Research Article

ETHNIC AND RACIAL SIMILARITY IN DEVELOPMENTAL PROCESS: A Study of Academic Achievement

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Abstract—*Correlation matrices were computed on academic achievement and family environment measures using longitudinal data on siblings. The 8 × 8 correlation matrices were computed on Hispanics, blacks, and whites separately. When compared employing a LISREL method, the matrices were equal across these ethnic-racial groups. Hence, developmental processes influencing academic achievement may be similar in Hispanics, blacks, and whites. A structural equation model with four free parameters was fitted successfully to a correlation matrix pooled across groups. As a single structural equation model fitted all groups, the existence of minority-specific developmental processes was not supported.*

In most public-school classrooms, children with very different levels of academic competence can be observed. One child might be a below-average reader, lagging behind her classmates, whereas another girl might be a good reader, a grade level or more ahead in reading. Most social scientists would consider family environmental, genetic, or some combination of the two explanations if asked why one student is more advanced than the other. For example, in one family, the level of intellectual stimulation and encouragement may be poor. Or, in one family, parental IQs may be substantially lower than in the other (with the potential for genes related to low IQ being transmitted to a child). Now imagine that one child is racially black, whereas the other is white. In this case, a common response is to suggest additional influences on the achievement of the minority child, factors that are not postulated to account for that of the majority child (Helms, 1992; Ogbu, 1991; Tarp, 1989; Spencer, 1990).

A variety of culturally specific influences on achievement have been proposed. Helms (1992) believes that cultural values in black communities can reduce performance on (or interest in) "Eurocentric" IQ tests, an argument easily extended to standardized tests of academic achievement. Although Ogbu's (1991) theory is too multifaceted for adequate treatment here, it assumes that involuntary minorities are particularly harmed by social discrimination against them. As a result, they develop attitudes and habits that reduce their motivation to succeed on academic tasks (e.g., the attitude that doing well in school is "acting white" and should be avoided). Other theories emphasize different child-rearing practices (see "Special Issue," 1990; Spencer, 1990). In each case, a psychological developmental process that is minority-specific (i.e., influences the academic achievement of only minority group members) has been proposed. At issue is whether such minority-specific processes exert effects on academic achievement that are detectable in the correlational structure of achievement.

The detection of minority-specific developmental processes requires, of course, that they produce variation within minority groups. If a developmental process affected everyone in a minority group equally, then it would be undetectable by statistics of variance and correlation within that group. Most postulated minority-specific developmental processes, however, would be expected to create individual differences in achievement; that is, minority children and their families differ from one another in their degree of exposure to social discrimination, in their adherence to minority cultural values, and in their use of socialization practices related to culture-specific values.

On the basis of previous research (Rowe, 1994b; Rowe, Vazsonyi, & Flannery, 1994), we hypothesized that one causal model of academic achievement would apply across ethnic and racial groups. In a recent study (Rowe et al., 1994), we compared cross-sectional correlation matrices (about 10 × 10) for blacks, Hispanics, and whites (and, in one case, Asians). These matrices contained both independent variables (e.g., home environment, peer characteristics) and developmental outcomes (e.g., achievement, delinquency). When the matrices were compared by a LISREL goodness-of-fit test, each ethnic group's covariance matrix was equal to the matrices of the other groups. In the present study, we extended this cross-sectional line of research by examining longitudinal data on academic achievement. The existence of minority-specific developmental processes affecting achievement should produce different covariance structures among ethnic and racial groups.

Note that a conceptual distinction must be made here between group means and correlations (see McCall, Appelbaum, & Hogarty, 1973). The mean is a group's statistical average on either an independent variable (e.g., home environment) or a developmental outcome (e.g., children's reading). It is sometimes thought that if ethnic group *a* has a higher mean level on an outcome than ethnic group *b*, then some different developmental process is necessarily implied; but, of course, this is not so. When a common causal model is shared by all groups, mean differences in outcomes (e.g., achievement) may arise from mean differences in developmental antecedents (Rowe et al., 1994).

MEASURED AND UNMEASURED INFLUENCES

This study examined two kinds of developmental antecedents. One was a direct measure of the home environment, the Home Observation for Measurement of the Environment (HOME) scale developed by Caldwell and Bradley (1984). As we show later, this measure explained about 2% to 12% of the

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variation in academic achievement in this study. The other was an indirect measure based on sibling correlations for achievement. The sibling correlation can reflect genetic variation among families, family environmental variation, or both. In the case of a heritable trait (but without family environmental influence), doubling the sibling correlation would estimate heritability because siblings share, on average, half their genes. In the case of a family environmental trait (but without a heritable component), the sibling correlation itself measures the shared environmental component of trait variation; the correlation is not squared to estimate variance explained, as is usually done in statistics, because the issue is not how well one sibling's score can be predicted from another's, but instead, how much the family background contributes to both siblings' scores.

THE MATRIX

The matrix examined in this study is an 8 × 8 correlation matrix that was based on a sample of siblings assessed twice, once in 1986 and again in 1988. The variables were Sibling A achievement in 1986, Sibling A achievement in 1988, Sibling B achievement in 1986, Sibling B achievement in 1988, Sibling A HOME score in 1986, Sibling B HOME score in 1986, Sibling A HOME score in 1988, and Sibling B HOME score in 1988. Hence, this matrix offered several types of statistical relationships potentially sensitive to changes in developmental process across groups, including correlations between the home environment and achievement, 1986 and 1988 sibling correlations, and the within-person stability of achievement.

Our analytic strategy had two parts. First, correlation matrices were computed on whites, blacks, and Hispanics separately. The equality of these matrices was then tested using an omnibus LISREL chi-square test of the equality of correlation matrices. Second, a structural equation model was proposed to account for the pattern of statistical relationships among achievement and home environment measures.

METHOD

Sample

The National Longitudinal Survey of Youth (NLSY) enrolled a nationally representative sample of youths 14 to 21 years old in 1979. Their children constitute the sample used in the present study. The children were participants in NLSY surveys in 1986 and 1988 (Center for Human Resource Research, 1991). They are not as nationally representative as their parents (the original study participants) because the children of young mothers were overrepresented in the NLSY children sample. Nevertheless, the sample represents the full range of socioeconomic levels in the United States and also contains a large representation of families of lower social class. The NLSY also oversampled blacks and Hispanics so that accurate data could be obtained for these minority groups.

The average level of maternal education in this sample was just under 12 years of education. In 1986, the children's mean age was 6.6 years; in 1988, 9.0 years (missing data meant that not every child was tested twice on every variable).

The NLSY children's survey did not originally identify sibling pairs. They were constructed using a computer algorithm for matching family members. Half siblings were separated from full siblings on the basis of whether the father of one child lived in the home and the other did not. Twins were identified on the basis of identical birthdays (see Rodgers, Rowe, & Li, 1994, for more details). This study reports only on pairs that were biologically full siblings (genetic relatedness = .5; 14 opposite-sex twin pairs were included as full siblings). Each pair was placed in a racial group according to their mother's report of the children's racial classification. The average number of sibling pairs available across variables was as follows: blacks, N = 149 pairs; whites, N = 296 pairs; and Hispanics, N = 120 pairs. The Hispanic category failed to discriminate among Hispanics of widely different cultural or ethnic backgrounds (e.g., Mexican vs. Cuban heritage).

Measures

The HOME scores in the NLSY data set were obtained using the HOME-SF (short form), a modification of the overall HOME inventory (Caldwell & Bradley, 1984). This instrument combines the mother's responses about her child and the interviewer's responses into an overall measure of the stimulatory quality of the child's home environment. The items cover issues such as the number of books read by a child, whether a musical instrument is in the home, whether a child has been taken to a museum, and the frequency of reading to a child. Other items deal with punitiveness (i.e., spanking), responsibility (child makes own bed), and involvement (mother introduced child by name to the interviewer). Because certain items are child-specific, siblings received separate scores. Different forms of the HOME were administered according to the age of the child: birth to 2 years, 3 to 5 years, 6 to 9 years, and 10 years or older. For this reason, the NLSY standardized the HOME scores by age-band (Baker & Mott, 1989).

Achievement was assessed using three subtests from the Peabody Individual Achievement Test (PIAT): Mathematics, Reading Comprehension, and Reading Recognition (Dunn & Markwardt, 1970). The Mathematics and Reading Comprehension subtests have a multiple-choice format. The math test involves skills ranging from recognizing numerals to understanding concepts in geometry and trigonometry. For reading comprehension, the child reads a printed sentence silently and then selects which one of four pictures portrays the meaning of the sentence best (66 items). The Reading Recognition subtest employs a combination of multiple-choice items and the identification of letters, words, and names that the child reads aloud to the examiner. Test-retest reliabilities for the subtests range from .64 for Reading Comprehension to .88 for Reading Recognition (Sattler, 1992). The NLSY created scores standardized for age and gender for each subtest. As these scores were highly intercorrelated (rs from .5 to .6), they were averaged for each child to form the single PIAT achievement score used here.

RESULTS

Table 1 shows the correlation matrices computed for Hispanics, blacks, and whites separately (correlation matrices were used, rather than covariance matrices, because both HOME and PIAT scores were already standardized in various

Table 1. *Correlation matrices for Hispanics, blacks, and whites*

	PIAT A_1	PIAT A_2	PIAT B_1	PIAT B_2	HOME A_1	HOME B_1	HOME A_2	HOME B_2
				Hispanics (N = 120 pairs)				
PIAT A_1	1.0							
PIAT A_2	.680	1.0						
PIAT B_1	.270	.290	1.0					
PIAT B_2	.290	.371	.680	1.0				
HOME A_1	.291	.308	.371	.302	1.0			
HOME B_1	.371	.302	.291	.308	.772	1.0		
HOME A_2	.278	.315	.204	.259	.612	.557	1.0	
HOME B_2	.204	.259	.278	.315	.557	.612	.777	1.0
				Blacks (N = 149 pairs)				
PIAT A_1	1.0							
PIAT A_2	.702	1.0						
PIAT B_1	.388	.356	1.0					
PIAT B_2	.356	.440	.702	1.0				
HOME A_1	.142	.176	.175	.197	1.0			
HOME B_1	.175	.197	.142	.176	.763	1.0		
HOME A_2	.148	.207	.145	.237	.517	.513	1.0	
HOME B_2	.145	.237	.148	.207	.513	.517	.700	1.0
				Whites (N = 296 pairs)				
PIAT A_1	1.0							
PIAT A_2	.722	1.0						
PIAT B_1	.436	.382	1.0					
PIAT B_2	.382	.417	.722	1.0				
HOME A_1	.239	.241	.176	.191	1.0			
HOME B_1	.176	.191	.239	.241	.753	1.0		
HOME A_2	.237	.328	.239	.288	.558	.528	1.0	
HOME B_2	.239	.288	.237	.328	.528	.558	.789	1.0

Note. Because of missing data, *N*s are mean sample sizes. The PIAT is the Peabody Individual Achievement Test, and the HOME is the Home Observation for Measurement of the Environment. The letter A or B designates the sibling in a family. The number subscript designates the year of observation: 1 = 1986, 2 = 1988.

ways). Each matrix was computed using a double-entry format in which the number of observations was twice the number of sibling pairs (i.e., the number of individuals). The first $N/2$ cases of a variable consist of Sibling A; the second $N/2$ cases consist of Sibling B. Entered in this way, a sibling correlation closely approximates an analysis of variance intraclass correlation (double entry is routine in behavioral genetic studies). In this format, a stability correlation (i.e., 1986 PIAT with 1988 PIAT) is a stability correlation within all individuals sampled. However, for model-fitting purposes, the sample size was adjusted back to the average number of sibling pairs. The *N*s shown in Table 1 are therefore the average number of sibling pairs across variables for each matrix.

Moderate sibling correlations on the PIAT occurred in all three groups (from .270 in Hispanics in 1986 to .440 in blacks in 1988). Except for the Hispanics, 1986 and 1988 sibling correlations were fairly similar. Sibling PIAT correlations over 2 years were typically close in magnitude to the concurrent sibling PIAT correlations in 1986 or 1988. PIAT achievement was highly stable between 1986 and 1988 (from r = .680 in Hispanics to r = .722 in whites). Although not as stable over 2 years as PIAT achievement, the HOME scores were nonetheless moderately stable (*r*s in the .50-to-.60 range). Sibling correlations on the HOME within year were also greater than these stabilities (*r*s in the .70-to-.80 range). HOME scores were associated with academic achievement (*r*s in the .15-to-.35 range, depending on year and group).

The equality of these ethnic group matrices was tested using LISREL VII. The matrix *lambda-x* was set to an identity matrix; *theta-delta* was set to a zero matrix; and *phi* was permitted to be free but restricted to be equal across groups. The overall goodness-of-fit chi-square was statistically nonsignificant (χ^2 = 54.6 df = 72, p = .94).[1] The goodness-of-fit indices were .95 in

1. The same analysis also can be done using the LISREL model of Green (1992) for testing the equality of correlation matrices. In this model, the diagonal variances would be set equal to 1.0 in all estimated correlation matrices. Using Green's LISREL specifications, we obtained a statistically nonsignificant $\chi^2(56)$ = 49.2 (p = .73).

Our analysis also was repeated on the covariance matrices. The goodness-of-fit (GFI) was satisfactory (mean *GFI* = .96). The chi-square was significant (χ^2 = 93.6) when evaluated for the degrees of freedom (df = 72, p = .044). However, we put greater emphasis on the GFI than on the sample-size-sensitive chi-square test for this kind of

Table 2. *LISREL-estimated correlation matrix*

	PIAT A_1	PIAT A_2	PIAT B_1	PIAT B_2	HOME A_1	HOME B_1	HOME A_2	HOME B_2
PIAT A_1	1.0							
PIAT A_2	.708	1.0						
PIAT B_1	.388	.356	1.0					
PIAT B_2	.356	.413	.708	1.0				
HOME A_1	.224	.238	.217	.216	1.0			
HOME B_1	.217	.216	.224	.238	.760	1.0		
HOME A_2	.222	.293	.207	.268	.559	.530	1.0	
HOME B_2	.207	.268	.222	.293	.530	.559	.763	1.0

Note: N = 188 pairs. The PIAT is the Peabody Individual Achievement Test, and the HOME is the Home Observation for Measurement of the Environment. The letter A or B designates the sibling in a family. The number subscript designates the year of observation: 1 = 1986, 2 = 1988.

Hispanics, .98 in whites, and .99 in blacks. The root-mean-square residual, averaged over the three groups, was .04. Given the excellent fit of each ethnic-racial group matrix to a common correlation matrix, we were satisfied that the correlation matrices were equal across groups.

Table 2 shows the pooled matrix generated by LISREL (i.e., the weighted average of the Hispanic, black, and white matrices). Because the matrices were equal statistically, this LISREL-estimated matrix was used to represent the developmental pattern of PIAT development and home environment in all three groups.

A SPECIFIC MODEL OF ACADEMIC ACHIEVEMENT

Considerable knowledge about the etiology of academic achievement has accumulated. These findings indicate that any etiologic model of achievement must allow for some degree of genetic influence. As in the case of intelligence (IQ), variation in academic achievement is heritable (Scarr & Weinberg, 1983; Thompson, Detterman, & Plomin, 1991). In previous research on the NLSY PIAT tests (Rodgers, Rowe, & May, 1994), the full set of available kinships (twins, full siblings, half siblings, and cousins) was used to estimate the genetic and environmental components of variance in achievement. The heritabilities were moderate and statistically significant for PIAT Mathematics (h^2 = .48), PIAT Reading Comprehension (h^2 = .50), and PIAT Reading Recognition (h^2 = .53). In contrast, estimates of shared environmental variation in the PIAT tests were relatively small (c^2 = .17, .14, and .16, respectively).[2] Because of sample-size limitations, separate heritabilities were estimated by neither ethnic nor racial groups. These findings, however, demonstrate that genetic variation should be considered when using structural equations to model PIAT achievement.

Genetic variation can present complexities for the analysis of family environmental measures. Environmental measures usually reflect aspects of parental behavior, such as deciding to put books in a home or encouraging children to complete their homework. But viewed as behaviors of a parent, the "environment" can contain genetic variation attributable to heritable parental traits. For instance, if higher IQ parents also purchase a greater number of books, then genetic covariation can occur between the "book count" measure of environment and parental IQ. Previous research has demonstrated that genetic variation contributes to variation in measures of family environment (Plomin & Bergeman, 1991; Rowe, 1994a), including the home environment as measured by HOME scores (Braungart, Fulker, & Plomin, 1992).

Genetic variation also may mediate correlations between family environment and children's achievement. This possibility can occur because child and parent share genes: Copies of parental genes affecting an "environmental measure" may also affect children's achievement. Only in an appropriate quasi-experimental research design will an association between environment and children's achievement be revealed as spurious if shared genes have induced it. For instance, in a comparison of adoptive and nonadoptive siblings, Braungart, Fulker, and Plomin (1992) found that the home environment-infant IQ association was mediated partly by genetic factors.

The need to permit genetic influences suggested to us the structural equation model of achievement in Figure 1. Briefly, this model can be described in terms of latent variables and their relationships. Home environment was represented in two latent variables: the first measured by the siblings' 1986 HOME scores; the second, by their 1988 HOME scores. Hence, the sibling correlation on the HOME was represented in the measurement model (sibling r = b^2). In contrast, 1986 and 1988 PIAT scores measured one PIAT latent trait for each child. That is, Sibling A's PIAT scores in 1986 and 1988 measured that child's trait, and similarly for Sibling B. In this case, the mea-

comparison. In related analyses (Rowe, Vazsonyi, & Flannery, 1994), we found that LISREL chi-square values computed from random samples within single ethnic groups were as great as those computed across different ethnic groups. Thus, a statistical rejection of equality using the sample-size-sensitive chi-square test is insufficient evidence to show ethnic group differences.

2. This study also showed that the HOME measure could explain nonshared environmental variation in PIAT achievement. However, the variance in achievement explained was 1% or less.

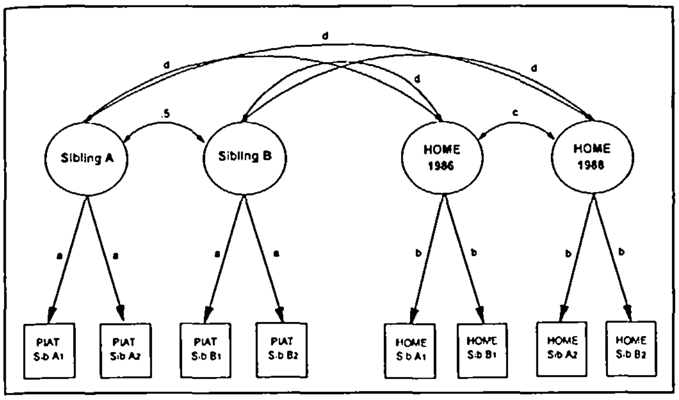

Fig. 1. A structural equation model of PIAT achievement and HOME score correlations (a = loading on achievement, b = loading on home environment, c = 1986–1988 correlation of family environments, and d = correlation of achievement and environment. The PIAT is the Peabody Individual Achievement Test, and the HOME is the Home Observation for Measurement of the Environment. The letter A or B designates the sibling in a family. The number subscript designates the year of observation: 1 = 1986, 2 = 1988.

surement model represented trait stability (stability $r = a^2$). Note that the measurement models of the PIAT trait and family environment were therefore quite dissimilar.

The model-estimated parameters were as follows: PIAT loading on achievement trait, a; HOME scores loading on home environment, b; the stability of home environment over 2 years, c; and the association of home environment and achievement traits, d. The model fixed a correlation of siblings' achievement traits at .50, as specified by genetic theory.

In fitting this model, the described equality constraints were imposed in the matrix *lambda-x*. *Phi* was set as symmetric and free with 1s in its diagonal and .50 in its first off-diagonal element. The error matrix (*theta-delta*) was diagonal and free. Despite only four free parameters for 28 correlation coefficients, the model's fit was outstanding. It yielded a chi-square of 13.1 with 24 degrees of freedom (p = .96, N = 188 pairs). The goodness-of-fit index was .98. The root-mean-square residual was .02. Although, of course, alternative models could be proposed for this matrix, the model chosen here is consistent with behavioral genetic findings, and it also provides an excellent fit with few free parameters. The model, however, does not disclaim family environmental influences from the HOME to the PIAT, if a part of the correlation d is interpreted as an environmental effect.

The parameter estimates appear in Table 3. The estimated PIAT sibling correlation was .35 ($.837^2 \times .50$). The estimated home environmental correlation was .54 between 1986 and 1988 ($.871^2 \times .714$). Over the same interval, the latent home environments correlated strongly (.714). The noncausal association of family environment and the achievement trait was .314. Notice that the correlation of home environment and PIAT achievement was the same for all sibling and date-of-measurement combinations. For instance, Sibling A's HOME score in 1988 was allowed to return to Sibling A's PIAT score in 1986. In a strictly causal model, such an association would have

Table 3. *LISREL parameter estimates for model of genetic and environmental effects*

Label	Parameter	Maximum-likelihood estimate
Loading on achievement	a	.837
Loading on home environment	b	.871
Correlation of home environments, 1986–1988	c	.714
Correlation of achievement and environment	d	.314
Correlation of Sibling A's and Sibling B's achievement	Fixed	.500

an improper temporal order, but it can be permitted here because the HOME–PIAT associations were indicated as noncausal.

DISCUSSION

This study investigated the similarity of developmental processes in Hispanics, blacks, and whites using correlation matrices. The matrices contained PIAT scores at two time points and a measure of environmental quality specific to each child. All measures were completed by siblings; hence, the correlational structure included all family effects through sibling psychological resemblance and all effects through the HOME measure of family environment. These correlation matrices were statistically equal across Hispanics, blacks, and whites.

From this equality of correlation matrices, we concluded that developmental processes that determine variation in PIAT scores were similar across ethnic and racial groups. Statistical power, of course, limits the ability of this study to detect ethnic and racial group differences. Each ethnic or racial group, however, had more than 100 sibling pairs. Small developmental effects may have gone undetected, but certainly larger ones would have appeared as differences in the correlational structures.

As a second step, we proposed a specific structural equation model to explain variation in achievement. It postulated an achievement latent trait specific to each child and treated any association between achievement and family environment as noncausal. Other research on the NLSY (Rodgers et al., 1994) found that heritable effects on PIAT subtests were moderate, whereas shared environmental effects were relatively weak. Thus, our model emphasizing genetic effects but minimal family environment effects on PIAT achievement variation is consistent with these direct behavior genetic analyses of the PIAT subtests in the NLSY. Nonetheless, the family environment (i.e., the HOME score) may also contain some environmental effects on achievement, but ones weaker than the family environment–achievement correlation parameter *d* (.314), which may contain genetic as well as environmental components.

This study's findings bear upon earlier studies of the construct validity of IQ across ethnic and racial groups. This previous research consisted essentially of showing the equality of 2 × 2 covariance matrices. In each such matrix, one variable was IQ and another was a theoretically related developmental outcome (e.g., course grades, job performance ratings). In general, such 2 × 2 matrices were statistically equal for blacks and whites (the groups most frequently studied; Barrett & Depinet, 1991; Cole, 1981; Jensen, 1980). By these statistical criteria, IQ was determined to be an equivalent psychological construct in different ethnic and racial groups.

In this study, however, the argument goes considerably further by proposing that the determinants of achievement are identical across ethnic and racial groups. Our explanation for the similarity of developmental processes is that (a) different ethnic and racial groups possess a common gene pool, which can create behavioral similarities, and that (b) among second-generation ethnic and racial groups in the United States, cultural differences are smaller than commonly believed because of the omnipresent force of our mass-market culture, from television to fast-food restaurants (see Rowe et al., 1994).

Certainly, a burden of proof must shift to those scholars arguing a cultural difference position. They need to explain how matrices representing developmental processes can be so similar across ethnic and racial groups if major developmental processes exert a minority-specific influence on school achievement. Further research on this topic should consider replacing the more distal categories of ethnicity and race with more proximal cultural variables to measure and identify local cultures. Although local cultures (e.g., a ghetto or barrio culture) may moderate developmental processes, this claim, like the claim about ethnicity and race, remains one that has been widely accepted in the social sciences without strong empirical evidence.

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