
The Nonshared Environment in Adolescent Development (NEAD) Project: A Longitudinal Family Study of Twins and Siblings from Adolescence to Young Adulthood

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The Nonshared Environment in Adolescent Development (NEAD) project is a longitudinal study of twins/siblings and parents that has been assessed 3 times: middle adolescence, late adolescence and young adulthood ($N = 720$ families at Time 1). Siblings varied in degree of genetic relatedness including identical twins, fraternal twins, full siblings, half siblings and genetically unrelated (or step) siblings. There were also two family types: nondivorced and step. A multi-measure, multirater approach was taken in NEAD, with data collected from all participants (2 twins or siblings, mother and father) as well as from coded videotaped observations of family interactions. Detailed assessments of family relationships, adolescent adjustment and competence were collected at all 3 times. The original aim of NEAD was to identify systematic sources of nonshared environmental influences that contribute to differences among family members. Although systematic sources of nonshared environmental influences were not found in NEAD, three major sets of findings emerged: (1) genetic influences on family relationships and on associations between family relationships and adolescent adjustment; (2) genetic and environmental influences on adolescent adjustment, comorbidity and stability and change in adolescent adjustment from middle to late adolescence; and (3) genetic influences on relationships outside the family.

The Nonshared Environment in Adolescent Development (NEAD) project is a longitudinal study of adolescents and parents that has been extended into young adulthood (Young Adult Sibling Study: YASS). The original aim of NEAD was to identify the nonshared environmental influences, particularly those within families that resulted in such large differences in adolescent development in siblings. This original focus, in part, was intended to address the question of why children reared in the same family are so different from one another (Plomin & Daniels,

1987). There are many approaches that could have been taken to address this question. NEAD chose to focus on differences within the family by carefully measuring family relationships — between parents and children, siblings and within the couple — in an effort to better understand sources of within-family differences. The young adult extension of NEAD (YASS) continued this focus on the family by examining relationships among the same NEAD participants, and adding assessment of other relevant relationships, when the siblings were young adults.

NEAD was one of the first studies to take advantage of the high rates of divorce and remarriage in the United States by recruiting a sizable sample of siblings of varying degrees of genetic relatedness from step-families as well as including twins and siblings from nondivorced households. Given the focus on non-shared environmental influences within the family, NEAD included detailed assessments of relationships among family members, including videotaped observations of family interaction, and a wide range of indices of adolescent adjustment and functioning. The sample was assessed twice during adolescence: once during middle adolescence and once during late adolescence. A detailed description of the NEAD project can be found elsewhere (Reiss et al., 1994, 2000). Most recently, the sample was reassessed during young adulthood, with a focus on family relationships, young adult functioning and DNA collection.

Recruitment

Three waves of data were collected as part of the NEAD/YASS studies. Detailed information on the

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sample and recruitment procedures for Time 1 and 2 data collection can be found elsewhere (Hetherington et al., 1999; Reiss et al., 1995, 2000). A summary of recruitment procedures and participation is provided here, in Table 1 and Figures 1a and 1b.

Table 1 lists the number of twin/sibling pairs participating at each time of data collection. The first assessment occurred in 1988 and targeted two-parent nondivorced and step families with two same-sex siblings who were no more than 4 years apart in age. Inclusion criteria for recruitment into NEAD required that all families consist of two same-sex adolescent siblings where both siblings resided at home at least half-time. Step families were required to be together for 5 years or more to avoid the unstable early years of step family formation. Finally, all four target family members were required to participate: mother, father and both siblings. Because of these stringent inclusion criteria over 675,000 households were screened, using a combination of random digit dialing and market panels, to meet the target sample size of 100 families of genetically unrelated siblings in step families. Time 1 included 720 families.

To be included in Time 2 data collection, 3 years later, both of the target adolescents were required to reside in the home at least half of the time with both parents who participated at Time 1. A flow chart detailing participation at Time 2 is presented in Figure 1a. As can be seen in Figure 1a, failure to meet these criteria resulted in a reduced sample of 395 families (of the ineligible families, 15% experienced a divorce, 79% of the adolescents had moved out of the home, and the remaining 6% were unable to be classified). Only 9% of the families who were eligible to participate at Time 2 refused to do so. There were no differences in demographic characteristics (parents' education, family income, gender of the siblings, and

Table 1

Number of Twin/Sibling Pairs by Family and Sibling Type

	Time 1 ^a	Time 2 ^b	Time 3 ^c
Nondivorced Families			
MZ Twins	93	63	55
DZ Twins	99	71	49
Full Siblings	95	57	36
Step Families			
Full Siblings	181	92	53
Half Siblings	110	59	35
Step Siblings	130	42	40

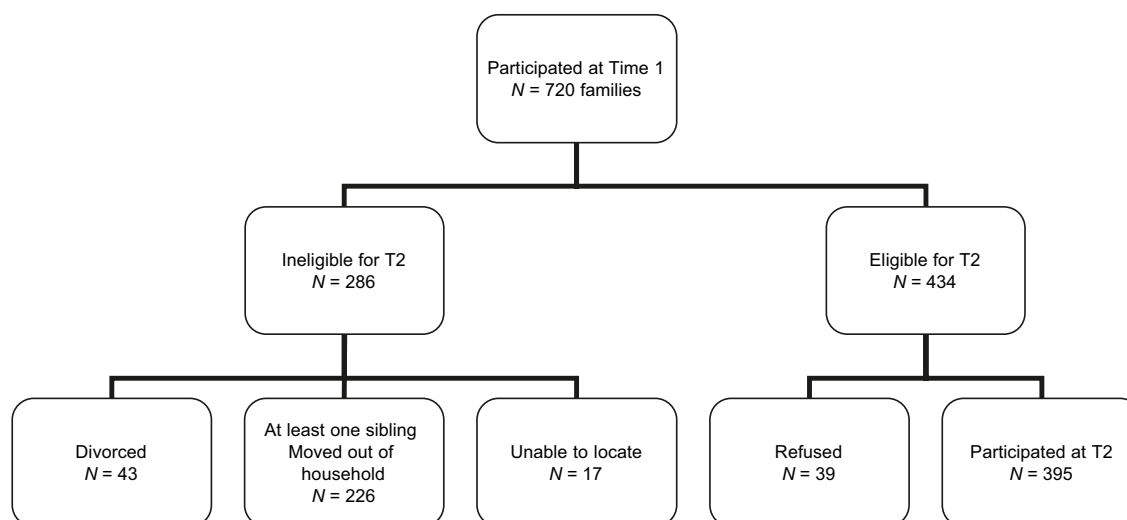
Note: ^aThere were 12 twin pairs that could not be classified as MZ or DZ.

^bThere were 11 twin pairs that could not be classified as MZ or DZ.

^cThese Ns refer to the number of twin/sibling pairs where we have self-report data on both members of the pair. There are also parent report data on the twins and siblings.

age difference between siblings) for families who were eligible for participation only at Time 1 versus families who were eligible to participate at both times, $F_{(5,681)} = 1.26, p < .28$. For the 39 eligible families who refused to participate at Time 2, analyses indicated significant main effects for age and variables related to age (i.e., the adolescents were older and received less parental monitoring) when compared to eligible families who chose to participate at Time 2.

Finally, all families who participated at Time 1 were eligible to participate in the Time 3 data collection (Figure 1b), occurring from 1999 to 2001, and consisting entirely of telephone and mailed questionnaires. Given the long time span between the last contact and Time 3 recruitment (7 to 13 years), it is not surprising that many of the families had moved and were difficult to locate. Nonetheless, 516 families

**Figure 1a**

Flow chart for NEAD recruitment and participation for Time 1 and Time 2 data collection.

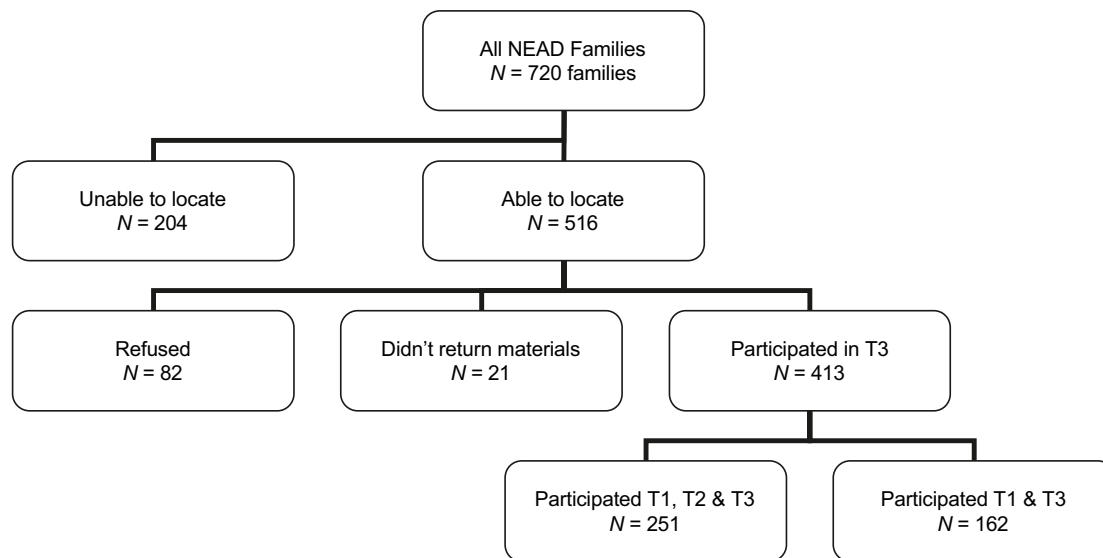


Figure 1b

Flow chart for NEAD recruitment and participation for Time 3 data collection.

were able to be recontacted and we collected data from 413 families. Only 16% of those contacted refused to participate and 4% did not return their materials. Of the 413 participating families, 61% participated at all three times of assessment, with the remaining 39% participating only at Time 1 and 3. There were no mean differences in demographic characteristics (gender of the siblings, antisocial behavior of siblings, peer college orientation, peer delinquency and substance use, parents' age, parents' education, and family income) for families who participated only at Time 1 versus families who participated at Time 3 with two exceptions. For families who did not participate at Time 3, mothers were significantly younger, $F(df = 340, N = 712) 1.44, p = .001$, and family income was significantly lower, $F(df = 361, N = 697) 1.27, p = .03$. We were able to collect data from at least two family members for 365 families and collected DNA from 96% of those participating. It is also worth noting that parents reported on a number of constructs for both of the children (general demographics, parent-young adult relationship, antisocial behavior and depressive symptoms). Therefore, if data were collected from one of the parents, information about both of the young adult siblings was available, regardless of whether the siblings also participated.

Procedure

At Time 1, most families were visited twice by two interviewers, while all families who participated in the Time 2 assessment were visited once by one interviewer. Both parents and the two adolescents completed questionnaires and were videotaped during the visit. Additional questionnaire data were obtained from questionnaires that were mailed ahead and col-

lected by the interviewer. Family members specified areas of disagreement that were then discussed in 10-minute videotaped dyadic, triadic, and tetradic combinations. A global coding system of 5-point Likert scales (Hetherington & Clingempeel, 1992) was employed to rate the videotaped interactions. The Time 3 assessment occurred when the siblings were young adults and focused on collecting data from all family members — mother, father and siblings — who participated in the Time 1 assessment. The Time 3 data collection consisted of a brief 10- to 15-minute telephone interview, mailed questionnaires and the collection of DNA via mail.

Sample

Families included five sibling types residing in two types of families: monozygotic (MZ) twins, dizygotic (DZ) twins, and full siblings (FI) in nondivorced families, and full (FS), half (HS), and genetically unrelated siblings (US) in step families. At all three time points approximately half of the sample was male. The families were primarily middle-class (average family income at Time 1 ranged from \$25,000 to \$35,000; with 12% earning less than \$20,000/year and 32% earning more than \$50,000/year), and Caucasian (94% of the mothers and 93% of the fathers). The average years of education were 13.6 for mothers and 14.0 for fathers. Only a few parents received less than a high school education (7% of mothers; 10% of fathers), more completed their education with high school graduation (42% of mothers; 35% of fathers), with the remainder receiving at least some post high school education. Demographic characteristics of the sample at each of the three assessments can be found in Table 2.

Table 2

Sample Characteristics for the Nonshared Environment in Adolescent Development (NEAD) Project at Times 1, 2 and 3

	Time 1 Middle Adolescence	Time 2 Later Adolescence	Time 3 Young Adulthood
Adolescent/Young Adult Characteristics			
Age range (years)	10–18	13–21	20–35
Mean age for Child 1	13.5 (2.0)	16.2 (2.1)	26.8 (2.5)
Mean age for Child 2	12.1 (1.3)	14.7 (1.9)	25.5 (2.6)
Mean age difference	1.61 (1.29)	1.47 (1.34)	1.23 (1.6)
% female pairs	48.4%	49.4%	48%
% married: Child 1	—	—	59%
% married: Child 2	—	—	50%
Family income: Child 1 (median)	—	—	\$40,000–\$49,999
Family income: Child 2 (median)	—	—	\$30,000–\$39,999
Mean years education: Child 1	—	—	14.9 (2.3)
Mean years education: Child 2	—	—	14.6 (2.3)
Parent Characteristics			
Mother age (years)	38.1 (5.2)	40.5 (4.8)	51.4 (4.6)
Father age (years)	41.0 (6.5)	43.0 (6.1)	54.2 (6.1)
Mean years education: Mother	13.8 (2.3)	13.9 (2.4)	14.2 (2.7)
Mean years education: Father	13.9 (2.7)	14.0 (2.6)	14.6 (2.8)
Family income (median)	\$25,000–\$35,000	\$25,000–\$35,000	\$60,000–\$69,999

Measures

Measurement of family relationships and adolescent outcomes was extensive for the Time 1 and Time 2 assessments. A multimeasure, multirater strategy was used for all constructs measured in NEAD. Mother–adolescent and father–adolescent relationships were indexed by parent reports, adolescent reports and videotaped dyadic interactions between each parent and each child. Sibling relationships were assessed through adolescent and parent reports as well as through videotaped observations. Marital relationships were indexed by self-reports and videotaped dyadic interactions as well as through adolescent ratings of their exposure and involvement in parental conflict. Adolescent adjustment and functioning was assessed through adolescent self-reports, mother reports, father reports, teacher ratings, as well as observer ratings for antisocial behavior, depressive symptoms and prosocial behavior. Finally, both parents reported on contextual and demographic factors as well as on their own personality characteristics and mental health.

A multi-measure, multi-rater strategy was also used for the Time 3 assessment, although no videotaped observations were used. The focus of the Time 3 assessment was on the functioning of the young adult siblings and their current family relationships. Therefore, relationships with romantic partners, adult attachment and close friendships were also examined in addition to assessments of parent–young adult relationships and adult sibling relationships. Whenever possible, reports from multiple family members were collected, including

from the spouse or cohabitating partner of the young adult sibling. Table 3 contains a summary of the constructs and measures assessed at Times 1, 2 and 3.

Findings from NEAD

There are a large number of published findings from the NEAD project. The phenotypic reports have focused on understanding stepfamilies in relation to nondivorced families, examining key facets of adolescent development, and in examining siblings and sibling relationships (e.g., Feinberg & Hetherington, 2001; Henderson et al., 1996; Hetherington et al., 1999; Kim et al., 1999; O'Connor et al., 1998). In this manuscript we focus on the findings from NEAD that have taken advantage of the twin and sibling variations in genetic relatedness. These findings can be grouped into three main categories: (1) genetic influences on family relationships and on associations between family relationships and adolescent adjustment; (2) understanding genetic and environmental influences on adolescent adjustment, comorbidity and stability and change in adolescent adjustment from middle to late adolescence; and (3) genetic and environmental influences on relationships outside the family. Before the main findings are detailed, we provide a brief overview of the models that have typically been used.

Modeling Strategies in the NEAD Study

NEAD was one of the first studies able to systematically examine a wide range of ‘environmental’ measures as phenotypes. A number of reports finding genetic

Table 3
Summary of Measures Collected for the NEAD/YASS Sample

	Time 1		Time 2		Time 3	
	Self ¹	Other ²	Self	Other	Self	Other
Mental health/problem behaviors						
Substance use/abuse (not tobacco)	x	x	x	x	x	x
Alcohol consumption	x		x		x	
Cigarette/tobacco use and history of use					x	
Externalizing behaviors/antisocial behaviors	x	x	x	x	x	x
Internalizing behaviors/depressive symptoms	x	x	x	x	x	x
Mental health/positive functioning						
Quality of life					x	
Harter Self-Perception Profile	x		x			
Autonomous functioning (adolescents)	x	x	x	x		
Mastery					x	
Personality/intelligence						
California Personality Inventory	x	x				
EAS Temperament Survey	x	x	x	x		
Optimism	x	x	x	x		
NEO Personality Inventory					x	
Temperament and Character Inventory					x	
Wechsler Intelligence Scales — Verbal Attitudes Questionnaire	x		x			x
Physical development/behavior						
Pubertal Development Scale	x	x	x	x		
Sexual Behavior Questionnaire			x			
Life events/beliefs/support						
Life Events Checklist	x		x			
Perceptions about child similarity, genetic inheritance and parenting responsibilities	x					
Social support	x					
Family process — parent–offspring						
Warmth/support	x	x	x	x	x	x
Conflict/negativity	x	x	x	x	x	x
Control/monitoring	x	x	x	x		
SIDE	x		x			
Family process — sibling						
Positivity/negativity in sibling relationships	x	x	x	x	x	
SIDE	x		x			
Marital/romantic partner relationships						
Marital conflict	x		x		x	x
Marital quality	x		x		x	x
Adult attachment to partner					x	
Conflict about child	x		x			
Expressed emotion					x	x
Peer relationships						
Perceptions of peer groups		x	x	x		
SIDE	x		x			
Relationship closeness					x	
Demographics/history						
Employment history and status	x		x		x	
Social and demographic information	x		x		x	
Marital history	x		x		x	
Household assets	x		x			
Education	x	x	x	x	x	

Note: ¹Self-report refers to reports about one's own behavior by either the adolescent/young adult or the parent.

²Other report refers to parent reports about the adolescent/young adult, adolescent/young adult reports about the parent/sibling, and teacher reports about the adolescent.

EAS = Emotionality, Activity and Sociability; NEO = Neuroticism, Extraversion and Openness to Experience; SIDE = Sibling Inventory of Differential Experience.

influences on measures typically thought of as environmental emerged just as analyses using NEAD data were getting underway (e.g., Braungart et al., 1992; Plomin & Bergeman, 1991; Plomin et al., 1985; Rowe, 1983). Therefore, a key strategy in analysis of NEAD data on family relations was to treat variables like parenting as phenotypes in order to disentangle genetic, shared environmental and nonshared environmental sources of variation in these constructs (Figure 2a).

The next logical step in such analyses was to examine the associations among 'environmental' variables and adolescent outcomes using multivariate biometric model-fitting approaches. Figure 2b illustrates a bivariate Cholesky model (showing just one twin/sibling in the pair). Derivations of this approach were taken in most papers examining parenting and adolescent adjustment (e.g., Neiderhiser et al., 1998, 1999; Pike et al., 1996). In models examining genetic and environmental influences on associations between parenting and adolescent adjustment, parenting is typically the first variable. In this way, genetic and environmental influences shared by the parenting construct and adolescent adjustment are estimated in the first set of genetic and environmental factors and genetic and environmental influences unique to adolescent adjustment are estimated by the second set of factors. In many cases a bivariate genetic model that allowed unique genetic and environmental influences on each of the constructs was estimated with the common paths for the genetic, shared environmental and nonshared environment constructs set to be equal (e.g., O'Connor et al., 1998; Reiss et al., 2000). Such a model is equivalent to that illustrated in Figure 2b.

Most of the major findings reported below used strategies similar to those described above. One exception is a paper examining differences in individuals who met the clinical cut-off for depression and the rest of the distribution (Rende et al., 1993) which

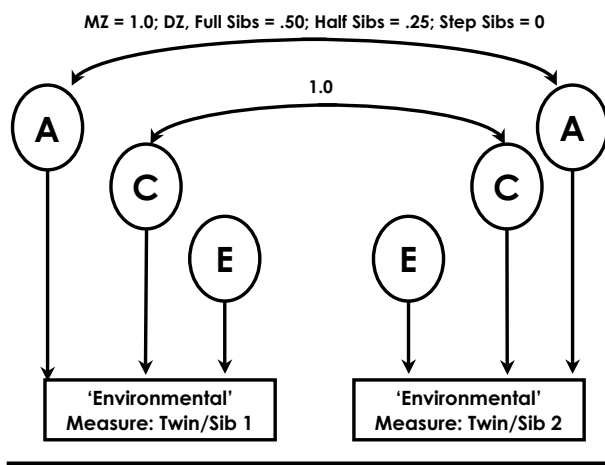


Figure 2a

Univariate genetic model for examining genetic and environmental influences on an 'environmental' measure.

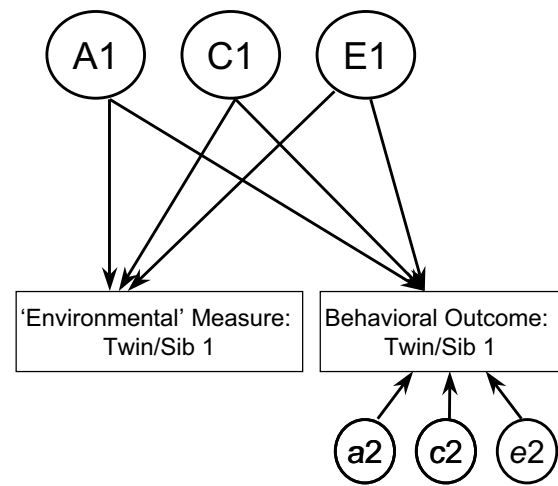


Figure 2b

Bivariate Cholesky model for examining genetic and environmental influences on covariation between an 'environmental' measure and behavioral outcome. Only one member of the sibling pair is presented.

used the regression-based DeFries-Fulker method (DeFries & Fulker, 1988).

Genetic Influences on Family Relationships

One of the most surprising findings from NEAD was the discovery of significant and systematic genetic influences on our measures of process and quality of family relationships (e.g., O'Connor et al., 1995; Plomin et al., 1994). Even more surprising was the finding that the covariation between parenting and adolescent adjustment could be explained by primarily genetic influences (e.g., Pike et al., 1996). In short, although the NEAD study did not find evidence of systematic nonshared environmental influences within families that make family members different from one another, findings from this study underscore the importance of the adolescent in influencing the environments that they experience. In an effort to better understand the mechanisms involved, longitudinal cross-lagged models were also examined for parental conflict and negativity and adolescent antisocial behavior and depressive symptoms (Neiderhiser et al., 1999). The findings indicated that genetic influences were responsible for the cross-lagged association between parenting to adolescent adjustment from Time 1 to Time 2. When this analysis was repeated for all of the parenting and adolescent adjustment composites the direction of effects was most often from parenting at Time 1 to adolescent adjustment at Time 2 and the most substantial influence on the cross-lagged path tended to be genetic (Reiss et al., 2000). Finally, marital conflict about the adolescent child was also found to be significantly influenced by genetic and shared environmental factors, as was the association between this construct and a number of adolescent adjustment constructs, both positive and negative (Reiss et al., 2000). This suggested that

heritable characteristics of middle adolescents influenced how parents responded to them and those parental responses, in turn, intensified the adolescent's pattern of behavior.

The collection of data from multiple sources across a wide variety of domains has served as the basis for another series of papers from NEAD. One such paper examined genetic and environmental contributions to the covariation across two family subsystems — mother–adolescent and sibling relationships (Bussell et al., 1999). Shared environmental influences were found to explain the bulk of the covariation between these two systems. Moreover, sibling relationships were linked to a broad range of adolescent adjustment measures and these linkages could be explained, in large part, by shared environment. In contrast, parental behavior was associated with many of the same adolescent adjustment measures by genetic influences common to both. This set of findings suggests that the shared environmental influences within a family that are most important in influencing outcome, at least in adolescents, are those within the sibling relationship. Another report examined genetic and environmental influences on the covariation among parent, adolescent and observer ratings of parenting and found differences based on parenting construct (Feinberg et al., 2001). Specifically, the covariation among reporters for parental negativity was due primarily to genetic influences, while shared environmental influences explained covariation among reports for parental warmth. Finally, in an effort to better understand how genetic influences contribute to the covariation between parenting and adolescent adjustment, adolescent perceptions of parenting were examined as a mediator of this effect (Neiderhiser et al., 1998). This study found that the bulk of genetic influences on the covariation between parenting and adolescent adjustment could be explained by genetic influences on adolescent perceptions of their parents' behavior. This series of papers emphasizes the importance of collecting data from multiple sources to enable a more nuanced understanding of the processes involved.

A recent set of analyses have focused on examining the moderation of genetic and environmental influences by measured 'environmental' measures like parenting, and more recently in examining what factors moderate heritability on parenting. The first of these papers found that parental negativity and low warmth moderated heritability on adolescent antisocial behavior but not depression. Specifically, genetic influences were greater for adolescent antisocial behavior when parenting was more negative or less warm (Feinberg et al., in press). A second set of analyses focused on marital quality as a moderator of genetic and environmental influences on parenting (Ulbricht et al., 2006). The findings differed somewhat for mothers and fathers with higher levels of shared environmental influences on mother's parental negativity when there is less marital conflict about the children and increasing heritability on mother's

parental negativity with increasing marital dissatisfaction. Father's negativity, on the other hand, was influenced less by genetic factors and more by non-shared environmental influences when there was little conflict about the child as well as at lower levels of marital dissatisfaction. The contributions of genetic and nonshared environmental factors reversed at higher levels of marital conflict about the child and marital dissatisfaction for father's negativity. We are continuing to explore the moderators of heritable influences on adolescent adjustment and on family relations in an effort to better understand the mechanisms involved.

One set of analyses using the young adult sample found that only shared environmental factors influenced longitudinal associations of adolescent antisocial behavior and young adult current relationships with their parents and with their romantic partners with no covariance between young adult's relationship with their partner and their parent independent of adolescent antisocial behavior (Neiderhiser, 2003a). Similarly, stability in parent–child relationships from adolescence to young adulthood were due primarily to shared environmental factors and covariation between parent–adolescent relationships and young adult romantic relationships were due to both genetic and shared environmental factors (Neiderhiser, 2003b). These two sets of findings are especially intriguing as they underscore the importance of shared environmental influences in relationship patterns over time and across individuals.

Adolescent Adjustment, Comorbidity and Psychopathology

Two series of papers examined adolescent adjustment from middle to later adolescence, providing insight into how genetic and environmental influences impact change and stability in adolescent functioning over time. Perceptions of self-worth and competence were examined in NEAD at Time 1 (McGuire et al., 1994) providing some of the first evidence that this construct is influenced by genetic and nonshared environmental factors, but not by shared environmental influences. When these constructs were examined at Time 2 a similar pattern of findings emerged, and stability in the constructs was found to be due primarily to genetic influences (McGuire et al., 1999). One exception was stability in social competence, which was due to primarily nonshared environmental influences. The second set of papers using Time 1 and 2 NEAD data examined genetic and environmental influences on the comorbidity between adolescent antisocial behavior and depressive symptoms cross-sectionally (O'Connor et al., 1998) and longitudinally (O'Connor et al., 1998). Genetic influences made the largest contribution to the comorbidity between antisocial behavior and depressive symptoms at both times and accounted for the majority of the stability in each dimension. Finally, genetic and environmental influences on depressive symptoms were examined using NEAD Time 1 data with a focus on understanding differences

between those reaching clinical cut-off and the rest of the population. This study found that although there were moderate genetic influences for the full sample for depressive symptoms, only shared and nonshared environmental influences were significant for those meeting clinical cut-off (Rende et al., 1993). These three sets of findings, taken together, helped to emphasize the importance of genetic influences in normative development, and in understanding the development of psychopathology within a normal sample.

Genetic and Environmental Influences on Peer Group Characteristics

Our findings of substantial genetic influences on family relationships and on adolescent adjustment led us to examine genetic and environmental influences on adolescent peer group characteristics. At Time 1 both parents reported on the peer group characteristics of college orientation, delinquent behavior, substance use and popularity for each of their children. When this measure was examined for genetic and environmental influences, it was found to be highly heritable, with little evidence of shared environmental influences for any of the subscales (Manke et al., 1995). At Time 2, adolescents also reported on their peer group characteristics, and although genetic influences were still indicated for college orientation and peer popularity, the majority of the variance could be explained by non-shared environmental influences (Iervolino et al., 2002).

Current and Future Projects

A number of papers are currently in preparation or under review examining genetic and environmental influences on the functioning of the young adult twin and sibling pairs. All of these analyses take a longitudinal approach and are taking full advantage of the longitudinal design of NEAD. As noted in the procedures, DNA has been collected from most of those who participated in the Time 3 assessment. We are in the midst of examining those data for association and interaction using a candidate gene approach. Given the modest sample size of the NEAD Time 3 assessment, we are being very cautious in interpreting these analyses and will attempt to replicate findings with another sample before submitting the findings for publication.

A new research project is recoding all of the videotaped sibling interactions from NEAD at Time 1 and Time 2 using a sibling deviancy coding scheme. This study will attempt to establish (a) whether siblings teach and reinforce one another's deviant behaviors; (b) whether older siblings are more inclined to 'train' their younger siblings in deviant behavior; (c) whether sibling deviancy training has an impact on one or both siblings' deviant behavior during adolescence through to young adulthood; and (d) how such sibling interactions and associations with deviant behavior are influenced by genetic and environmental influences. This research project, a collaboration between Cheryl Slomkowski, Richard Rende and Jenae Neiderhiser,

represents a continuation of work begun during the earliest years of NEAD.

Although the last data collection effort was completed in 2003, the NEAD project has continued to be an important resource for researchers interested in answering a wide range of research questions. The data set is currently being maintained at the George Washington University where it continues to be used by students and researchers from a number of locations worldwide. We encourage students and other researchers to analyze the data available through a formal proposal process. This involves submitting a brief summary of the research question for approval and involves sponsorship by one of the study investigators. A detailed list of completed and ongoing projects is available from the first author, upon request.

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