Keeler, & Angold, 2003). Both nature and nurture in resilient development are important focal points for investigation. We hypothesized that children's resilience and protective factors would show significant environmental influences.

Using data from the Environmental Risk Longitudinal Twin Study (E-Risk Study), the present study had three goals. The first was to replicate previous research by examining whether SES deprivation is significantly associated with higher antisocial behavior and lower IQ in this population sample of 5-year-old twins. The second was to replicate previous research by testing the link between hypothesized protective factors and behavioral and cognitive resilience. The third, innovative, and main goal of this study was to extend previous research by estimating the contribution of genetic and environmental influences to explaining individual differences in children's resilience and in the association between resilience and hypothesized protective factors.

Method

Participants

Participants are members of the E-Risk Study, which investigates how genetic and environmental factors shape children's development. The E-Risk sampling frame was two consecutive birth cohorts (1994 and 1995) in a birth register of twins born in England and Wales (Trouton, Spinath, & Plomin, 2002). Of the 15,906 twin pairs born in these two years, 71% joined the register.

The E-Risk Study sought a sample size of 1,100 families to allow for attrition in future years of the longitudinal study while retaining statistical power. An initial list of families who had same-sex twins was drawn from the register to target for home visits, with a 10% oversample to allow for nonparticipation. The probability sample was drawn using a high-risk stratification sampling frame. High-risk families were those in which the mother had her first birth when she was 20 years of age or younger. We used this sampling (a) to replace high-risk families who were selectively lost to the register because of nonresponse and (b) to ensure sufficient base rates of problem behavior given the low base rates expected for 5-year-old children. Age at first childbearing was used as the risk-stratification variable because it was present for virtually all families in the register, it is relatively free of measurement error, and early childbearing is a known risk factor for children's problem behaviors (Maynard, 1997; Moffitt & The E-Risk Study Team, 2002). The sampling strategy resulted in a final sample in which two-thirds of study mothers accurately represent all mothers in the general population (aged 15–48) in England and Wales in 1994 to 1995 (estimates derived from the General Household Survey; Bennett, Jarvis, Rowlands, Singleton, & Haselden, 1996). The other one-third of study mothers (younger only) constitute a 160% oversample of mothers who were at high risk based on their young age at first birth (15–20 years). To provide unbiased statistical estimates that can be generalized to the population of British families with children born in the 1990s, the data reported in this article were corrected with weighting to represent the proportion of young mothers in that population.

Of the 1,203 families from the initial list who were eligible for inclusion, 1,116 (93%) participated in home-visit assessments when the twins were age 5 years, forming the base sample for the study; 4% of families refused, and 3% were lost to tracing or could not be reached after many attempts. With parent's permission, questionnaires were posted to the children's teachers, and teachers returned questionnaires for 94% of cohort children. After complete description of the study to the participants, written informed consent was obtained from mothers. The E-Risk Study has received ethical approval from the Maudsley Hospital Ethics Committee.

Zygosity was determined using a standard zygosity questionnaire, which has been shown to have 95% accuracy (Price et al., 2000). Ambiguous cases were zygosity-typed using DNA. The sample includes 56% monozygotic (MZ) and 44% dizygotic (DZ) twin pairs. Sex is evenly distributed within zygosity (49% male).

Measures

Socioeconomic deprivation was assessed multidimensionally using three indexes measuring the family's SES disadvantage, housing problems, and the mother's perception of economic hardship. The SES disadvantage scale is a count of seven SES disadvantages, which were defined as follows: (a) head of household has no educational qualifications; (b) head of household is employed in an unskilled occupation or is not in the labor force; (c) total household gross annual income is less than £10,000; (d) family receives at least one government benefit, excluding disability benefit; (e) family housing is government subsidized; (f) family has no access to a vehicle; and (g) family lives in the poorest of six neighborhood categories, in an area dominated by government-subsidized housing, low incomes, high unemployment, and single-parent families. Summing across these seven items yielded a composite index of SES disadvantage, ranging from 0 to 7 ($M = 1.19$, $SD = 1.71$). Alpha reliability was .79. The housing problems scale is a count of five problems related to the conditions of the family home. Housing problems were defined by the following: (a) house cleanliness was rated by the interviewer as poor or very poor, (b) house repair was rated by the interviewer as poor or very poor, (c) mother reported that it is very difficult to keep the house warm enough during winter, (d) mother reported that the house is very damp, and (e) mother reported that the house feels crowded. The count of housing problems ranges from 0 to 5 ($M = 0.70$, $SD = 0.96$). Alpha reliability was .51. Perceived economic hardship was measured using four items that assess the mother's perception of how difficult it is to meet the cost of the family's basic needs. Mothers were asked how often they found it difficult to meet the cost of: (a) food and other necessities, (b) rent or mortgage, (c) household bills, and (d) an occasional night out or presents for the family (Mayer & Jencks, 2000). Mothers responded using a 5-point scale (i.e., never, rarely, occasionally, monthly, weekly, or daily) and items were added to create a total score, ranging from 0 to 20 ($M = 3.71$, $SD = 3.83$). Alpha reliability was .78.

Children's antisocial behavior was assessed with the Achenbach family of instruments (Achenbach, 1991a, 1991b). We combined mother interviews and teacher reports of children's behavior on the Aggression and Delinquency scales by summing the items from each rater (items scored from 0–2). These scales were supplemented with items assessing conduct and oppositional defiant disorder (e.g., "spiteful, tries to get revenge," "uses force to take something from another child") from the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed. [*DSM–IV*]; American Psychiatric Association, 1994). Scores ranged from 0 to 130 ($M = 21.17$, $SD = 16.27$). Mother and teacher reports of antisocial behavior correlated .29 ($p < .001$), which is typical in interrater studies of children's behavioral problems (Achenbach, McConaughy, & Howell, 1987). The alpha reliability of the combined score was .94.

Children's IQ. Each child was individually tested using a short form of the Wechsler Preschool and Primary Scale of Intelligence–Revised (WPPSI–R; Wechsler, 1990) comprising Vocabulary and Block Design subtests. IQs were prorated following procedures described by Sattler (1992, pp. 998–1004). The children's IQs ranged from 52 to 145, normally distributed ($M = 98$, $SD = 14$).

Maternal warmth. Expressed emotion (EE) maternal warmth toward each twin was measured using procedures adapted from the five-minute speech sample (FMSS) method (Magana et al., 1986). Interviewers asked mothers to describe their child ("For the next 5 minutes, I would like you to describe [child] to me, what is [child] like?"). Two raters coded the EE audiotapes according to developmentally appropriate guidelines for use with preschool children (Caspi et al., 2004; Daley, Sonuga-Barke, & Thompson, 2003). The raters underwent 2 weeks of training in coding procedures. Interrater reliability was established by having the raters individually code a test-standard audiotape describing 40 children. The interrater agreement was .90. A single rater coded twins in the same family.

Warmth is a global measure of the whole speech sample and was assessed by tone of voice, spontaneity, sympathy, and empathy toward the child. For example, "I love taking her out, she is my ray of sunshine," or "I feel really sorry for her. I worry for her." Warmth was coded on a 6-point scale. High warmth (5) and moderately high warmth (4) were coded when there was definite tonal warmth, enthusiasm, interest in, and enjoyment of the child. Moderate warmth (3) was coded when there was definite understanding, sympathy, and concern but only limited warmth of tone. Some warmth (2) was coded when there was a detached and clinical approach, with little or no warmth of tone, but moderate understanding, sympathy, and concern. Very little warmth (1) was rated when there was only a slight amount of understanding, concern, enthusiasm about, or interest in the child. No warmth (0) was reserved for mothers who showed a complete absence of the qualities of warmth as defined ($M = 3.36$, $SD = 0.98$).

Children's outgoing temperament included six items reflecting little caution when approaching the examiner, quick adjustment to the new situation, extreme ease in social interaction, talkativeness, self-confidence, and self-reliance. This factor appears to reflect a child who is willing and eager to explore new situations (Bates, 1989; Caspi, Harrington, et al., 2003). An examiner coded items on a 3-point scale after observing the child in the data-collection session in the child's home ($M = 9.53$, $SD = 2.90$). Interrater reliability was .81. Alpha reliability was .89.

Stimulating activities is a family environment variable that is common to or shared by twin pairs. Mothers were asked whether they had engaged in any of 12 activities with their twins in the past year. Examples of activities include: visited a zoo, been to a park, or been to a church or mosque. Count scores ranged from 1 to 12 ($M = 8.50$, $SD = 1.93$). Alpha reliability was .57.

Mother's perceived social support, an environmental variable shared by twins, was measured using a 12-item scale. Mothers were asked to report to what extent they felt they could turn to their parents, siblings, in-laws, and friends for three components of social support: (a) financial support, (b) support with rearing the twins, and (c) emotional support (Simons & Johnson, 1996). Responses were coded on a 3-point scale (i.e., not true, sometimes true, very true) and were added to create a scale ranging from 0 to 24 ($M = 15.44$, $SD = 5.44$). Higher scores reflect that the mother perceived she had more social support. Alpha reliability was .76.

Data Analyses

Statistical analysis was complicated by the fact that our twin study contained two children from each family. Data were analyzed with tests based on the sandwich or Huber–White variance estimator (Rogers, 1993; Williams, 2000) using Stata 7.0 (StataCorp, 2001), which adjusts estimated standard errors to account for this dependence in the data.

Using maximum likelihood estimation techniques, quantitative genetic analyses were conducted with three goals. First, univariate ACE models estimated the proportions of variance in children's behavioral and cognitive resilience that is explained by genetic and environmental influences. In the simple ACE twin model for a resilience measure, the variance in resilience is partitioned into the variance due to additive genetic (A), shared environmental (C), and nonshared environmental influences including error (E). Second, bivariate Cholesky models (Loehlin, 1996) were fitted to decompose the covariance between resilience measures and putative child-specific protective factors into genetic and environmental components. Third, a univariate ACE model with a measured environmental variable (i.e., ACmE; cf. Caspi, Taylor, Moffitt, & Plomin, 2000) tested the contribution of a family-wide environmental protective factor to explaining the variance in children's resilience. The statistical packages Mplus (Muthen & Muthen, 2001) and Mx (Neale, 2002) were used to conduct the quantitative genetic analyses.

The full ACE model is fitted first. Then, to attain the most parsimonious model, parameters that do not significantly contribute to the fit of the model are dropped. Because E includes measurement error, it is not usually dropped in univariate analyses. The AE and CE models are nested within the full ACE model; that is, AE and CE models are identical to the ACE model with the exception of constraints placed on the submodels. For variables that suggest a possible dominance genetic effect, a full ADE model is also fitted. (For detailed explanations of the statistical methods that are applied to operationalize the logic behind behavior genetic designs, see Carey, 2003; Plomin, DeFries, McClearn, & McGuffin, 2001; Purcell, 2000.)

The goal of bivariate genetic analyses was to parse the genetic and environmental components of covariation between resilience and child-specific protective factors thought to promote resilience. To do this, two measures must covary at least modestly to detect genetic and environmental influences on their covariance (Neiderhiser, Reiss, Hetherington, & Plomin, 1999; Plomin et al., 2001). MZ and DZ correlations are compared across traits; that is, one twin's resilience score is correlated with the cotwin's score on a putative protective factor. If the cross-trait twin correlations are greater for MZ than for DZ twins, this implies that genetic factors contribute to the phenotypic correlation between the protective factor and resilience. A genetic correlation (r_A) indicates the extent to which genetic influences on a protective factor overlap with those on the outcome variable regardless of their respective heritabilities (i.e., r_A can be high even if the heritability of each trait is low). Based on the genetic correlation and the individual heritability of each trait, the extent to which common genetic and environmental influences generate a phenotypic correlation between the protective factor and resilience can be estimated. Bivariate models were fitted using the Cholesky decomposition method (Loehlin, 1996), and the proportions of the phenotypic correlations that are explained by common genetic and environmental effects were calculated from the parameter estimates.

A univariate ACmE model was fitted to examine the association between resilience and a familywide protective factor. A family-wide variable, such as stimulating activities, that is common to both twins can be conceptualized as a measured aspect of the environment that contributes to the variance in children's resilience, which is explained by the latent shared environmental factor C.

Results

Does SES Deprivation Predict More Antisocial Behavior and Lower IQ Scores for Children?

Each SES deprivation variable—SES disadvantage ($r = .23$, $p < .001$), housing problems ($r = .23$, $p < .001$), and economic hardship ($r = .19$, $p < .001$)—was significantly correlated with children's antisocial behavior. In a multiple regression, the three SES deprivation variables together accounted for 8% of the variance in children's antisocial behavior (multiple $R = .29$, $p < .001$). Each SES deprivation variable—SES disadvantage ($r = -.33$, $p < .001$), housing problems ($r = -.19$, $p < .001$), and economic hardship ($r = -.20$, $p < .001$)—was significantly associated with children's IQ. In a multiple regression, the three SES deprivation variables together accounted for 12% of the variance in children's IQ (multiple $R = .34$, $p < .001$).

How Can We Identify Children Who Are Resilient to the Harmful Effects of SES Deprivation?

For the purposes of this study, resilience was conceptualized as behavioral or cognitive functioning that is better than that predicted by a child's level of SES deprivation. Operationally, the continuum from resilience to vulnerability was measured by the difference between children's actual score on an outcome (either antisocial behavior or IQ) and the score predicted by their level of SES deprivation. Thus, a measure of behavioral resilience was created by saving the standardized residuals from a linear multiple regression analysis predicting children's antisocial behavior from the three SES deprivation variables. Residual scores were recoded so that higher scores reflect more behavioral resilience (range = −6.59 to 1.90). A cognitive resilience measure was created using the same method. The standardized residuals were saved from a regression analysis predicting children's IQ from the three SES deprivation variables. Higher scores reflect more cognitive resilience (range = −3.47 to 3.39). Behavioral resilience and cognitive resilience were correlated ($r = .09$, $p < .001$).

What Protective Factors Are Associated With Children's Resilience to SES Deprivation?

Table 1 shows the correlations among behavioral resilience, cognitive resilience, and the four hypothesized protective factors. Maternal warmth had a significant and moderate correlation with behavioral resilience and was therefore selected for further examination in model-fitting analyses. Children's outgoing temperament and stimulating activities had significant and moderate correlations with cognitive resilience and were therefore selected for further examination in model-fitting analyses. Mother's perceived social support was not significantly correlated with either behavioral or cognitive resilience and was dropped from subsequent analyses.

Do Genetic and Environmental Processes Contribute to Children's Resilience to SES Deprivation?

Univariate twin models. MZ and DZ within-pair correlations provide rough estimates of the extent to which genetic, shared environmental, and child-

Table 1
Correlations Between Putative Protective Factors and Behavioral and Cognitive Resilience

	Behavioral resilience	Cognitive resilience
Child-specific protective factors		
Maternal warmth	.25***	.10***
Children's outgoing temperament	−.05	.27***
Family-wide protective factors		
Stimulating activities	.03	.16***
Mother's perceived social support	.05	.05

Note. Because of missing data, observations are based on sample sizes ranging from 1,974 to 2,220.
***$p < .001$.

specific environmental factors contribute to behavioral and cognitive resilience. The within-pair MZ correlation for behavioral resilience ($r = .72$, $p < .001$) was higher than the DZ correlation ($r = .26$, $p < .001$), suggesting that genetic factors contribute to children's behavioral resilience to SES deprivation. For behavioral resilience, the AE model provided the best fit to the data (Table 2). The proportion of variance in behavioral resilience accounted for by additive genetic effects was 71% (95% confidence interval [CI] = .66, .74) and by child-specific environmental factors was 29% (95% CI = .26, .34). The within-pair twin correlation for behavioral resilience was more than twice the DZ correlation, which raised the possibility of a dominance effect, but when the ADE model was tested (see fourth row of Table 2), it did not offer any increase in fit over the more parsimonious AE model.

For cognitive resilience, the within-pair MZ correlation ($r = .67$, $p < .001$) was less than twice the DZ correlation ($r = .47$, $p < .001$), suggesting that, in addition to genetic factors, family-wide environmental influences contribute to children's cognitive resilience to SES deprivation. The ACE model provided the best fit to the data for cognitive resilience. The proportion of variance in cognitive resilience accounted for by additive genetic effects was 46% (95% CI = .32, .62), by shared environmental factors was 22% (95% CI = .08, .34), and by child-specific factors was 32% (95% CI = .28, .36).

For the purpose of this article, the residual score is labeled as resilience, although it is a continuous measure ranging from vulnerability to resilience. One may argue that the degree of genetic or environmental influence at one end of the continuum may differ significantly from that at the opposite end. Likewise, being the most resilient member of a cohort at the end of the continuum may be qualitatively different from being just a little bit resilient. We tested these two possibilities using the DeFries–Fulker (1985) multiple regression methodology for analyzing twin data. When comparing the top and bottom 25th percentiles, we found no significant difference in estimates of group heritability for either behavioral or cognitive resilience (Table 3). Therefore, the entire continuous measure was used in subsequent model-fitting analyses.

Maternal warmth and behavioral resilience—bivariate twin model. Table 4 presents the MZ and DZ cross-twin, cross-trait correlations for behavioral resilience

Table 2
Quantitative Genetic Models Examining Children's Behavioral and Cognitive Resilience (Univariate Models)

	Proportion of variance (%)				Fit of the models							Comparison between models		
Model	a^2	c^2	e^2	d^2	χ^2	*df*	*p*	AIC	BIC	RMSEA (90% CI)	Comparison models	$\Delta\chi^2$	Δdf	*p*
Behavioral resilience														
ACE	70.6	0.0	29.4	–	9.39	3	.02	3.39	– 11.65	.06 (.02, .11)				
AE	**70.5**	**–**	**29.5**	**–**	**9.39**	**4**	**.05**	**1.39**	**– 18.66**	**.05 (.00, .09)**				
CE	–	52.9	47.1	–	130.12	4	.00	122.12	102.07	.24 (.20, .27)				
ADE	39.2	–	29.1	31.7	5.63	3	.13	– 0.37	– 15.41	.04 (.00, .09)	2 vs. 4	3.76	1	*ns*
Cognitive resilience														
ACE	**45.8**	**22.2**	**32.0**	–	**6.24**	**3**	**.10**	**0.24**	**– 14.73**	**.05 (.00, .09)**				
AE	68.9	–	31.1	–	15.46	4	.00	7.46	– 12.52	.07 (.04, .11)				
CE	–	57.2	42.8	–	48.84	4	.00	40.84	20.86	.14 (.11, .18)	1 vs. 2	9.22	1	$p < .01$

Note. a^2 = proportion of variance accounted for by additive genetic effects; c^2 = proportion of variance accounted for by shared environmental influences; e^2 = proportion of variance accounted for by nonshared environmental influences; d^2 = proportion of variance accounted for by nonadditive genetic influences. A = latent additive genetic factor, C = latent shared environmental factor, and E = latent nonshared environmental factor. The four model fit statistics are as follows. The first is the chi-square goodness-of-fit statistic: Large values compared with model degrees-of-freedom indicate poor model fit to the observed covariance structure. When two models are nested, the difference in fit between them can be evaluated with the chi-square difference, using as its degrees-of-freedom the degrees-of-freedom difference from the two models. When the chi-square difference is not statistically significant, the more parsimonious model is selected. The second statistic is the Akaike information criterion (AIC; Burnham & Anderson, 1998): When comparing two models, the model with the lowest AIC value is selected as the best fitting model. The third statistic is the Bayesian information criterion (BIC): Increasingly negative values correspond to increasingly better fitting models. In comparing two models, differences of BIC between 6 and 10 give strong evidence in favor of the model with the smaller value (Raftery, 1995). The fourth statistic is the root mean square error of approximation (RMSEA): an index of the model discrepancy, per degrees-of-freedom, from the observed covariance structure (MacCallum, Browne, & Sugawara, 1996), with 90% confidence intervals (CI; Browne & Cudeck, 1993). An RMSEA of less than or equal to .06 indicates a good fitting model (Hu & Bentler, 1999). The best fitting model is in bold.

Table 3
Heritability Estimates for Behavioral and Cognitive Resilience at the Top 25% Extreme and Vulnerability at the Bottom 25% Extreme, and in the Full Sample

	Behavioral resilience		Cognitive resilience	
Portion of sample	h^2g	95% CI	h^2g	95% CI
Top 25%	.72	.43 – .99	.26	.01 – .51
Bottom 25%	.86	.57 – 1.15	.42	.18 – .65
Full sample	.71	.66 – .74	.46	.32 – .62

Note. h^2g = group heritability; CI = confidence interval.

and maternal warmth. These correlations were substantially greater for MZ than for DZ twin pairs, suggesting that genetic influences are important for explaining the covariation between maternal warmth and children's behavioral resilience. The bivariate model that provided the best fit to the data consisted of the AE model for children's behavioral resilience and the ACE model for maternal warmth (Table 5). The proportion of the phenotypic correlation between behavioral resilience and maternal warmth ($r = .25$; see Table 1) that is explained by shared genetic effects can be estimated from the parameter estimates in the bivariate twin model (Table 5). Specifically, this estimate (.165) is obtained by multiplying the latent genetic effect parameter for behavioral resilience (.83; Figure 1) by the latent genetic effect parameter for maternal warmth (.35) by the genetic correlation between behavioral resilience and maternal warmth ($r_A = .57$). Thus, 66% (.165/.25) of the phenotypic correlation between behavioral resilience and maternal warmth was accounted for by genetic influences that are shared by behavioral resilience and maternal warmth. The remaining proportion of the phenotypic correlation between behavioral resilience and maternal warmth was accounted for by child-specific environmental experiences (34%).

Table 4
Cross-Twin/Cross-Trait Correlations Between Protective Factors and Resilience

	MZ		DZ	
	r	N	r	N
Twin 1 behavioral resilience and Twin 2 maternal warmth	.17***	536	.04	452
Twin 2 behavioral resilience and Twin 1 maternal warmth	.19***	541	.02	456
Twin 1 cognitive resilience and Twin 2 outgoing temperament	.24***	591	.11*	508
Twin 2 cognitive resilience and Twin 1 outgoing temperament	.24***	594	.19***	509

Note. MZ = monozygotic; DZ = dizygotic.
*$p < .05$. ***$p < .001$.

Children's outgoing temperament and cognitive resilience—bivariate twin model. The MZ and DZ cross-twin, cross-trait correlations for cognitive resilience and children's outgoing temperament are presented in Table 4. These correlations were substantially greater for MZ than for DZ twin pairs, suggesting that genetic influences are important for explaining the covariation between outgoing temperament and children's cognitive resilience. The bivariate model that provided the best fit to the data was the ACE model (Table 5). The proportion of the phenotypic correlation between children's cognitive resilience and their outgoing temperament ($r = .27$; see Table 1) that is explained by shared genetic effects (.192) can be estimated by multiplying the latent genetic effect parameter for cognitive resilience (.68; Figure 2) by the latent genetic effect parameter for outgoing temperament (.62) by the genetic correlation between cognitive resilience and outgoing temperament ($r_A = .46$). Thus, 71% (.192/.27) of the phenotypic correlation between cognitive resilience and outgoing temperament was accounted for by genetic influences that are shared by cognitive resilience and outgoing temperament. The proportion of the phenotypic correlation between cognitive resilience and outgoing temperament that can be explained by shared environmental influences is estimated by multiplying the latent shared environmental effect parameter for cognitive resilience (.47; Figure 2) by the latent shared environmental effect parameter for outgoing temperament (.52) by the shared environmental correlation between cognitive resilience and outgoing temperament ($r_A = .19$). Thus, 17% (.045/.27) of the phenotypic correlation between cognitive resilience and outgoing temperament was accounted for by family-wide environmental influences that are common to both cognitive resilience and outgoing temperament. The remaining proportion of the phenotypic correlation between cognitive resilience and outgoing temperament was accounted for by child-specific environmental experiences (12%).

Stimulating activities and cognitive resilience—ACmE model. The moderate correlation observed between children's cognitive resilience and the level of stimulating activities provided for the twins ($r = .16$) lead us to estimate a univariate ACE model in which stimulating activities was included as a measured environmental variable. The approach

Table 5

Estimates of Genetic and Environmental Contributions to the Associations Between Behavioral Resilience and Maternal Warmth, and Between Cognitive Resilience and Children's Outgoing Temperament (Bivariate Models)

						Phenotypic *r* due to:		Fit of the models					
Model	r_A	r_C	r_E	Phenotypic *r*	Genes	Family-wide environment	Child-specific environment	χ^2	*df*	*p*	AIC	BIC	RMSEA (90% CI)
Behavioral resilience and maternal warmth	.57	–	.25	.25	.165 (66%)	–	.085 (34%)	19.67	13	.10	− 6.33	− 69.92	.03 (.00, .06)
Cognitive resilience and outgoing temperament	.46	.19	.10	.27	.192 (71%)	.045 (17%)	.034 (12%)	26.49	11	.01	4.49	− 50.43	.05 (.03, .08)

Note. For maternal warmth, the ACE model provided the best fit. The proportion of variance in maternal warmth accounted for by additive genetic factors was 15% (95% confidence interval [CI] = .01, .30), by shared environmental factors was 48% (95% CI = .34, .60), and by nonshared environment factors was 37% (95% CI = .33, .42). For children's outgoing temperament, the ACE model provided the best fit to the data. The proportion of variance in outgoing temperament accounted for by additive genetic factors was 34% (95% CI = .20, .50), by shared environmental factors was 32% (95% CI = .17, .45), and by child-specific environmental factors was 34% (95% CI = .31, .39). r_A = genetic correlation; r_C = shared environmental correlation; r_E = nonshared environmental correlation; AIC = Akaike information criterion; BIC = Bayesian information criterion; RMSEA = root mean square error of approximation.

used in this analysis differed from the bivariate model used to examine the relation between children's outgoing temperament and cognitive resilience because outgoing temperament is a child-specific variable that was measured separately for each twin whereas stimulating activities is common to each twin pair (i.e., it is a family-wide environmental variable).

Figure 3 shows the parameter estimates from a structural equation model of children's cognitive resilience, which includes stimulating activities as a specified family-wide environmental variable that helps protect children's cognitive development against SES deprivation. This model assumes that stimulating activities is not a factor separate from C, but rather one of the ingredients that go into C. The model leads to

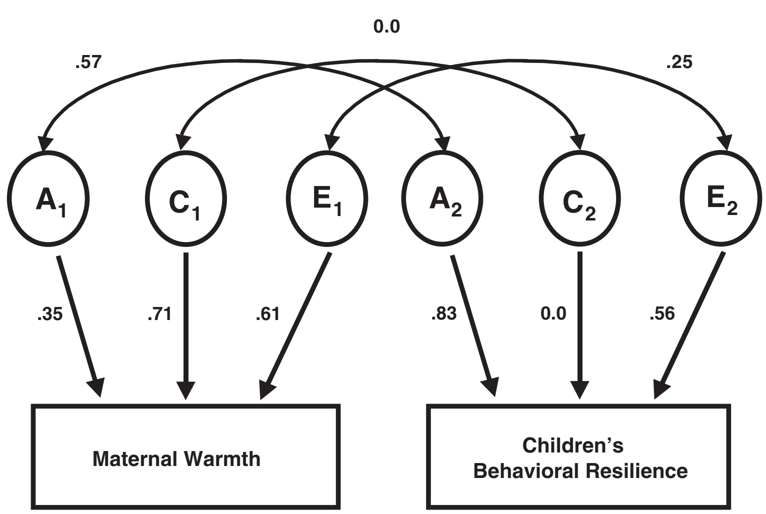

Figure 1. Bivariate model-fitting results between children's behavioral resilience and maternal warmth—common factors model. Rectangles represent the measured variables and circles represent latent variables whose loadings on the measured variables are shown as standardized path coefficients, which are squared to yield the proportion of variance explained. A = latent additive genetic factor, C = latent shared environmental factor, and E = latent nonshared environmental factor. Because parameter estimates are identical for Twins 1 and 2, only one set of parameters is displayed. The variances of latent variables are fixed at 1.

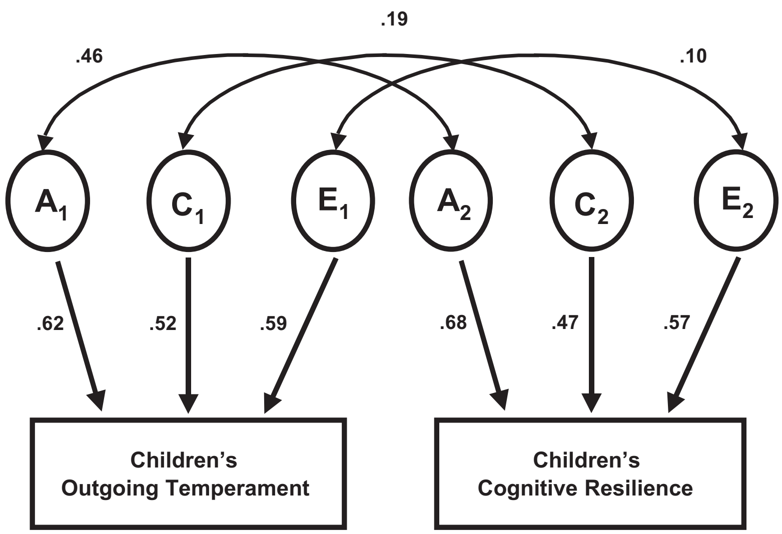

Figure 2. Bivariate model-fitting results between children's cognitive resilience and outgoing temperament—common factors model. Rectangles represent the measured variables and circles represent latent variables whose loadings on the measured variables are shown as standardized path coefficients, which are squared to yield the proportion of variance explained. A = latent additive genetic factor, C = latent shared environmental factor, and E = the latent nonshared environmental factor. Because parameter estimates are identical for Twins 1 and 2, only one set of parameters is displayed. The variances of latent variables are fixed at 1.

two relevant variance estimates: the variance in C that can be predicted from stimulating activities, and the population variance in children's cognitive resilience that is explained by stimulating activities. Family-wide environmental influences accounted for 22% (95% CI = .09, .35) of the population variation in children's cognitive resilience, and stimulating activities accounted for 11% (95% CI = .04, .30) of this family-wide environmental effect, thus explaining 2% (95% CI = .01, .04) of the total population variation in cognitive resilience. Fit statistics indicated that this model was a good fit to the data, $\chi^2 = 9.45$, $df = 7$, $p = .22$; Akaike information criterion (AIC) = −4.55; Bayesian information criterion (BIC) = −39.51; root mean square error of approximation (RMSEA) = .03, 90% CI = .00, .06 (Browne & Cudeck, 1993).

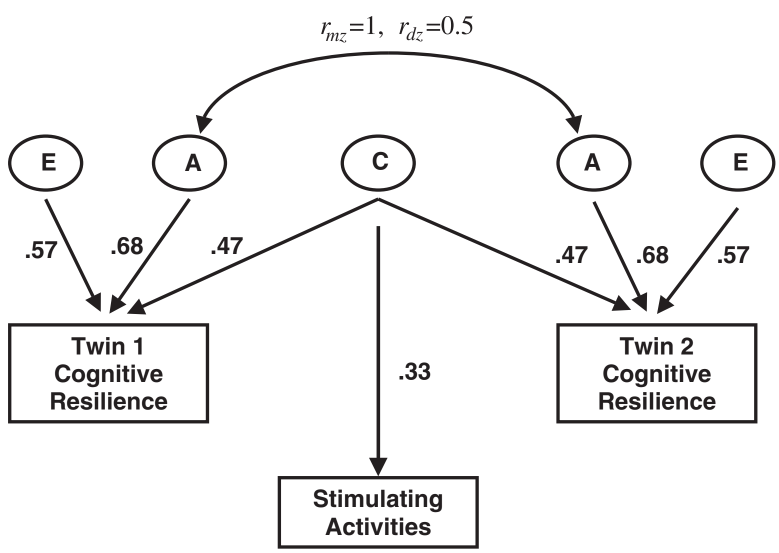

Figure 3. Parameter estimates for the ACE model with a measured environmental variable (ACmE) twin model as applied to children's cognitive resilience with stimulating activities included as a measured index of shared environment. A = latent additive genetic factor, C = latent shared environmental factor, and E = latent nonshared environmental factor. Rectangles represent the measured variables and circles represent latent variables whose loadings on the measured variables are shown as standardized path coefficients, which are squared to yield the proportion of variance explained. r_{MZ} = monozygotic twin correlation; r_{DZ} = dizygotic twin correlation.

Discussion

This study's primary goal was to uncover the genetic and environmental processes in children's resilience and vulnerability to SES deprivation. To do so, we first had to determine whether basic findings in the resilience literature also applied in our sample of 5-year-old twins. Consistent with prior research, we found that SES deprivation was significantly associated with children's lower IQ and higher antisocial behavior. Also consistent with prior research, we found that children's outgoing temperament, maternal warmth, and stimulating activities appeared to promote children's resilience to SES adversity. Our study presents new information by being the first to demonstrate that resilience to SES deprivation is partly heritable and that protective factors have both genetic and environmental elements.

What Promotes Cognitive Resilience?

The present study found that some children who grow up under conditions of SES deprivation are cognitively resilient for both genetic and environmental reasons. Approximately 46% of the variation in children's cognitive resilience was accounted for by additive genetic effects, and the rest of the variation was accounted for by environmental effects (plus measurement error). Young children's outgoing, sociable temperament was associated with cognitive resilience against SES adversity, and this association was mediated primarily through genetic, but also through environmental, processes. How is it possible that the association between children's outgoing temperament and cognitive resilience can be mediated genetically?

A child's outgoing temperament can be correlated with good cognitive functioning in the context of unfavorable economic conditions through passive or active means (Rutter & Silberg, 2002; Scarr & McCartney, 1983). A passive gene–environment correlation would result if children's cognitive resilience and their outgoing temperament are associated because both are provided by their parents. In other words, parents may provide children with genes or environments, or both, that influence hardy intellectual development, and with genes or environments, or both, that influence a highly sociable temperament. Prior research has shown that extraverted and highly sociable parents behave in more cognitively stimulating ways toward their children (Belsky, Crnic, & Woodworth, 1995; Manglesdorf, Gunnar, Kestenbaum, Lang, & Andreas, 1990), thereby supporting the premise that parents supply the ingredients, both genetic and environmental, for the development of cognitive resilience and a sociable temperament in their children.

An active gene–environment correlation results when children's genetically inherited characteristics evoke, elicit, or create certain responses or situations that then further influence the child's development in ways that correlate with their genotype. Thus, some children may have inherited an outgoing temperament that then leads them to evoke from their caregivers and others in their environment more attention, stimulation, and learning experiences, leading to cognitive resilience. For example, a highly sociable and talkative child may elicit more exchanges with a teacher, which in turn help the child develop better cognitive skills, despite growing up under SES adversity. Prior research suggests that young children's temperament is associated with the level of maternal responsiveness and stimulation a child receives (Karrass, Braungart-Rieker, Mullins, & Lefever, 2002). Another active gene–environment correlation would result if children proactively select environments that are correlated with their genetically inherited characteristics, interests, and talents. Thus, some children may have inherited an outgoing temperament that leads them to seek out actively experiences that support their intellectual development, leading to cognitive resilience (Shiner & Caspi, 2003).

In addition to identifying genetic influences, this research used a twin design to demonstrate that the environment does play an important role in children's cognitive resilience to SES adversity beyond any heritable influences. Stimulating activities that children experienced with their mothers were associated with better intellectual functioning and, as a measured environmental variable, helped account for the shared environmental effect on the familial aggregation of children's cognitive resilience. The effect size, though small, is nontrivial (McCartney & Rosenthal, 2000). It is similar in size to the impact of neighborhood deprivation on children's behavior problems (Leventhal & Brooks-Gunn, 2000) and to the impact of childhood loss of a parent on later psychopathology (Kendler, Neale, Kessler, Heath, & Eaves, 1992; Kendler et al., 1996). Moreover, our finding suggests that if poor families are provided with the means to engage in stimulating activities with their young children, it may be possible to counteract some of the negative effects that living in a socioeconomically impoverished environment has on children's intellectual development. A caveat is in order. Although we assume that stimulating activities is an environmental variable, it is possible that this variable is also influenced by parental IQ, which is partly heritable. A study that incorporates more extensive data on parental IQ could go further to estimate the environmental influence of stimulating activities with more precision.

What Promotes Behavioral Resilience?

This study found that approximately 70% of the variation in children's behavioral resilience against SES deprivation was accounted for by additive genetic effects, and the rest of the variation was accounted for by unique environmental effects and measurement error. The level of emotional warmth mothers had for their children was associated with children's behavioral resilience, and this link was mediated partly through genetic and partly through environmental processes.

Passive and active models of gene–environment correlation may be involved in the association between maternal warmth and children's good behavioral functioning in the context of SES deprivation. Thus, parents who provide warm and loving care for their children may also transmit genes to their children that promote good behavioral regulation and less antisocial behavior. Parents' personality is a central determinant of parenting (Belsky & Barends, 2002; Clark, Kochanska, & Ready, 2000) and has a moderate genetic transmission from parent to child (Bouchard & Loehlin, 2001).

An active gene–environment correlation would result if children have heritable characteristics that evoke warmth and affection from adults, which in turn help the child curb problem behaviors. Researchers have found that genetic risk for antisocial behavior influences the level of warmth and harsh discipline that adopted children receive from their adoptive parents (Ge et al., 1996). Passive and active models of gene–environment correlations are not mutually exclusive, and they are likely to be jointly involved in explaining the genetically mediated processes involved in children's positive adaptation to risk.

Social support was not significantly associated with behavioral or cognitive resilience. Prior research has indicated that perceived social support has a protective effect on parental behavior, mainly among low-income families (Hashima & Amato, 1994). The current study may not have detected a significant association between social support and children's resilience because our residual measures of children's resilience, in effect, control for the effects of family SES on children's outcomes. Additional analyses of our sample did not indicate a significant interaction between family SES and mother's perceived social support on children's behavior problems or IQ.

Limitations

Four limitations of this study deserve mention. First, the present study is correlational and cross-sectional in design and therefore was not able to prove that hypothesized protective factors cause children to be resilient to SES adversity. Second, results from this twin study can suggest various models of gene–environment correlations, but this study is limited in that passive and active patterns of gene–environment correlation and gene $\times$ environment interaction could not be disentangled. Third, our sample comprised twins and their parents living in England and Wales. Therefore, we cannot be certain that our findings will generalize to singletons or to cohorts in other countries. However, the correlation between SES deprivation and behavioral problems in our twin sample ($r = .28$) is similar to that from a study of economic hardship and externalizing problems in U.S. singletons ($r = .24$; Bolger et al., 1995). The correlation between SES deprivation and IQ in our twin sample ($r = -.34$) is similar to that from a U.S. study of poverty and cognitive ability in singletons ($\beta = -.33$; Smith et al., 1997). Further research using other kinds of genetically sensitive designs (e.g., adoption, stepfamily) is needed to determine how genetic and environmental findings about resilience generalize. Fourth, this study examined only the protective role of mothers, but future research should examine how fathers affect children's resilient development (Jaffee, Moffitt, Caspi, & Taylor, 2003).

Implications

The present study reports findings with two implications for theory. First, that resilience is partly heritable suggests that multiple genes are likely to be involved in helping individuals withstand adversity. For instance, recent studies have found that maltreated children were less likely to develop antisocial behavior if they have a particular genotype that confers high levels of the monoamine oxidase A enzyme (Caspi et al., 2002), and less likely to develop depression if they have a particular genotype that confers efficient transport of serotonin (Caspi, Sugden, et al., 2003). Although the specific mechanisms by which these gene markers might moderate the deleterious effects of maltreatment are not yet clear, genetic influences may operate by shaping the way children react to misfortune (e.g., through cognitive mechanisms such as emotion recognition and attributional biases). Findings from the present study provide impetus for a search for genes involved not only in the expression of a phenotype but also in the processes of successful (and unsuccessful) adaptation to risk.

Second, our finding that resilience is partly heritable suggests that positive adaptive capacities tend to run in families, and therefore it may be fruitful to conceptualize resilience as a family process as well as an individual process. Focusing on the family as a unit of analysis can be useful for uncovering the unique processes through which families respond to crisis and overcome challenges (Cowan, Cowan, & Schulz, 1996; Patterson, 2002). Family cohesiveness, communication, and shared meaning have been implicated in resilient processes at the family level (Patterson, 2002).

Findings from the present study also have three implications for research methodology. First, we found different protective factors for behavioral and cognitive resilience, which supports conceptualizing and measuring resilience not as a single construct but as a multidimensional construct (Cicchetti & Rogosch, 1997; Luthar et al., 2000; Masten & Coatsworth, 1998). Previous research has identified protective factors that promote resilience defined in broad, general terms (Cowen et al., 1990; Werner & Smith, 1992). The present study adds to the literature by identifying specific protective factors for different types of resilient outcomes among socioeconomically disadvantaged children.

Second, using the standardized residual from a regression model appeared to be a useful method for measuring children's resilience and vulnerability to SES. Essentially, what the residual represents is variance in children's outcomes that is left over after the effects of SES have been removed. Therefore, one benefit of the residual score is that it is completely uncorrelated with the risk factor in question. We faced the possibility that residual variance left over from a regression model would be too heavily saturated with measurement error to be meaningful as an index of resilience. On the contrary, our measures of cognitive and behavioral resilience were correlated with hypothesized protective factors in ways that are consistent with theory and with prior empirical findings, and their variation could be attributed to the effects of genes and common environment. This finding applied to children at the extremes of the continuum who had very good outcomes despite very poor SES conditions—the essence of the resilient child.

Third, findings from this study apply to both resilience and vulnerability to SES deprivation. The genetic and environmental influences on children's resilience to SES deprivation also helped explain why some children had behavioral and cognitive outcomes that were less positive than expected, given their social class background. Therefore, researchers need to bear in mind that risks come in multiple forms, and even children in relatively comfortable economic situations may face other hazards that challenge the course of their development. Why a child from a middle-class home has problems and why a child from a poor family does well are both questions that give purchase on the interplay between genes and environments in risk and protective processes.

Finally, the present study has implications for clinical intervention. We used a genetically sensitive design to demonstrate that environmental effects can make a positive difference in the lives of poor children. Providing cognitively stimulating activities can forestall the negative effects of SES deprivation on children's cognitive development (Burchinal, Campbell, Bryant, Wasik, & Ramey, 1997). Emotional warmth from a caregiver is associated with children's behavioral development for both environmental and genetic reasons. Even child temperament promoted resilience through environmental processes. Findings from the present study suggest that young children are not merely passive recipients of the socializing influences of their parents, families, and environments, but that children can act in evocative and proactive ways to shape their environments and make themselves more resilient. Previous research has revealed that children influence the development of their own characteristics and the types of interactions they have with parents and with others around them (Anderson, Lytton, & Romney, 1986). When children attempt to seek out experiences that will help them overcome adversity, it is critical that resources, in the form of supportive adults or learning opportunities, be made available to them so that their own self-righting potential can be fulfilled.

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