Effects of Early Intervention on Intellectual and Academic Achievement: A Follow-up Study of Children from Low-Income Families

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CAMPBELL, FRANCES A., and RAMEY, CRAIG T. *Effects of Early Intervention on Intellectual and Academic Achievement: A Follow-up Study of Children from Low-Income Families.* CHILD DEVELOPMENT, 1994, **65**, 684–698. Follow-up data, obtained 4–7 years after intervention ended, are presented for the Carolina Abecedarian Project, an experimental study of early childhood educational intervention for children from poverty families. Subjects were randomly assigned to 1 of 4 intervention conditions: educational treatment from infancy through 3 years in public school (up to age 8); preschool treatment only (infancy to age 5); primary school treatment only (age 5–8 years), or an untreated control group. Positive effects of preschool treatment on intellectual development and academic achievement were maintained through age 12. School-age treatment alone was less effective. Results generally supported an intensity hypothesis in that scores on cognitive and academic achievement measures increased as duration of treatment increased.

A relation between poverty, suboptimal cognitive development, and academic failure is well established (e.g., Birch, Richardson, Baird, Horobin, & Illsley, 1970; Jencks, 1972; Patterson, Kupersmidt, & Vaden, 1990; Ramey & Finkelstein, 1981; White, 1982), although the mechanisms and processes involved remain poorly understood. Because no known genetic or physiological cause has yet been identified to explain most cases of mild retardation, the psychosocial environment has been implicated in its etiology. Investigators have attempted to explain the relation between poverty and suboptimal development by identifying differences in the early physical and sociolinguistic environments provided by low-income and middle-income families (Bradley & Caldwell, 1984; Heath, 1983; Hess & Shipman, 1967; Wachs, 1976). At the same time, interventionists have developed many early childhood programs for economically disadvantaged children, either targeting the low-income family or providing children with early educational programs in preschool settings. Whether mediated through the parent or more directly child-centered, the logic underlying early intervention is the same. The child's cognitive development should be enhanced through strengthening the intellectual stimulus value and developmental appropriateness of the early environment. Coming from this "improved" environment, the child should enter school with a greater degree of school readiness and an enhanced likelihood of success. Early school success should increase the likelihood of later success, leading in turn to an eventual command of higher-paying jobs and other social and cultural rewards.

Early educational programs for impov-

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erished children have now been a focus of social policy and research for almost 3 decades (Cicirelli, 1969; Kennedy, 1977, 1978; McKey et al., 1985). The most widely known evidence concerning the efficacy of early intervention comes from the Consortium for Longitudinal Studies formed by the leaders of 11 programs collectively serving economically disadvantaged children between 1962 and 1973. When their long-term intellectual and educational gains were assessed in the 1980s, treated children had significantly fewer placements into special education and fewer grade retentions (Lazar, Darlington, Murray, Royce, & Snipper, 1982), and a subset of the programs found a 12.3% increase in high school graduation for participants (Royce, Darlington, & Murray, 1983). When considering "developed abilities," however, the Consortium found that IQ gains of treated children largely disappeared after 3 years in public school, and significant treatment/control differences in academic accomplishment did not endure past 5–6 years (Lazar et al., 1982). One consortium member, the Perry Preschool Project, found that, despite an early narrowing of treatment/control differences, treated children regained an academic advantage over untreated controls in junior high school (Schweinhart & Weikart, 1980). Thus, while there is consensus that early educational intervention for poor children is beneficial in terms of school progress, more needs to be known about its long-term benefits with respect to "developed abilities" and, in particular, the maintenance of its effects.

One question not yet answered concerns the extent to which educational treatment in very early childhood may be critical. Several lines of research suggest that intellectual development might be most malleable in the very young (Bloom, 1964; Hebb, 1947; Hunt, 1961; Kessen, 1979). Although all of the programs in the Consortium on Longitudinal Studies targeted young children, with one exception the intervention programs were offered to children aged 2 or older. For five of the programs, the target children were aged 4 years or older. The present study gives results of a follow-up for participants in the Carolina Abecedarian Project, an intensive early educational program investigating the degree to which mild retardation and school failure could be prevented through the provision of a supportive learning environment, beginning in infancy (Ramey & Campbell, 1984; Ramey & Haskins, 1981; Ramey, Yeates, & Short, 1984).

The Abecedarian study was based on General Systems Theory (Bertalanffy, 1975), in which developmental outcomes are viewed as the result of transactions between systems at many levels, ranging from that of the child, the parents, the school, the community, to society as a whole. This conceptualization is very similar to Sameroff's transactional model (Sameroff, 1985) and to Bronfenbrenner's ecological model (Bronfenbrenner, 1986).

Evaluating the outcomes of the Abecedarian program along with those of other intervention programs that also began treatment in early infancy for full-term, healthy children, and that also have postintervention results in middle childhood, limits considerably the number of studies to which it may be compared. In the Florida Parent Education program (Gordon, Guinagh, & Jester, 1977), home-based, parent-mediated intervention was provided for children from infancy to age 3 in a complex design involving different entry ages and different durations of treatment. When participants were followed up, the available data showed no significant treatment/control IQ or academic differences by fifth grade, but treated children were significantly less likely to be placed in special education. In a second program provided for infants of African American teenaged mothers in Washington, DC, primary pediatric care and parenting education was provided for 3 years. Treated children showed IQ gains over untreated controls at age 3 (Gutelius et al., 1972), but no long-term follow-up IQ or achievement results were reported (Gutelius, Kirsch, MacDonald, Brooks, & McErlean, 1977). The Parent Child Development Center (PCDC) programs are also relevant because two of its original sites, Birmingham and New Orleans, provided intervention from early infancy for children of low-income African American parents; the third PCDC site, Houston, began treatment for Mexican American families when target children were 12 months old (Andrews et al., 1982). All PCDC programs made extensive use of parents as interveners with their own children. A middle-childhood (age 7–10 years) follow-up of the Houston children showed that treated subjects significantly outscored untreated controls in both reading and mathematics. No differences in grade retention and assignment to special education were found (Johnson & Walker, 1991).

These infant programs were largely par-

ent-mediated, and their treatment phases ended by the time children were 3 years old. Only two have middle-childhood follow-up data, with mixed results. None of them addressed the question of the magnitude or duration of treatment effects if intervention lasted longer and used a more child-centered program format. Two studies to date, however, do address this question: the Milwaukee Project and the Carolina Abecedarian Project. The Milwaukee Project (Garber, 1988), which followed a sample of 40 African American children born to low-income, very low IQ (below 75) mothers, reported preschool IQ levels for treated children that were dramatically higher than those of the controls—an average of 29.5 IQ points. Although a number of concerns about the Milwaukee program and its research procedures have been raised (Farran, 1990; Flynn, 1987; Page & Gandon, 1981), and its outcomes are interpreted with caution, it does appear that the treatment-control IQ differences of children in the Milwaukee study were greater and more enduring than those of other programs targeting infants (Garber, 1988). However, after 7 years in school, no treatment/control academic differences were found (H. L. Garber, personal communication, June 8, 1992).

Method

Design

Eligibility for enrollment in the Carolina Abecedarian Project (Ramey & Campbell, 1984, 1991; Ramey et al., 1984) was based on sociodemographic factors which were weighted and combined into a High Risk Index with a prespecified cut point (Ramey & Smith, 1977). Infants from qualifying low-income families were randomly assigned either to an Experimental Preschool group (E) or to a Control group (C). Within each E and C group a second randomization occurred prior to kindergarten entry, giving half of each preschool group a school-age intervention program. The experimental treatment thus varied in intensity (duration) from 8 years for children who had both preschool and school-age intervention (Experimental-Experimental, EE), to 5 years for those with preschool intervention only (Experimental-Control, EC), to 3 years for those with school-age intervention only (Control-Experimental, CE), to none (Control-Control, CC). The design permitted the investigators to estimate the relative efficacy of the preschool and early elementary school programs alone, as well as the importance of reinforcing preschool gains during the transition to early elementary school.

Subjects

Four cohorts of subjects were admitted to the study between 1972 and 1977. All children were full-term infants initially judged free from conditions having known genetic or infection-related links to mental retardation. Families were identified through screening social service agencies and public health clinics. One hundred twenty-two qualified families were invited to enroll. One declined and one mother miscarried; the remaining 120 families were given group assignments, but seven E group families and one C group family declined participation after learning their random assignment. Two C group children were reassigned to the day-care condition at the request of local authorities and were dropped as subjects, and one child was not included in the research because biological retardation was diagnosed in early infancy. Of the 111 children born to the remaining 109 families (one set of twins and one sibling pair), 57 were randomly assigned to the preschool group and 54 were controls. Fifty-nine were female, 52 male. Sixty-seven percent of the E group and 61% of the C group were first-borns.

Overall attrition from birth to the treatment endpoint, based on the number of subjects with 8-year IQ data, was 18.9%. Table 1 details the history of the sample, showing attrition during the preschool and elementary school years and the number of children assigned to each school-age condition. At the treatment endpoint, IQ data for 90 and academic test score data for 88 of the original 111 subjects are available. Table 1 also shows the number of subjects available for the 12-year follow-up.

The fact that 98% of the subjects enrolled in the study were African American reflects both the confounding of poverty and race generally found in the United States and the history of the study site, a university town without many economically disadvantaged white families. Within the original sample, the IQs of the biological mothers averaged 85 points, with a range from 49 to 124 points. Mean maternal age was 19.9 years when the target child was born, with a range from 13 to 44 years. Approximately half the mothers in both groups were teenagers (19 years or younger): E = 49.2%, C = 50.8% teenagers. Maternal education averaged less than high school (M = 10.62 years), and the

TABLE 1

HISTORY OF ABECEDARIAN STUDY SAMPLE

	PRESCHOOL GROUP		
	Experimental Treatment	Control	Total (*n*)
Birth to age 5, preschool years:			
Assigned to group (*N*)	57	54	111
% male	51%	43%	47%
% firstborn	67%	61%	64%
Died in infancy	1	2	3
Moderate retardation	1	0	1
Withdrew	1	1	2
Moved before 18 months	4	2	6
Moved after age 2	0	3	3
Died at age 4	1	0	1
Given school-age assignment	49	46	95

	SCHOOL-AGE GROUP				
	EE	EC	CE	CC	Total
School years 1–3:					
Assigned to group (*N*)	25	24	24	23[a]	96
% male	44%	63%	46%	48%	. . .
Moved prior to school entry	. . .	. . .	3	. . .	3
Moved, no end-point data	. . .	. . .	1	. . .	1
Withdrew, no end-point data	. . .	. . .	. . .	1	1
Have 96-month IQ	25	23	20	22	90
Have 96-month WJ	25	23	20	20	88
Age 12 follow-up:					
Eligible for analysis	25	24	21	23	93
Living overseas	. . .	2	. . .	. . .	2
Declined to participate	. . .	. . .	. . .	1	1
Number tested	25	22	21	22	90
Attrition subjects tested = 11, 5E, 6C					

[a] One C group subject who moved away before 18 months returned at age 5 and was readmitted to the CC group.

median earned income reported by the families was none. At admission, only about one-quarter of the children in either preschool group lived with both biological parents; 61% of the E mothers and 56% of the C mothers lived with their children in multigenerational households or otherwise extended families.

Treatment

Preschool program.—Mean age at entry to the day-care center was 4.4 months. The center operated 8 hours a day, 5 days per week, 50 weeks per year. Sparling and Lewis (1979) created especially for this program an infant curriculum to enhance cognitive, language, perceptual-motor, and social development. In the later preschool years, emphasis was placed on language development and preliteracy skills (Ramey, McGinness, Cross, Collier, & Barrie-Blackley, 1982). Treated children also received their primary medical care on site.

Many efforts were made to involve families in the preschool program. Parents served on the day-care center's advisory board and were offered a series of voluntary programs covering such topics as family nutrition, legal matters, behavior management, and toy making. Supportive social services were available to families facing problems with housing, food, transportation, or the like. In addition, social events were held at the center for families of treated children.

Preschool C group infants were provided with iron-fortified formula for the first 15 months of life to ensure comparable first-year nutrition in the E and C groups. In addition, C group families were given free

disposable diapers until the child was toilet trained—a popular incentive. Supportive social work services were also available to C group families as needed.

School-age treatment.—The Abecedarian school-age program was designed to increase family support for the child's learning by having a Home School Resource Teacher provide for treated children individualized sets of supplemental educational activities. These activities addressed learning needs identified by the classroom teacher, primarily targeting basic skills in reading and math. The curriculum packets served as the focal point for biweekly home visits where parents were taught to use the learning activities with their children. Parent participation in school conferences and other school events was encouraged and facilitated. Home School Resource Teachers advocated for the school if parents misinterpreted or misunderstood actions of the staff; they advocated for the child and family if teachers lacked understanding of the realities of life in low-income families or overlooked the strengths and needs of unassertive children in highly competitive classrooms. They also helped families to secure such community services as child care, decent housing, medical care, or adult literacy classes.

Previous Findings

Previous results of this program through age 8 have been reported elsewhere (Martin, Ramey, & Ramey, 1990; Ramey & Campbell, 1984, 1991; Ramey et al., 1984). Briefly recapitulated, the preschool E and C groups showed no differences in 3-month infant test scores (Mean Bayley MDI scores for the follow-up sample were 95.04 and 96.17 for the E and C groups, respectively, $t(88) = 0.43$, $p < .67$), but by 18 months and thereafter through age 8 years, E group children displayed a significant advantage in IQ test scores relative to C group children, and they outperformed preschool C group children in both Reading and Mathematics after 3 years in school (Ramey & Campbell, 1984, 1991). The likelihood of a child being retained in grade during the first 3 school years was negatively and significantly related to the amount of educational intervention experienced by the child (Horacek, Ramey, Campbell, Hoffmann, & Fletcher, 1987). The likelihood of being identified as needing special education or related services during the first 3 years in elementary school was not significantly related to early treatment status (Campbell et al., 1993).

Early Adolescent Follow-up

The present follow-up was conducted 4 years after the treatment endpoint to learn whether effects of the Abecedarian treatment on IQ and scholastic achievement persisted through 7 years in public school. If never retained, the subjects would just have completed sixth grade. Treatment effects reported here include intellectual test performance, scholastic achievement, grade retentions, and assignment to special education.

Hypotheses.—It was hypothesized that there would be a linear relation between the number of years of early intervention and positive intellectual and academic outcomes through age 12. The EE group, with 8 years of treatment, would outperform all other groups in IQ and school achievement and would have had fewer retentions in grade and fewer assignments to special education. The EC group, having had 5 years of preschool education, would show higher scores than the CE group but, lacking the follow-through program, would score below levels attained by the EE group. The CE group, having had the benefit of 3 years' support in the primary grades, would show better intellectual and academic outcomes at age 12 than the CC group. The CC group would have the lowest overall IQ and achievement scores and the highest number of retentions and placements into special classes.

Subjects

Ninety of the 93 subjects treated as assigned through both phases participated in the 12-year follow-up study; thus the 12-year follow-up includes 81% of the original infant sample and 93.4% of those assigned to both phases of treatment. In addition, 11 subjects earlier lost to attrition were tested.

To provide a perspective on the high-risk sample, a same-sex-grade or age-school match was randomly chosen for each Abecedarian 12-year-old attending local schools. Labeled the Local Population Sample (LPS), this group of 56 early adolescent peers of the high-risk subjects took the same battery of tests as the Abecedarian subjects. The cross-sectional LPS included representatives of most ethnic groups and a wide range of socioeconomic conditions, but was weighted toward children of professional, academic families, reflecting the characteristics of the study site. The LPS was 73% white, 19.6% African American, and 4% Oriental.

Instruments and Measures

The Wechsler Intelligence Scale for Children—Revised (WISC-R; Wechsler,

1974) was used to measure intellectual levels at age 12. The reliability and validity of this instrument are well established. The Woodcock-Johnson Psycho-educational Battery, Part 2, Tests of Academic Achievement (WJ; Woodcock & Johnson, 1977) was used to assess scholastic achievement. All academic areas covered by the test were administered, yielding age-referenced standard scores for Reading, Mathematics, Written Language, and Knowledge (science, social studies, and humanities). The WJ, like the WISC-R, is a well-standardized instrument; split-half reliabilities for the clusters used here ranged from .91 to .96 for grade 5 (Woodcock, 1978).

School records, including contents of Special Services files, were abstracted using the School Archival Records System (SARS; Walker, Block, Todis, Barkley, & Severson, 1988) to derive measures of grade retention and the use of special education and resource help. Assignment to special education and the use of related services were coded as follows: if the school record contained no evidence that the child ever used any extra service or resource during the first 7 years, the child was coded 0. If the record documented the use of related services such as Chapter 1 reading programs or meetings with the school counselor, the child was assigned a code of 1. If the record contained evidence of placement into a self-contained classroom or a formal diagnosis and a signed IEP, the child was coded as 2, indicating assignment to some sort of special education program.

Procedures

Twelve-year-olds were administered IQ and academic tests in the summer after their seventh year in public school. These procedures were carried out in two individual sessions at the research center. Child examiners were blind with respect to the children's earlier group assignment(s).

Parents were interviewed about current life circumstances and their attitudes toward their children and also completed psychological instruments describing their family and child. In consideration of the significant amounts of time required for participation in the follow-up study, families were paid for participation.

Project personnel abstracted school records. For children who changed schools, records were sometimes lost, but these records are complete through the first 7 years in school for all 93 of the longitudinal subjects who were treated as assigned. However, fewer of the LPS had complete records for all years. School records are complete for only 44 of 56 LPS subjects.

Results

Two sets of results are presented: first, longitudinal IQ results through age 12 are given; second, the age 12 results in isolation are described.

Longitudinal IQ Results

Figure 1 recapitulates the IQ results from 3 months through 12 years. The points graphed in this figure represent all data available at each age.

A multivariate analysis of variance for repeated measures tested mean differences on standardized intelligence tests from 6 months to 12 years as a function of treatment, age, and treatment × age interactions. Complete data are available for 83 subjects. A cubic polynomial growth curve was selected to describe intellectual development, with separate intellectual growth curves estimated for the four treatment groups. When averaged across ages, preschool treatment, but not school-age treatment, was significantly related to the children's overall IQ. The four-group ordering of intensity was related to IQ change over time. All groups of children showed time changes described by significant linear, quadratic and cubic trends. The linear term represented a downward change from the infancy scores to those at age 12. Treatment interacted significantly with time: the preschool E group maintained an advantage but had more linear change than the preschool C group, whereas the preschool C group had more variability in patterns of change over time.

Incidence of mild mental retardation and borderline intellectual functioning.— The incidence of mild mental retardation (IQ < 70) was very low in this high-risk population, but there were more cases than would have been predicted from the known population base rates for a randomly selected group of this size. In the general population of individuals aged 10–14, 1.15% would be expected to fall into the retarded category (Robinson & Robinson, 1976). Of the Abecedarian 12-year-olds, 2.9% (three of 101 children) fell within this category. All three of these individuals were in the preschool C group. Table 2 gives the numbers and percentages of nonattrition preschool E and C subjects who scored in the Normal and Borderline (or lower) ranges at age 12.

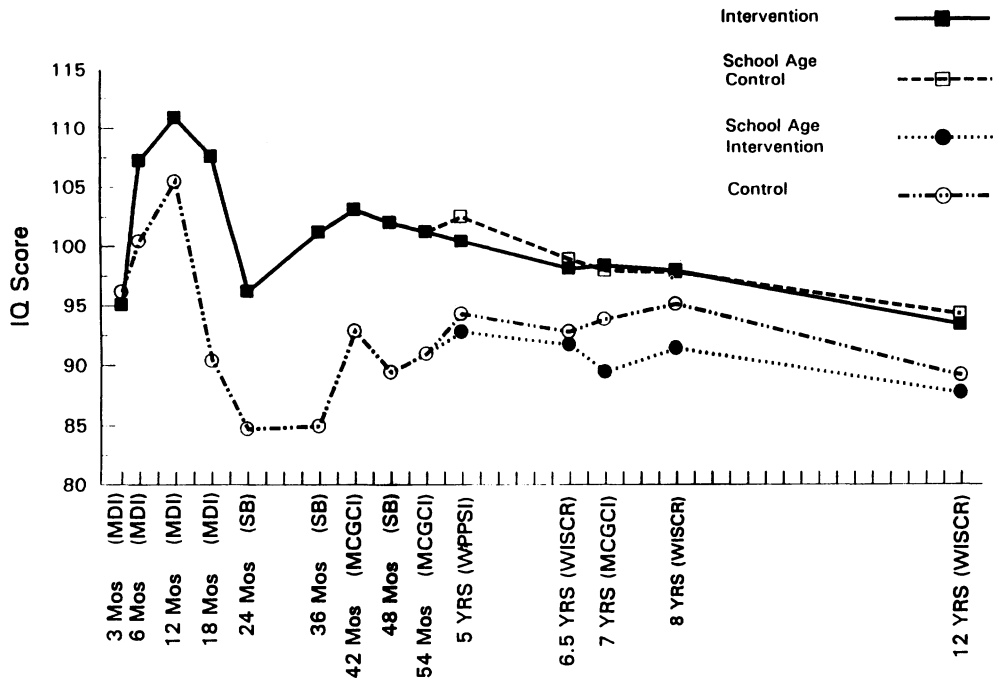

FIG. 1.—Cognitive test and age in months

Expanding the range of IQ scores to include all children who fell within the Borderline category of intellectual functioning (IQ below 86) showed that the incidence was significantly greater for children in the preschool C group, $\chi^2(1) = 12.19$, $p < .0001$.

Factor analysis of age-12 IQ and academic data.—Because cell sizes are relatively small and the IQ and academic outcomes to be examined are highly interrelated, the age-12 data set was first reduced by computing a principal components factor analysis entering the Verbal and Performance IQs and the age-referenced standard score for each Woodcock-Johnson subject. This analysis yielded two factors accounting for 81% of the variance. The first factor contained Verbal IQ and all four of the WJ scores and accounted for 68% of the variance explained; this factor was labeled "Verbal/achievement." The second contained only the Performance IQ score and accounted for an additional 13% of the variance.

A multivariate analysis of variance tested the degree to which there were overall group differences, an overall ordering of scores consistent with the duration length of treatment (i.e., EE > EC > CE > CC) on

TABLE 2

NUMBERS AND PERCENT OF ABECEDARIAN PRESCHOOL EXPERIMENTAL AND CONTROL GROUPS SCORING IN RETARDED, BORDERLINE, AND NORMAL IQ RANGES AT AGE 12

	IQ LEVEL					
	Mild MR IQ < 70		Borderline IQ = 70–85		Normal IQ IQ ≥ 86	
PRESCHOOL GROUP	*N*	%	N	%	*N*	%
E (*N* = 47).....	0	0	6	12.8	41	87.2
C (*N* = 43).....	3	7.0	16	37.2	24	55.8

the defined factors, and finally testing multivariate contrasts for the effects of preschool treatment, school-age treatment, and the preschool × school-age treatment interaction. The overall group difference associated with these two factors was significant, $F(6, 170) = 2.63$, $p < .02$, as were multivariate tests of the intensity/duration hypothesis, $F(2, 85) = 4.08$, $p < .02$, the effect of preschool treatment, $F(2, 85) = 3.21$, $p < .05$, and the effect of school-age treatment, $F(2, 85) = 3.54$, $p < .04$. There was not a significant preschool × school-age interaction. The multivariate tests thus indicated that further examination of the age-12 test scores for mean differences related to treatment intensity, preschool treatment, and school-age treatment was appropriate.

Group differences in age-12 IQ and academic achievement.—The mean WISC-R Full Scale, Verbal, and Performance IQs of the Abecedarian subjects at age 12 are shown in Table 3. Table 4 gives the means and standard deviations for age-referenced standard scores for the WJ Reading, Mathematics, Written Language, and Knowledge clusters. These data are arrayed by preschool and school-age E and C groups and also by five groups—the four school-age treatment groups and the LPS.

Each set of test scores was analyzed separately using General Linear Models to test three univariate models. In the first, only the group term was entered, testing the significance of a linear trend related to duration of treatment and then examining the four group contrasts. In the second, the IQ of the biological mother was entered as a covariate. Although under the logic of random assignment there should have been no initial group differences in maternal IQ, and there were none, $t(105) = 0.50$, $p = .62$, such a powerful source of influence on children's later intellectual and academic performance might nevertheless overshadow treatment effects by age 12. In the third, to control for the possibility that age-12 results were actually a function of differences in maternal educational levels within children's concurrent home environments, the education of the environmental mother was also covaried. The age-12 "environmental mother" was the biological mother in 78 of the 90 cases, a grandmother, aunt, adoptive, or foster mother in the others. The maternal education score was the Hollingshead Four-Factor Index code for years of education (Hollingshead, 1975).

Table 5 presents the univariate contrasts for the first two of these models. The first

TABLE 3

MEANS AND STANDARD DEVIATIONS FOR WECHSLER INTELLIGENCE SCALE FOR CHILDREN—REVISED FULL SCALE, VERBAL, AND PERFORMANCE IQS FROM THE ABECEDARIAN 12-YEAR FOLLOW-UP BY GROUP

GROUP	*N*	IQ SCORE		
		Full Scale	Verbal	Performance
Preschool group:				
E	47	93.74	93.09	96.04
		(9.08)	(10.16)	(9.70)
C	43	88.44	86.79	92.72
		(12.06)	(11.29)	(15.23)
School-age group:				
E	46	90.76	91.15	92.17
		(11.81)	(11.92)	(12.09)
C	44	91.68	88.95	96.84
		(9.92)	(10.22)	(12.98)
Two × two:				
EE	25	93.32	92.92	95.08
		(9.87)	(10.52)	(9.70)
EC	22	94.23	93.27	97.14
		(8.29)	(9.98)	(9.79)
CE	21	87.71	89.05	88.71
		(13.38)	(13.35)	(13.89)
CC	22	89.14	84.64	96.54
		(10.92)	(8.68)	(15.78)
LPS	55	110.51	110.45	108.20
		(16.80)	(17.19)	(15.06)

TABLE 4

MEANS AND STANDARD DEVIATIONS FOR AGE-REFERENCED STANDARD SCORES FROM THE WOODCOCK-JOHNSON PSYCHOEDUCATIONAL BATTERY, PART 2, FOR THE ABECEDARIAN 12-YEAR FOLLOW-UP BY GROUP

GROUP	N	SUBJECT AREA			
		Reading	Mathematics	Written Language	Knowledge
Preschool group:					
E	47	90.23	91.28	95.55	92.96
		(13.92)	(12.20)	(16.17)	(12.48)
C	43	84.74	86.02	89.47	85.30
		(11.36)	(14.84)	(14.79)	(12.52)
School-age group:					
E	46	88.59	89.26	94.91	89.70
		(14.12)	(14.97)	(17.82)	(13.16)
C	44	86.59	88.25	90.27	88.89
		(11.76)	(12.40)	(13.01)	(12.99)
Two × two:					
EE	25	90.96	90.80	97.68	92.24
		(14.05)	(12.01)	(17.25)	(12.72)
EC	22	89.41	91.82	93.14	93.77
		(14.04)	(12.67)	(14.87)	(12.46)
CE	21	85.76	87.43	91.62	86.67
		(14.00)	(18.01)	(18.33)	(13.33)
CC	22	83.77	84.68	87.41	84.00
		(8.34)	(11.30)	(10.41)	(11.85)
LPS	55	106.11	111.15	111.78	111.52
		(14.71)	(16.34)	(15.83)	(17.72)

two columns present F ratios and p values for the simplest case, without covariates. The last two give the results with maternal IQ covaried. Because concurrent maternal education added little, given the other variables, results of the second covariance analysis are not shown. With one exception, the preschool × school-age interactions were not significant and are also not shown in Table 5.

A significant linear trend was found for the Verbal IQ but not Performance IQ. Similarly, when the 2 × 2 models were tested, a significant effect for preschool treatment was found for the Verbal IQ but not for Performance IQ.

The linear term was significant for the WJ Reading, Knowledge, and Written Language scores. Significant positive main effects for preschool treatment were found for the Reading and Knowledge scores. None of the four academic subjects showed independent main effects of the school-age treatment.

There were significant main effects for maternal IQ for every intellectual and academic outcome tested. Despite the strength of maternal IQ as a predictor of child cognitive and academic performance, however, the covariance analyses indicated that the effects of treatment were essentially independent of maternal IQ. The mother's educational level generally added little to the prediction of child cognitive and academic outcomes. The one exception is that, with both covariates in the model, there was a significant preschool × school-age interaction for the Verbal IQ score, $F(1, 85) = 4.70$, $p < .04$. Examination of the adjusted means suggests that, only for children untreated in preschool but given the school-age program, adjusting for levels of maternal IQ and the environmental mother's education does strengthen the apparent effect of treatment on children's performance.

Analysis of variance followed by Tukey's studentized contrasts showed that, for all three WISC-R and all four Woodcock-Johnson scores, the LPS group scored significantly higher than all groups of high-risk subjects on IQ and academic test scores.

Grade retention and the use of special services.—Grade retention and the use of special services during the first 7 years in school for the Abecedarian and LPS groups are summarized in Table 6. After 7 years in

TABLE 5

ANALYSIS OF VARIANCE FOR 12-YEAR INTELLECTUAL AND ACADEMIC ACHIEVEMENT RESULTS

	Model			
	Group		Group + Maternal IQ	
Test Score and Source	$F(1, 86)$	p	$F(1, 86)$	p
WISC-R:				
Verbal IQ:				
Maternal IQ	. . .	. . .	23.71	.0001
Duration	8.52	.0045	9.49	.003
Preschool	7.62	.007	9.97	.002
School age	.80	.37	.21	.65
Performance IQ:				
Maternal IQ	. . .	. . .	7.69	.0068
Duration	.12	.73	.06	.81
Preschool	1.74	.19	1.97	.16
School age	3.52	.064	5.05	.027
Woodcock-Johnson:				
Reading:				
Maternal IQ	. . .	. . .	16.30	.0001
Duration	4.45	.038	4.50	.04
Preschool	3.97	.049	4.87	.03
School age	.42	.52	.06	.80
Mathematics:				
Maternal IQ	. . .	. . .	14.20	.0003
Duration	3.23	.076	3.14	.080
Preschool	3.32	.072	4.00	.049
School age	.09	.76	.01	.92
Woodcock-Johnson:				
Knowledge:				
Maternal IQ	. . .	. . .	25.48	.0001
Duration	7.41	.008	8.27	.005
Preschool	8.32	.005	11.05	.001
School age	.05	.83	.10	.75
Written language:				
Maternal IQ	. . .	. . .	11.93	.0009
Duration	5.02	.027	4.99	.028
Preschool	3.22	.076	3.78	.055
School age	1.78	.18	1.04	.31

TABLE 6

PERCENTAGES OF ABECEDARIAN GROUPS AND LPS USING SPECIAL EDUCATION AND RELATED SERVICES AND RETAINED IN GRADE IN FIRST 7 YEARS

	Group					p Value for Chi-Square		
Chi-Square Index of Progress	EE %	EC %	CE %	CC %	LPS %	PS[a]	SA[a]	PS × SA
No services recorded	36	25	24	26	93	. . .	. . .	. . .
Related services only	28	63	43	26	0	. . .	. . .	. . .
Special education	36	13	33	48	7	.07	. . .	.04
Percent retained	32	38	52	57	9	.057	. . .	. . .
Percent retained or in special education	48	46	62	70	16	.07	. . .	. . .

NOTE.—Group N's: EE = 25; EC = 24; CE = 21; CC = 23; LPS = 44; . . . = $p > .10$.

[a] PS = preschool treatment effect; SA = school-age treatment effect.

school, there was a strong trend for children with preschool treatment to be retained in grade less often, but a log linear model analysis indicated that the association between earlier treatment and grade retention was not statistically significant at the .05 level.

Similarly, a strong trend for children having preschool treatment to avoid placement in special education (code 2) did not attain statistical significance. The log linear analysis did show a significant preschool × school-age interaction, such that, as predicted, CC children were more likely than the CE group to be assigned to special education, but EE children were more likely than EC children to be so assigned.

When the data for the use of related services (code 1) or special education (code 2) were combined, it developed that, across the four Abecedarian groups, from 64% to 76% had received one or both forms of help. Combining retention and special education placement to create a single (negative) index of school progress shows that children with preschool intervention were more likely to avoid these pitfalls.

The available LPS data show a striking difference between the four Abecedarian groups and the LPS with respect to the incidence of retention and the use of special resources. Of the 44 subjects for whom complete school records could be located, only four had recorded incidences of retention and three had documented use of special education. None used related services.

Discussion

In contrast to the report by the Consortium for Longitudinal Studies that early IQ gains eroded within 3 years of school entry, and academic gains within 5–6 years, the intellectual and academic gains from the Abecedarian program persisted through 7 years in school. That preschool treatment/control IQ and academic achievement gains were maintained to that point represents one of the broadest and most longlasting benefits reported to date for an early childhood program. In fact, the Abecedarian preschool treatment/control IQ difference is slightly more pronounced at age 12 than at age 8. These results pertain whether the Full Scale or the Verbal IQ scores are compared, although results for the Full Scale IQ are somewhat attenuated by the fact that Performance IQ scores do not conform to the expected pattern. The critical point to be made from the Abecedarian longitudinal IQ results is that, from infancy through age 12, subjects having preschool treatment maintained an IQ advantage over those without the early treatment.

The children treated in this study were judged to be full-term, healthy infants, but at risk for mild mental retardation and academic failure on the basis of a developmental context associated with the "environtype" of poverty (Sameroff, 1989). The High Risk Index initially used to determine subject eligibility more successfully predicted academic problems than mild mental retardation, given that, overall, 44% of the Abecedarian subjects repeated a grade during the first 7 years in school, and 72% utilized some form of special resource. Although only three 12-year-olds of 101 tested earned IQ scores of 70 or below, it is noteworthy that all who scored in this range lacked the preschool educational experience. The likelihood of scoring in the Borderline range was significantly reduced for children who experienced the Abecedarian preschool program.

Because it began in early infancy and continued until the age of 8, the Abecedarian intervention represents, for children treated in both the preschool and school-age phases, an unusually protracted period of continuous educational intervention, possibly the longest yet provided a group of poverty children. The Abecedarian children treated only in preschool had the same length of exposure to preschool intervention as those treated in Milwaukee. The length of treatment may be one reason why both programs have found IQ gains persisting longer than those reported by most other early intervention programs. While these results imply that very early treatment is important, they do not permit a definitive test of the degree to which having intervention during the sensorimotor period might have been critical to the maintenance of an IQ advantage. Only a study with staggered age at entry could definitively address that question.

Ceci (1991) argues that schooling, per se, has a positive impact on IQ. The present data do imply that, for impoverished children, the earlier in the life span education occurs, the greater its benefit is likely to be. In support of Ceci's thesis is the fact that, as greater numbers of preschool C children enrolled in other community preschools, an upturn in their preschool IQ was seen (Burchinal, Lee, & Ramey, 1989; Ramey &

Campbell, 1984). Although family involvement in the educational process has been associated with better school progress in low-income children (Comer, 1985; Epstein, 1984), the present results indicate that preschool intervention had the stronger impact.

The maintenance of gains in academic achievement through age 12 represents a critical and practical outcome for Abecedarian subjects. The hypothesis that academic test scores would show a linear increase as a function of the number of years of previous treatment was confirmed for WJ Reading, Knowledge, and Written Language scores. The pattern did not hold for Mathematics; children who had preschool treatment alone (EC) scored slightly better on math at age 12 than did the EE group. For all subjects, the positive effects of the school-age treatment were very much overshadowed by those of the preschool program. That the biological mother's IQ was also highly related to academic outcomes is to be expected, but it is gratifying that the treatment effect remains strong even when the effects of this major influence and that of the concurrent educational level of the mother are controlled.

Putting the Abecedarian academic outcomes in the context of other early intervention studies, the significantly improved academic test scores found for previously treated Abecedarian 12-year-olds is in contrast to the lack of treatment/control differences in early adolescent academic performance for children treated in the Florida and Milwaukee studies. The Houston PCDC shows similar treatment/control differences in academic outcomes for early adolescents, but their positive results are tempered by an attrition rate of almost half of their subject pool. The same caveat applies to the lack of differences found for children in the Florida program. Attrition for the Abecedarian study was minimal. At age 12, with over 90% of the appropriately treated subjects participating, the present follow-up can demonstrate a continued advantage in academic test performance for children treated in infancy and the preschool years.

Basing his argument on the Consortium for Longitudinal Studies finding of no lasting effect on "developed abilities" but significantly better "school progress," Woodhead (1988) contends that the benefit of early treatment may lie not so much in producing higher levels of academic accomplishment as in changing children's behavioral styles. Treated children may relate to schools in a different way and, hence, be perceived differently by teachers, allowing them to avoid retention and special class placement. The Abecedarian results only partially support this contention. Retention rates were somewhat lower for subjects treated in preschool, but children with treatment in both phases (EE) were placed into special education more often than those with preschool treatment only. It is possible that having a Home School Resource Teacher actually resulted in more placements because Resource Teachers advocated for treated children to receive costly and scarce resources.

The majority of the subjects in this study were African American, and it is to low-income African Americans that the results should be generalized. The design does not permit us to separate the effects of poverty from those of cultural forces in African American children which may have influenced their adjustment to a school system in which they represented a minority. It is important to note, however, that all treatment/control differences described in this study are not among different racial groups but, rather, among initially comparable groups of African American children.

The most important policy implication of these findings is that early educational intervention for impoverished children can have long-lasting benefits, in terms of improved cognitive performance. This underscores the critical importance of good early environments and suggests that the focus of debate should now be shifted from whether government should play a role in encouraging good early environments to how these environments can be assured.

Impoverished parents need and want economic independence, but along with the need to work goes the need for child care. There must be available caregiving facilities of high quality. Therefore, support for good-quality child care, whether in preschool centers or family day-care homes, needs to be provided at all levels: local, state, federal, and within the private sector.

Finally, it might be argued that the Abecedarian program could not be replicated on a wider scale because of cost. Certainly providing 5–8 years of intervention was costly, but so is the lifelong loss of productivity associated with academic failure and hopelessness. The present results imply that treatment during the preschool years was more beneficial. Societal trends are clearly

toward more, not less, out-of-home-care for the very young. Nothing was done in the Abecedarian program that could not be done in other preschool centers or school systems. If we are to provide truly fair opportunities for children born into poverty, we must see to it that adequate resources exist to enable their families to support them and enhance their cognitive growth. Better early environments can improve the chances that poor children will acquire the preparation they need for academic success.

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