Developmental Psychology
1983, Vol. 19, No. 5, 731-739

Maternal IQ and Home Environment as Determinants of Early Childhood Intellectual Competence: A Developmental Analysis

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This study sought to demonstrate the need for a developmental viewpoint in investigations of the contributions of maternal IQ and home environment to intelligence. Children at risk for sociocultural mental retardation were studied longitudinally from birth to 4 years of age. Maternal IQs were assessed before the children's births, and children's IQs and home environments were assessed at regular intervals during the first 4 years of life. Multiple regression analyses were then conducted to separate the contributions of maternal IQ and home environment to child IQ at 24, 36, and 48 months. When the effect of maternal IQ was controlled, home environment's association with child IQ was not significant at 24 and 36 months but was significant at 48 months. When the effect of home environment was controlled, maternal IQ's association with child IQ was significant at 24 months but not at 36 and 48 months. Taken together, the two predictors explained 11%, 17%, and 29% of the variance in child IQ at the three respective times. The overall pattern suggested a monotonic increase in the predictability of child IQ within the context of a shift in the relative importance of maternal IQ and home environment as predictors. This pattern is discussed in light of McCall's (1981) recent model, which proposes that an important shift takes place in the process of intellectual development at about 2 years. We conclude by suggesting that the integration of the study of behavioral genetics with the study of the process of intellectual development requires an ontogenetic perspective.

The relative importance of genetic and environmental contributions to individual differences in intelligence has been debated for more than a century. Despite pleas for the study of *how* genetic and environmental forces determine development (Anastasi, 1958; Lehrman, 1970), psychologists persist in asking *how much* these forces contribute to intelligence. A recent example of this approach was presented by Longstreth and his colleagues (Longstreth et al. 1981). Building on earlier research by Campbell (Note 1)[1], they selected a group of families and assessed maternal IQ, intellectual environment of the home, and child IQ. The contributions of maternal IQ and home environment to child IQ were then estimated using hierarchical regressions. Maternal IQ was a significant predictor of child IQ when the effects of home environment were removed, but home environment was *not* a significant predictor of child IQ when the ef-

The research was supported by Grants HD09130 and HD07178 from the National Institute of Child Health and Human Development. We would like to thank Marie Butts and Pam Mann for their help in preparing the article.

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[1] Longstreth et al. (1981) described their study as a replication of Campbell's (Note 1) research, which found that total scores on the Home Observation for Measurement of the Environment (HOME) inventory (Caldwell, Heider, & Kaplan, Note 2) measured at 6 months of age did not predict children's 48-month Stanford-Binet IQs when maternal IQ was controlled. We should note, though, that Campbell was solely concerned with the *prediction* of child IQ, using information available in infancy. One cannot conclude from her findings that the home environment has little effect on children's intelligence, because her data, unlike that in the present study, did not include contemporaneous measures of the quality of children's homes. Longstreth et al. (1981) also suggested that Campbell's (Note 1) study reported results of the early intervention program from which the sample for the present study was drawn (see Method section). Campbell's sample, however, was only partly composed of families in the intervention program; it also contained a number of families from the general population, some of whom were drawn from a considerably higher socioeconomic class than those in the program.

fects of maternal IQ were removed. Based on arguments that the association found between maternal IQ and child IQ, with home environment controlled, reflects parental genes, Longstreth et al. (1981) concluded that genetic variance was relatively important and environmental variance relatively unimportant in the determination of children's intelligence.

Such a conclusion, however, may be premature. Research designs such as Longstreth et al.'s (1981) typically cannot separate the genetic and environmental components of familial resemblance. Although Longstreth et al. (1981) attempted to overcome this difficulty by providing separate indices of genetic and environmental variation, those indices lacked precision. Maternal IQ is a phenotypic characteristic that is the product of both genetic and environmental factors, and any measure of home environments is necessarily selective and unable to assess all possible environmental influences on intellectual development. That these measures are not as precise as desired is illustrated by the finding that taken together they accounted for only slightly more than 25% of the variance in child IQ—that is, much less than genetic and environmental influences typically do (see Plomin, DeFries, & McClearn, 1980). At the very least, then, the indices failed to account for the *absolute* contributions of genetic and environmental variation to individual differences in intelligence. Of course, the indices were not totally inaccurate. Maternal IQ is undoubtedly related to maternal genetic variation, and a valid measure of home environments is likely to capture some of the variance in intelligence accounted for by environmental variation. Thus, Longstreth et al. (1981) may simply have intended the indices to reflect the *relative* contributions of genetic and environmental variation to mental development.

Nevertheless, their research design remains conceptually troublesome. Longstreth et al.'s (1981) approach to the nature–nurture issue and intelligence treated developmental change as a nuisance variable. Thus Longstreth et al. entered age in their regression equations only to control for its effects on child IQ, *not* to study developmental changes in the contributions of maternal IQ and home environment. Such an approach reflects a *static* view of intellectual development, which assumes that the contributions of genes and environments to individual differences in intelligence are consistent across ages. Yet a substantial body of evidence suggests that those contributions change during the course of ontogenesis (Carew, 1980; Elardo, Bradley, & Caldwell, 1975; McCall, 1979; Wilson, 1977, 1978). Thus, an approach that reflects a *dynamic* view of intellectual development requires asking not only about the relative contributions of genes and environments but also about how those contributions may change ontogenetically. Such an approach, which may be required if we are to generate hypotheses about shifts in the process of intellectual development (McCall, 1977), would be best reflected through longitudinal analyses. By adopting a nonlongitudinal design and failing to consider developmental change even within that design (cf. Ho, Foch, & Plomin, 1980), Longstreth et al.'s (1981) approach must therefore be regarded as essentially nondevelopmental.

The present study, then, which relied on data collected as part of an ongoing early intervention program (see Ramey, MacPhee, & Yeates, 1982), attempted to supplement Longstreth et al.'s (1981) research. Although our goal was also to investigate the separate contributions of maternal IQ and home environment to child IQ, we differed in perspective—adopting a dynamic rather than static view of development. Thus we focused our attention on a group of children at risk for sociocultural mental retardation who had been studied longitudinally from birth to 4 years of age. Maternal IQs were assessed before the children's births, and the children's IQs and home environments were assessed at regular intervals of a year or less during the first 4 years of life. By investigating the importance of maternal IQ and home environment as determinants of child IQ at selected points during development (i.e., 2, 3, and 4 years), we sought to demonstrate the need for an ontogenetic perspective in studying the nature–nurture issue with respect to intelligence.

Method

Subjects

The families participating in this study were drawn from the control group of an experimental early intervention program meant to prevent the occurrence of sociocultural mental retardation (see Ramey, MacPhee,

& Yeates, 1982). Families were referred to the program through local hospitals and clinics, the county Department of Social Services, and other community agencies. Once referred, preliminary interviews were conducted to determine whether the families appeared to meet selection criteria. If so, mothers were invited to participate in further assessments. During these assessments, which typically occurred during the last trimester of pregnancy, mothers provided demographic information about themselves and their families. In addition, their intelligence was assessed using the Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1955). Final determination of eligibility followed these procedures. Criteria for selection included maternal IQ, family income, parental education, intactness of family, and seven other factors that were weighted and combined to yield a score on a High-Risk Index (see Ramey & Smith, 1977, for details). Only families at or above a predetermined cutoff score were considered eligible.

Four cohorts of families were admitted between 1972 and 1977. Of 122 families judged to be eligible and invited to join the program, 121 accepted the condition of random assignment to the experimental or control group; of these 121 families, 118 (98%) accepted their actual group assignment. Since assignment, four children have died and two have been diagnosed as retarded due to organic etiology. The base sample, then, consists of 112 families, of which 55 are in the control group. Of these 55, 4 have dropped out of the program, resulting in an attrition rate of less than 8%. The control group was selected for this study because we wanted high-risk families whose children had experienced a relatively natural ecology of development, that is, those families whose children had not experienced early intervention. For the purposes of this study, we also eliminated all families where the child did not live with the mother through the first 4 years of life (n = 4) or where complete data were unavailable during that period (n = 1). Thus the final sample consists of 46 families, with 19 male and 27 female children. All of the children in these families are black; at the time of the children's births, over half (63%) of the families were headed by the mother, and average earned family income was less than $1,500. The mothers had a mean education of about 10 years and a mean IQ of approximately 85.

Procedure

Intellectual assessment. As mentioned previously, mothers were given a WAIS at the time they were interviewed for the program. Children were tested with the Bayley Scales of Infant Development (Bayley, 1969) at 6 and 18 months of age (the Mental Development Index, or MDI, is reported here) and with the Stanford-Binet Intelligence Scale (Terman & Merrill, 1973) at 24, 36, and 48 months of age. The tests were administered by experienced female examiners, whose assignment to children was performed more or less at random, depending on who was available at a given time. The child's primary caregiver was present during all assessments. Because of a possible shift in the contributions of genetic and environmental variance to intellectual development at about 2 years (McCall, 1981), we decided to concentrate our analyses on the 24- to 48-month Stanford-Binet IQs; the Bayley MDIs are presented, however, to illustrate shifts in both the stability and the predictability of early childhood intelligence.

Home environment assessment. The home environments of the families were assessed using the Home Observation for Measurement of the Environment (HOME) inventory (Caldwell, Heider, & Kaplan, Note 2) at 6, 18, 30, and 42 months of age. The HOME inventory consists of 45 items representing six categories of environmental stimulation at 6, 18, and 30 months of age and of 80 items representing seven categories of environmental stimulation at 42 months of age. Scoring of the items requires a combination of direct observation and interviewing, with almost two thirds of the items scored from direct observations of the mother–child dyad. Both category and total scores are obtained; for the purposes of this study, only the total scores are used. All data for this study were collected by three female interviewers, again more or less at random, in the families' own homes when the primary caregiver and child were both present. Interobserver agreement across items in both this sample (see Ramey, Mills, Campbell, & O'Brien, 1975) and other samples (e.g., Elardo, Bradley, & Caldwell, 1975) has consistently exceeded 90%.

Table 1 presents the means, standard deviations, and correlations for the raw total HOME scores, as well as their correlations with children's IQs. The means for this sample, as might be expected, are lower than those typically found in middle-class homes (e.g., Ramey et al., 1975); the stability correlations, though, are comparable to those found in other studies (e.g., Bradley, Caldwell, & Elardo, 1979), with a median 1-year stability of .62. Furthermore, the correlations between HOME scores and children's IQs, although lower than those found in heterogeneous samples (e.g., Elardo, Bradley, & Caldwell, 1975), are similar to those in other lower-class samples (e.g., Bradley, Caldwell, & Elardo, 1979). Thus for our sample, the HOME inventory appears to have provided a stable and valid measure of the home environment.

We wanted, however, to have summary indexes of home environments for each child's IQ assessment. Because of scaling differences in the HOME across the assessment points, the scores at each assessment were first standardized (M = 0, SD = 1). A global HOME total score was then computed for each family at each outcome age, consisting of the sum of all standardized HOME total scores temporally prior to the respective 24-, 36-, and 48-month child IQ assessments. This procedure is justified, we feel, because HOME total scores from year to year are stable (see Table 1) and because the effects of home environments may be cumulative. These standardized and summed scores, then, represent indexes of the total environmental stimulation available in children's homes prior to particular intellectual assessments; hereafter, they are referred to as total home indexes.

Results

The means, standard deviations, and correlations of all variables are presented in Table 2. Several points are worth noting:

1. Children's IQs become increasingly more stable from 6 to 48 months. The cor-

Table 1
Means, Standard Deviations, and Stability/Validity Correlations of Raw Total Scores on the HOME Inventory

Variable (months)	HOME 6	HOME 18	HOME 30	HOME 42	*M*	*SD*
HOME (6)	—				27.33	4.94
HOME (18)	.43*	—			28.52	5.90
HOME (30)	.38*	.62*	—		30.33	5.52
HOME (42)	.23	.56*	.68*	—	54.70	9.65
MDI (6)	.31*	.07	−.02	.10		
MDI (18)	.21	.37*	.28	.11		
SB (24)	.07	.19	.20	.31*		
SB (36)	.10	.27	.39*	.31*		
SB (48)	.23	.32*	.51*	.50*		

Note. HOME = Home Observation for Measurement of the Environment; MDI = Bayley Mental Development Index; SB = Stanford-Binet IQ.
* $p < .05$.

relation between 6- and 18-month MDIs (r = .27) is significantly lower than the correlations between 18-month MDIs and 24-month Binet IQs (r = .55, z = 2.13, $p < .05$), 24- and 36-month Binet IQs (r = .70, z = 2.96, $p < .01$), and 36- and 48-month Binet IQs (r = .79, z = 3.65, $p < .001$). In turn, the correlation between 18-month MDIs and 24-month Binet IQs is significantly lower than that between 36- and 48-month Binet IQs (z = 2.35, $p < .05$). The increasing stability parallels that found elsewhere in the literature (see McCall, 1981).

2. Children's IQs also become increasingly more predictable from 6 to 48 months, by both home environment and maternal IQ. The correlations between 6-month total home indexes and 6-month MDIs (r = .31), 18-month total home indexes and 24-month Binet IQs (r = .15), and 30-month total home indexes and 36-month Binet IQs (r = .31) are all significantly lower than the correlation between 42-month total home indexes and 48-month Binet IQs (r = .51, minimum z = 2.05, $p < .05$). The correlation between maternal IQs and 6-month MDIs (r = .22) is also lower, albeit nonsignificantly, than that between maternal IQs and 48-month Binet IQs (r = .42, z = 1.21, $p < .15$). The increased predictability also parallels that found elsewhere in the literature (see McCall, 1981).

3. The correlation between maternal IQs and total home indexes is consistently moderate (median r = .455).

Table 2
Zero-Order Correlations, Means, and Standard Deviations of Variables

Variable (months)	1	2	3	4	5	6	7	8	9	10	11	CSEX	*M*	*SD*
1. MIQ	—	.34*	.22	.36*	.33*	.39*	.42*	.29	.45*	.48*	.46*	−.22	84.41	11.35
2. MED		—	.09	.03	.14	.09	.08	.20	.38*	.39*	.43*	.01	10.17	1.80
3. MDI (6)			—	.27	.48*	.27	.30*	.31*	.22	.15	.15	.01	101.52	15.46
4. MDI (18)				—	.55*	.56*	.46*	.21	.34*	.35*	.31*	.22	89.93	12.68
5. SB (24)					—	.68*	.64*	.07	.15	.19	.25	.04	84.89	9.07
6. SB (36)						—	.79*	.10	.22	.31*	.34*	.08	83.87	13.70
7. SB (48)							—	.23	.33*	.43*	.50*	.12	88.04	13.94
8. THI (6)								—	.84*	.75*	.65*	−.06	0.00	1.00
9. THI (18)									—	.95*	.88*	−.10	−0.05	1.70
10. THI (30)										—	.96*	−.05	0.04	2.37
11. THI (42)											—	−.03	0.07	3.10

Note. MIQ = maternal WAIS IQ; MED = maternal education; MDI = Bayley Mental Development Index; SB = Stanford-Binet IQ; THI = total home index; CSEX = child's sex.
* $p < .05$.

4. Maternal education correlates moderately with maternal IQs ($r = .34$) and the total home indexes (median $r = .385$) but very poorly with children's IQs (median $r = .09$).

The correlational results, then, reveal the typical relationships among maternal IQ, maternal education, home environment, and child IQ. The only exception is the low correlation between maternal education and child IQ, which, although interesting, may have resulted from a restricted range of maternal education. The results, finally, also suggest increasing contributions to child IQ by both maternal IQ and home environment.

Regression Analyses

Inferring increased contributions from increasing correlations with child IQ, though, fails to take into account the interdependency of maternal IQ and home environment. What is needed is a method of comparing their contributions so that the effects of each variable can be tested while controlling for the effects of the other. Hierarchical regression is an appropriate technique. In hierarchical regression, one tests the significance of the addition to the multiple correlation—that is, the squared semipartial correlation—as each predictor is added to the regression equation. Thus testing for the effect of maternal IQ while controlling for the effect of home environment calls for entering home environment first and maternal IQ second; testing for the effect of home environment while controlling for the effect of maternal IQ, on the other hand, calls for the opposite order of entry.

A summary of the hierarchical regressions of maternal IQ and total home indexes onto children's Stanford-Binet IQs at 24, 36, and 48 months is presented in Table 3. The analysis at 24 months reveals that when maternal IQ is entered first in the regression equation, home environment fails to be a significant predictor, $F(1, 43) = .002$; its zero-order correlation of .15 shrinks to a semipartial correlation of .01. When home environment is entered first, though, maternal IQ remains a significant predictor, $F(1, 43) = 4.07$, $p < .05$; its correlation with child IQ is reduced from .33 to .30. Finally, at 24 months, these two predictors taken together explain 11% of the variance in child IQ, $F(2, 43) = 2.60$, $p > .05$.

Table 3
Child IQ Regressed on Maternal IQ and Total Home Indexes at 24, 26, and 48 Months

Predictor (entered)	r	R	R^2	Semi partial r	B[a]
		24 months			
MIQ (1st)	.33*	.33	.11**	.30*	.33*
THI (2nd)		.33	.11		
THI (1st)	.15	.15	.02	.01	.01
MIQ (2nd)		.33	.11**		
		36 months			
MIQ (1st)	.39*	.39	.15**	.26	.31
THI (2nd)		.41	.17*		
THI (1st)	.31*	.31	.10**	.14	.16
MIQ (2nd)		.41	.17*		
		48 months			
MIQ (1st)	.42*	.42	.17**	.20	.24
THI (2nd)		.54	.29**		
THI (1st)	.50*	.50	.25**	.35*	.39*
MIQ (2nd)		.54	.29*		

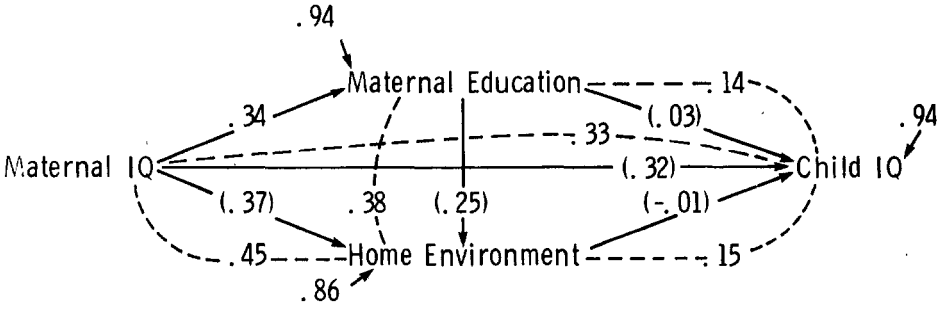
Note. THI = appropriate total home index; MIQ = Maternal IQ.
[a] Standardized regression weight.
* $p < .05$. ** Significant increase from previous value.

At 36 months the pattern undergoes a change. As at 24 months, when maternal IQ is entered first, home environment is not a significant predictor, $F(1, 43) = 1.08$; its correlation with child IQ is reduced from .31 to .14. When home environment is entered first, however, maternal IQ is also not a significant predictor, $F(1, 43) = 3.77$; its correlation with child IQ is reduced from .39 to .26. Although neither variable makes a unique contribution, at 36 months these two predictors combined explain 17% of the variance in child IQ, $F(2, 43) = 4.43$, $p < .05$, a 6% increase from 24 months.

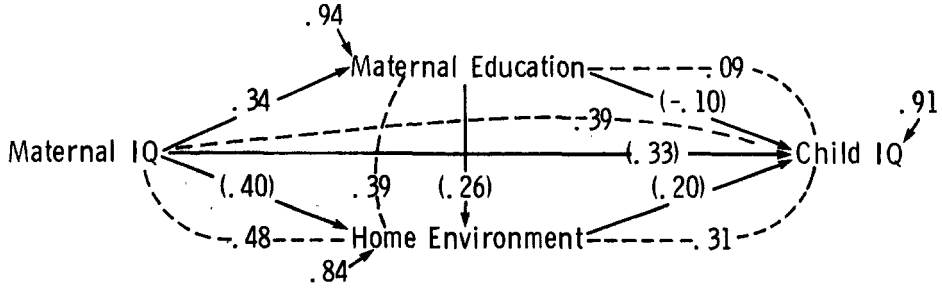
At 48 months the pattern undergoes still another change. Unlike at 24 and 36 months, when maternal IQ is entered first, home environment remains a significant predictor, $F(1, 43) = 7.01$, $p < .05$; its correlation with child IQ is reduced from .50 to .35. As at 36 months, though, when home environment is entered first, maternal IQ is not a significant predictor, $F(1, 43) = 2.71$; its correlation with child IQ is reduced from .42 to 20. Finally,

at 48 months these two predictors explain 29% of the variance in child IQ, $F(2, 43) = 8.83, p < .05$, a 12% increase from 36 months and an 18% increase from 24 months.

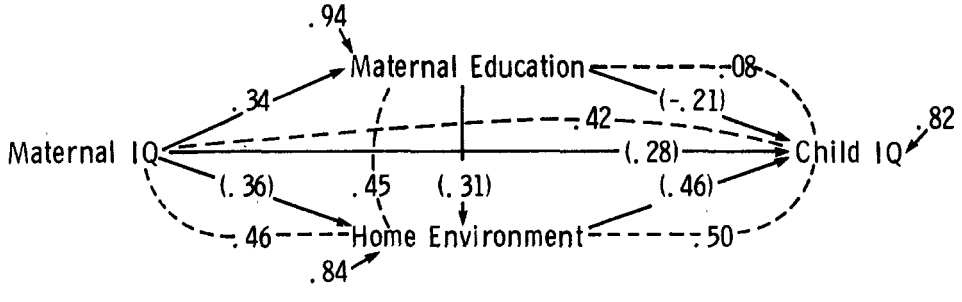
The regression findings, then, point to a monotonic increase in the predictability of child IQ within the context of a shift in the relative importance of maternal IQ and home environment as predictors. At 24 months, 11% of the variance in child IQ is explained, largely as the result of maternal IQ; at 36 months, 17% of the variance in child IQ is explained, although neither maternal IQ nor home environment plays a uniquely significant role; and at 48 months, 29% of the variance in child IQ is explained, largely as the result of home environment. This shift in the relative importance of maternal IQ and home



24 MONTHS



36 MONTHS



48 MONTHS

Figure 1. Path analyses of child IQ at 24, 36, and 48 months.

environment can further be illustrated by comparing the standardized regression weights of these predictors. The weights of maternal IQ are .33, .31, and .24 at 24, 36, and 38 months, respectively (see Table 3); similar weights for home environment are .01, .16, and .39. Thus the ratio of the weight of maternal IQ to the weight of home environment shifts from 33 to 1.93 to .62 over the 2-year span, indicating a substantial change in the roles of maternal IQ and home environment as determinants of child IQ.

Path Analyses

A comparison of standardized regression weights, in path analytic terms, only compares the *direct* effects of variables; it does not allow for the *indirect* effects that a variable may have through other variables, depending on particular causal assumptions. Estimating the total (i.e., direct and indirect) effects of variables using path analysis also requires hierarchical regression. In this case, though, the predictors are entered in order of their temporal priority in the causal hierarchy, and the increment to the multiple correlation is tested as each successive predictor is added. Following Longstreth et al. (1981), we added maternal education to the list of predictors and conducted path analyses at 24, 36, and 48 months, with the order of entry into the regression equations reflecting the assumption that maternal IQ was temporally prior to maternal education, which in turn was assumed temporally prior to home environment.[2]

A graphic portrayal of the path analyses is presented in Figure 1; path coefficients and direction of effects are represented by straight lines, zero-order correlations are represented by broken lines, and unexplained variance is represented as the square root of $1 - R^2$, R^2 being the square of the multiple correlation for all temporally prior predictors. A summary of the total contributions to explained variance of child IQ by each predictor is presented in Table 4. At 24 months, the total 11% of explained variance is accounted for by the direct effect of maternal IQ. At 36 months, a shift takes place; of the 18% explained variance, the direct effect of maternal IQ accounts for 11%, its indirect effects for 4%, and the direct effect of home environment for 3%. Finally, at 48 months, another shift takes place; of the 33% explained variance, the direct effect of maternal IQ accounts for 9%, its indirect effects for 8%, the direct effect of home environment for 15%, and the effects of maternal education for 1%. Thus the path analyses indicate an absolute increase from 24 to 48 months in the contributions of both maternal IQ and home environment to child IQ. They also indicate a relative decrease in the role of maternal IQ and a relative increase in the role of home environment. These mixed results are explained (see Figure 1) by the increasing importance of home environment as an intervening variable, that is, as home environment's direct effect increases, maternal IQ's direct effect on home environment becomes an indirect effect on child IQ.

Table 4
Total Contributions to Explained Variance of Child IQ by Three Predictors at 24, 36, and 48 Months

	Occasion (months)		
Predictor (%)	24	36	48
Maternal IQ	11*	15*	17*
Maternal education	0	0	1
Home environment	0	3	15*
Total	11	18*	33*

Note. Home environment represents the total home index for each occasion.
* $p < .05$.

Discussion

While discussing their findings, Longstreth et al. (1981) suggested that "studies that re-

[2] The causal assumptions adopted here (and by Longstreth et al., 1981) represent a simplified model. Children undoubtedly are shapers of, as well as shaped by, their home environments—probably such that more intelligent children seek out more stimulating environments (see Scarr, 1981). One method of testing for these reciprocal effects is cross-lagged panel analysis (see, e.g., Bradley, Caldwell, & Elardo, 1979). Our own cross-lagged correlations suggest that the effects of home environment on the child are at least as large as the reverse effects. For the purposes of the path analyses, therefore, we have adopted a simplified causal hierarchy.

port only zero-order correlations between home environment and child IQ vastly overestimate the true relationship between these variables. When maternal IQ covariance is removed, the relationship is considerably attenuated" (p. 539). Our findings, however, indicate that whether the relationship is overestimated depends on the particular point during development at which it is assessed; when the effect of maternal IQ is removed, home environment's association with child IQ is not significant at 24 and 36 months but is significant at 48 months. Longstreth et al. (1981) also stated that "maternal IQ . . . continues to share significant variance with child IQ when home environment [is] removed" (p. 539). Our findings, though, indicate that the extent of the relationship between maternal IQ and child IQ also depends on the particular point during development at which it is assessed; when the effect of home environment is removed, maternal IQ's association with child IQ is significant at 24 months but is not significant at 36 and 48 months. The overall pattern of our results, therefore, argues for caution in describing the relative contributions of maternal IQ and home environment to child IQ; more specifically, the pattern confirms the need to study these contributions developmentally, preferably through the use of longitudinal analyses.

Such analyses are particularly useful because of their ability to either support or challenge general models of intellectual development. Recently, for example, McCall (1981) proposed that individual differences in early and later mental development may be differentially responsive to genetic and environmental factors. According to McCall (1981), mental development during the first 2 years of life, although characterized by unstable individual differences, is relatively canalized, that is, it is largely maturational and not highly related to either genetic or environmental variation (see also Scarr-Salapatek, 1976). After about 2 years, though, individual differences begin to stabilize, and mental development becomes increasingly more related to both genetic and environmental factors. Our findings generally support McCall's (1981) arguments. First, the correlations of child IQ during the first 2 years studied are significantly lower than those during the latter 2 years, indicating increasingly stable individual differences. Second, the path analyses show increasing contributions by both maternal IQ and home environment to child IQ, indicating the decreasing salience of purely maturational forces. Thus, the present study helps to corroborate the notion that an important shift occurs toward the end of infancy in the role of both genes and environments as determinants of intelligence.

Of course, McCall's (1981) model, as he noted, cannot predict the specific degree of importance of genetic and environmental factors after the weakening of canalization. Our findings, though, may suggest that the weakened canalization of mental development is marked by an initial and gradual increase in the role of genetic factors and only later by a marked increase in the role of environmental factors. At the same time, however, this pattern may be limited to the specific sample and age range studied here. Our sample is composed of at-risk children and their families; by definition, such children experience environmental circumstances that are far from the norm for most children. Scarr and Weinberg (1978) have suggested that with the exception of such unusual circumstances, most environments are functionally equivalent with respect to intellectual development. The large contribution of home environment to child IQ found in our sample, therefore, may not be paralleled in more advantaged samples. Furthermore, we studied only the years 2 to 4. Across this age range, changes occurred in the contributions of maternal IQ and home environment to child IQ; we do not know, however, whether these contributions continue to change or whether they stabilize. Both of these qualifications, then, point to the need for further developmental studies, particularly in more advantaged families and older age ranges.

Regardless of these future studies, the present findings do indicate an important shift in the relative importance of maternal IQ and home environment as determinants of child IQ. By 48 months, home environment is nearly equal in importance to maternal IQ, and much of the effect of maternal IQ is exercised indirectly through home environment. Why might this shift occur? Unfortu-

nately, our findings cannot supply an explanation; further study of the processes of intellectual development is required. But this last point—that studies of the relative contributions of genetic and environmental variation to intelligence can raise questions about the process of mental development—may be perhaps the most important of this study. Questions concerning *how much* genetic and environmental determinants contribute to intelligence, as mentioned at the outset, have typically failed to add to our knowledge of *how* such determinants affect intellectual development; in fact, "how much" and "how" approaches are often seen as antithetical (see Overton, 1973). We would argue, though, that the failure of traditional investigations of the nature–nurture issue to speak to the process of intellectual development is largely a result of their nondevelopmental nature. The study of behavioral genetics can be linked to the study of developmental processes; such a linkage, though, requires an ontogenetic perspective.

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Received March 8, 1982
Revision received August 5, 1982 ■