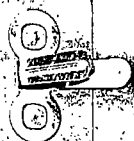




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Campbell

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Slides

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Description of Item(s)	13 color slides illustrating features of the Abecedarian study. For description, see slide list.			

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Slide list for Abecedarian Study, prepared for the White House, February 1996

1. Design of the Abecedarian Study, showing the two phases of treatment and the two follow-up ages. Preschool treatment extended from birth to age five; school-age treatment was for the first three years on elementary school (age 5 to 8). Children were randomly assigned to preschool education and control conditions. Preschool treatment was delivered in a childcare setting 5 days/week all year long, starting in early infancy. At kindergarten entry, preschool treatment and control groups were re-randomized into school-age treatment and control groups. School-age treatment consisted of having a Home/School Resource Teacher make bi-weekly visits to the classroom to learn what concepts the child was learning then designing individualized activities to be done at home by parents. Parents were then visited bi-weekly to deliver activities. Treatment ended after 3 years in school when children were approximately 8 years old.
2. Infant with Head of Abecedarian Infant Nursery in early years of program.
3. Caregiver talking to infant, stimulating language development.
4. Caregiver with child.
5. Social interaction between toddlers in nursery.
- 6 Toddler in nursery.
7. Toddler on playground.
- 8 Toddler with gross motor activity.
- 9 Eye-hand coordination and art activity, preschooler.
- 10 Abecedarian Home/School Resource Teacher meets with classroom teacher in primary grade classroom.
11. Home Activity; individualized mathematics game made for parent to use at home with first grade child.
12. Parent and school-age child doing home activity.
13. Academic achievement scores, age 8 (treatment endpoint) with follow-up scores at age 12 and age 15, as a function of preschool treatment/control status. Longitudinal scores for Woodcock-Johnson Psychoeducational Battery, Skills subtest. Treatment/control difference is statistically significant at every point.



Frank Porter Graham Child Development Center

DATE: March 11, 1996

TO: Ms. Liz Bowyer

FROM: Frances A. Campbell *FAC*

RE: Slides of Abecedarian study

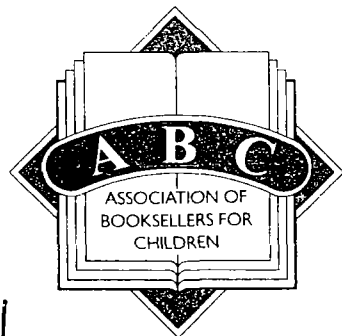
Enclosed are copies of slides that illustrate features of the Abecedarian study. I have also enclosed a caption sheet, although most have no need of captions. We have contacted the individuals depicted and they have assented to our sending the pictures to you.

One (Slide # 1) is included to explain how the four Abecedarian treatment conditions varied. The four groups varied with respect to the timing and duration of treatment as follows: the most intensively treated group had 8 years of intervention - five in preschool and three in primary school (EE); the next most intensively treated group had five years of intervention in preschool only (EC); one group had three years in primary school only (CE) and all were compared with untreated controls (CC).

Slide # 13 illustrates one of our strongest findings, the significant treatment control difference in academic performance through age 15, a persistence of significance in actual academic test scores beyond the point usually found in early intervention research. The scores graphed here are the Skills scores from the Woodcock-Johnson Psychoeducational Battery, Part 2: Tests of Achievement.

I am also enclosing copies of three reprints, describing Abecedarian outcomes at age 8, age 12, and age-15.

Thank you for your interest in this study. If you have questions, I will be happy to try to answer them. I can be reached at (919) 966-4295.



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

Frances A. Campbell

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Civitan International Research Center, University of Alabama

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 improv-

This research was supported by NICHD Grant 5 RO1 HD21782 awarded to Craig Ramey, PI and Frances Campbell, Co-PI. The authors wish to thank Drs. Mark Everson, Barbara Boat, and Donna Bryant for consultation on the conceptualization of the study and Drs. Margaret Burchinal and Ronald Helms for assistance with data analysis. Without the tireless efforts of Lisa B. Lau, Katherine Polk, Carrie D. Bynum, and Marie Butts, this work would have been impossible. The merits of the study owe much to these individuals; its shortcomings and any factual errors are the responsibility of the authors. In particular, we want to express our appreciation to the early adolescents and their families who took part in the study. Requests for reprints should be sent to Frances A. Campbell, Frank Porter Graham Child Development Center, University of North Carolina at Chapel Hill, CB #8180, Chapel Hill, NC, 27599-8180.

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 firstborns.

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 multi-generational 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 $\times$ 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.

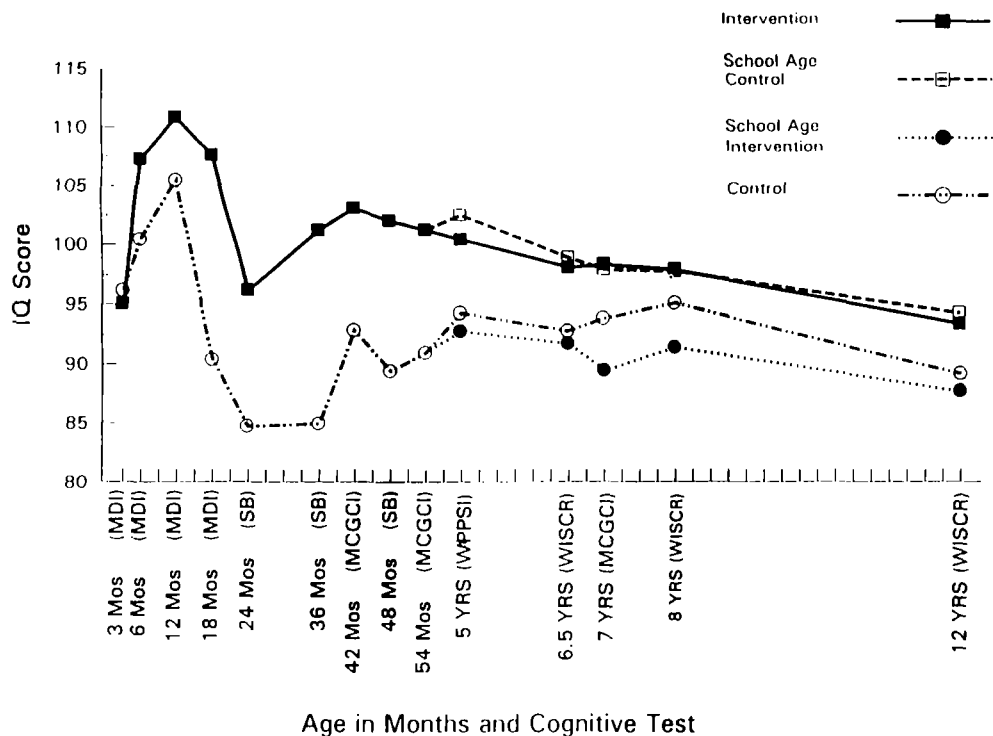


FIG. 1.—Cognitive test and age in months

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 pre-school 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

PRESCHOOL GROUP	IQ LEVEL					
	Mild MR IQ < 70		Borderline IQ = 70–85		Normal IQ IQ ≥ 86	
	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 $\times$ 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 $\times$ 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 (9.08)	93.09 (10.16)	96.04 (9.70)
C	43	88.44 (12.06)	86.79 (11.29)	92.72 (15.23)
School-age group:				
E	46	90.76 (11.81)	91.15 (11.92)	92.17 (12.09)
C	44	91.68 (9.92)	88.95 (10.22)	96.84 (12.98)
Two × two:				
EE.....	25	93.32 (9.87)	92.92 (10.52)	95.08 (9.70)
EC.....	22	94.23 (8.29)	93.27 (9.98)	97.14 (9.79)
CE.....	21	87.71 (13.38)	89.05 (13.35)	88.71 (13.89)
CC.....	22	89.14 (10.92)	84.64 (8.68)	96.54 (15.78)
LPS	55	110.51 (16.80)	110.45 (17.19)	108.20 (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 (13.92)	91.28 (12.20)	95.55 (16.17)	92.96 (12.48)
C	43	84.74 (11.36)	86.02 (14.84)	89.47 (14.79)	85.30 (12.52)
School-age group:					
E	46	88.59 (14.12)	89.26 (14.97)	94.91 (17.82)	89.70 (13.16)
C	44	86.59 (11.76)	88.25 (12.40)	90.27 (13.01)	88.89 (12.99)
Two × two:					
EE.....	25	90.96 (14.05)	90.80 (12.01)	97.68 (17.25)	92.24 (12.72)
EC.....	22	89.41 (14.04)	91.82 (12.67)	93.14 (14.87)	93.77 (12.46)
CE.....	21	85.76 (14.00)	87.43 (18.01)	91.62 (18.33)	86.67 (13.33)
CC.....	22	83.77 (8.34)	84.68 (11.30)	87.41 (10.41)	84.00 (11.85)
LPS.....	55	106.11 (14.71)	111.15 (16.34)	111.78 (15.83)	111.52 (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 cogni-

tive 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

TEST SCORE AND SOURCE	MODEL			
	Group		Group + Maternal IQ	
	<i>F</i> (1, 86)	<i>p</i>	<i>F</i> (1, 86)	<i>p</i>
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

CHI-SQUARE INDEX OF PROGRESS	GROUP					<i>p</i> VALUE FOR CHI-SQUARE		
	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.

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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 $\times$ 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 re-

sults 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 "environment" 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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Cognitive and School Outcomes for High-Risk African-American Students at Middle Adolescence: Positive Effects of Early Intervention

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Long-term intellectual and academic benefits related to early childhood educational intervention were found in a sample of students from low-income families (98% African American). The subjects were randomly assigned to preschool and school-age treatment conditions in a study design that permits a comparison of outcomes in students with preschool treatment followed by early elementary treatment (infancy-8 years), preschool treatment only (infancy-5 years), early elementary school treatment only (5 years-8 years), and untreated controls. At age 15, seven to ten years after any treatment was provided, those students who had preschool treatment scored significantly higher on individually administered tests of reading and mathematics and had fewer instances of grade retention and assignments to special education. The results support the relative efficacy of preschool treatment over that given in early elementary school. Policy implications stress the importance of providing high quality early childhood environments for impoverished children.

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The purpose of this article is to examine the duration of effects of early childhood educational intervention on the intellectual development and academic achievement of a sample of African-American adolescents born into poverty. The belief that early childhood education can positively influence the life success of the poor goes at least as far back as the 18th century writings of Jean Jacques Rousseau. Today, that belief is manifested through the allocation of over 10 billion state and federal dollars for early childhood programs such as Head Start, Follow Through, and Chapter I, all initiatives designed to prevent academic failure among children from low-income families. There is no doubt that the problem facing educators and policymakers today is extremely serious. Despite universal free education, many students from low-income, minority families drop out of school, unprepared to compete in the workplace (Hill & Duncan, 1987). African Americans are three times more likely than Whites to be poor (Duncan, 1991). In her book, *Children of Color*, Jewell Gibbs noted that, in 1980, nearly one quarter of African Americans between the ages of 18 and 21 were out of school but had not graduated (Gibbs, 1989). Similarly, poverty is associated with an increased likelihood of teenage pregnancy (Sullivan, 1993) and of juvenile delinquency and subsequent crime (Garmezy, 1985). All these factors contribute to the perpetuation of impoverishment and social pathology.

The theory underlying preschool intervention programs may be briefly stated as follows. Enhancement of early cognitive development in poor children is important because of the "realization that cognitive processing will have a great deal to do with [academic and] vocational success" (Gallagher, 1991). Experiences very early in the life span are thought to provide a critical foundation for subsequent cognitive development (Bloom, 1964; Hunt, 1961), but the early environment of the poor or socially disadvantaged child may not support optimal cognitive development (Scarr, 1981). Early educational intervention can potentially enhance cognitive development, leading to a greater transfer of cognitive-academic skills to later settings, such as school (Ceci, 1991). Early academic success in school can lead to higher levels of academic confidence and motivation (Zigler, Abelson, Trickett, & Seitz, 1982), which may in turn help to prevent school dropout, leading to better vocational preparation, subsequent higher rates of employment, and ultimately greater economic power and social contribution. Despite this compelling logic, there are actually few scientifically rigorous studies of the efficacy of early educational programs, with subjects randomly assigned to treatment and control conditions, and periodic long-term assessment of the outcomes.

Many analysts have assessed outcomes of the most widespread of early childhood programs, Project Head Start (e.g., Cicirelli, 1969; McKey, Condelli, Ganson, Barrett, McConkey, & Plantz, 1985); the results have been, on the whole, disappointing. A meta-analysis of Head Start's benefits indicated that, despite some exceptions, by the end of the second year in public school, educationally meaningful differences between Head Start participants and control children were no longer apparent (McKey et al., 1985). Another

important source of information about the effects of early intervention is the Consortium for Longitudinal Studies in which 11 early childhood programs (not Head Start) assessed their graduates several years after the programs ended. The Consortium found no lasting program effects on IQ scores or academic test performance but did find robust, enduring benefits in the form of fewer retentions in grade, fewer placements into special education, and improved attitudes toward education (Lazar, Darlington, Murray, Royce, & Snipper, 1982).

Haskins (1989), in reviewing long-term benefits of early childhood programs, concluded that "social scientists should be modest in claiming that research supports new public investments in preschool education" (p. 274). Zigler and Muenchow (1992) disagree insofar as Head Start is concerned, challenging the idea that early gains invariably fade. Also supporting the value of early education, investigators studying long-term outcomes from one of the Consortium programs, the Perry Preschool Project, found greater educational gains, better employment records, and fewer instances of law-breaking among 19-year-olds who had preschool treatment in their program (Bernueta-Clement, Schweinhart, Barnett, Epstein, & Weikart, 1984). Benefits through age 27 have now been reported for Perry Preschool participants in terms of increased rates of high school graduation for females and better records of employment for males (Schweinhart, Barnes, & Weikart, 1993). Thus, controversy over the value of early childhood educational intervention continues. There are unanswered questions about the timing, duration, and service delivery models of such programs (e.g., Wasik, Ramey, Bryant, & Sparling, 1990).

Head Start is neither as intense, in terms of the number of hours per day, nor as long-lasting a program as might be provided for poor children. It began as a limited summer program and, even when expanded to the full school year, typically has been provided only for 4-year-olds, and often for only half days. Similarly, most of the programs included in the Consortium for Longitudinal Studies enrolled youngsters aged 2 years or older; many began treatment when children were aged 4 years or older. More information is urgently needed on the long-term outcomes of scientifically valid, experimental studies of more intensive and longer lasting early intervention (Farran, 1990; Haskins, 1989).

How much might the development of children from economically impoverished backgrounds be enhanced by an intensive program that began early in the life span? An experimental examination of this question faces formidable barriers because ethical restrictions rightly limit the degree to which human lives are amenable to experimental manipulation. However, the increasing need for out-of-home care for infants permitted the original investigators of the Abecedarian Project to design a prospective, longitudinal study to test the efficacy of early educational intervention that was delivered, beginning in early infancy, in an educational childcare setting. This study thus affords an experimental examination of outcomes from one of the most

intensive (in terms of the degree of exposure to an educational milieu) early childhood educational programs ever provided for children of poor families.

Long-term intellectual and academic benefits of the Abecedarian study, as seen when study participants had completed 10 years in school and were 15 years old, are the focus of the present article. The results at the end of the preschool phase (Ramey & Campbell, 1984), at the elementary school treatment endpoint (Ramey & Campbell, 1991), and at an initial follow-up at age 12 (Campbell & Ramey, 1994) have been reported in detail elsewhere and will be only briefly summarized in the methods section below. In the current study, the following questions are addressed:

1. Were there different patterns of intellectual development from infancy through mid-adolescence for children who had early educational intervention compared with untreated controls?
2. Were there detectable effects of early educational intervention in the academic test scores of treated individuals at age 15, seven years after all intervention ended?
3. Across 10 years in school, were there differences in negative indexes of school progress (retention in grade or use of special education) as a function of early intervention?
4. What was the more optimal timing for intervention: preschool or early elementary school?
5. How do the outcomes of this program compare to those of other early childhood programs?

The Carolina Abecedarian Project. Based on cross-sectional data, progressively lower intellectual test scores have been found as age increases among children being raised in poverty (Garber, 1988). The intent of the Abecedarian Project (ABC) was to test the degree to which continual, consistent enrichment of the early environment might alter this negative trend toward developmental retardation and also reduce academic failure in such children. The project's outcomes were evaluated within a multidisciplinary framework that included measures of cognitive functioning, social development, and health.

The target subjects were biologically healthy infants born to impoverished families living in a small, southern town. The children were considered at risk for suboptimal cognitive development based on family demographic characteristics and psychological risk indicators. Selection criteria were based on a High Risk Index derived from factors reported in the literature to be related to lower levels of intellectual functioning and/or academic failure (Ramey & Smith, 1977). The 13 factors included: maternal and paternal educational levels, family income, absence of the father from the home, poor social or family support for the mother, indications that older siblings had academic problems, the use of welfare, parents working at unskilled jobs, indications of low parental IQ, family members seeking counseling, and other evidence of a need for support from community agencies. The greatest weight was given to parental educational levels and income. Families scoring above 11 points on this index were eligible for participation in the study.

Method

Design

Figure 1 presents the experimental design of the Abecedarian study showing the two phases of treatment and the two follow-up studies completed to date. The 2×2 design contrasts outcomes in students with and without preschool and school-age intervention. Equivalent preschool groups were created through matching subjects on the basis of High Risk scores and then randomly assigning one of each pair to the preschool experimental treatment (E) group, the other to the preschool control (C) group. Children in the E group received systematic educational intervention in a day care setting beginning in the first half of their first year of life and continuing up to age 5, or the point of kindergarten entry. The study design involved a randomized crossover in that, prior to kindergarten entry, pairs of children within the preschool E and C groups were equated on the basis of their 48-month IQ score, with one of each pair randomly assigned to a school-age intervention group, the other to the school-age control group. For those assigned to this phase of treatment, intervention was provided for the first 3 years in elementary school. The resulting 4-cell design permitted a comparison of outcomes in children who had a total of 8 years of intervention—5 in preschool and 3 in early elementary school (EE), 5 years of intervention in preschool only (EC), 3 years of school-age intervention only (CE), or no educational intervention at all (CC). The random assignment of children to the various treatment conditions is a very important feature of this study because it permits the investigators to attribute group differences to the treatment, rather than to differences in family factors. This procedure avoided one especially important

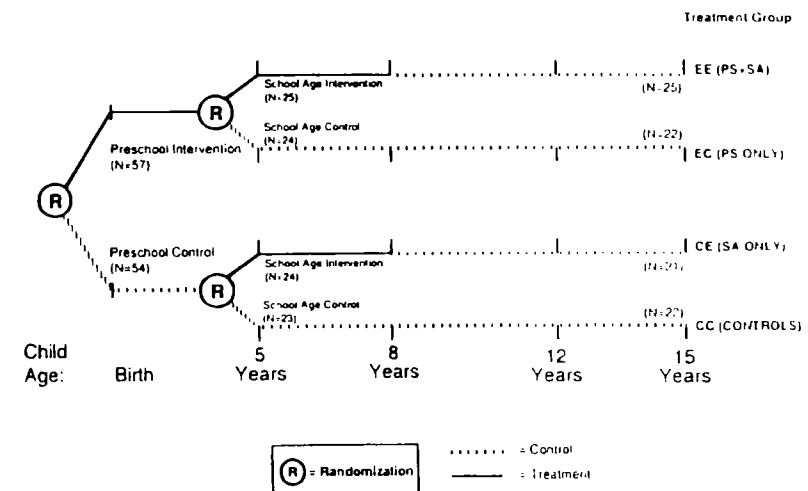


Figure 1. Experimental design of Abecedarian project

confound—that of systematic differences among low-income families who sought full-time child care for their infants compared to those who did not. It also served to randomize school-age children within public schools because school-age treatment status was determined before school entry.

Study Participants

Four cohorts of infants were admitted to the project between 1972 and 1977. A cohort generally consisted of 28 infants born within the same year. (The maximum size of a cohort was limited to twice the capacity of the infant nursery used for the treatment program: 14 infants.) Families were nominated by social welfare departments and prenatal clinics; they were subsequently visited at home by project staff who explained the program and scored the High Risk Index to estimate their suitability for the study. Mothers who qualified on the High Risk Index then visited the child development center where they were interviewed further, and the Wechsler Adult Intelligence Scale (Wechsler, 1955) or the Wechsler Intelligence Scale for Children (Wechsler, 1949) was administered to them. Some mothers were tentatively accepted for enrollment before their expected child was born. As a final condition for inclusion, only full-term infants judged at birth to be free of physical handicaps and genetic or physical conditions associated with mental retardation were enrolled. Ethnicity had nothing to do with the selection criteria. As it developed, however, 98% of the families ultimately enrolled were African American because, in the local area, as in the United States in general, ethnicity and poverty are confounded.

One-hundred twenty-two families were nominated by local agencies. Of these, only one declined to consider enrollment; a second potential subject miscarried. The other 120 families agreed to participate, but 8 (7 E, 1 C) subsequently did not, once they learned their random assignment. The higher rate of study rejection by families offered preschool treatment was generally related to mothers wanting to care for their infants at home. Almost no families declined enrollment in the control group.

One infant assigned to the preschool E group proved to have idiopathic moderate retardation associated with a seizure disorder (not detectable at birth, but clear within 6 months), and two infants randomly assigned to the C group were subsequently admitted to the child care program at the extreme urging of protective service officials. Although all three of these children attended the day care center as regular members of their cohorts and underwent the regular series of assessments, these special circumstances rendered them ineligible for participation in the research portion of the study, and their data are not included. Thus, the base sample consisted of 111 subjects.

Table 1 gives family characteristics of the base sample, excluding the ineligible children. There were 59 females and 52 males in the base sample, of whom 57 (55 families) were assigned to the E group and 54 (54 families) to the C group. As Table 1 shows, the families in the E and C groups were closely matched with respect to mean levels of maternal education, mean maternal IQ, and maternal age.

Table 1
Entry Level Demographic Data for Preschool Experimental and Control Families

Variable	Experimental (<i>n</i> = 55)	Group control (<i>n</i> = 54)	Total (<i>n</i> = 109)
Mean High Risk Index	20.08 (5.72)*	21.14 (5.88)	20.75 (5.81)
Mean maternal age (yrs.)	19.56 (3.88)	20.28 (5.77)	19.94 (4.89)
Mean maternal education (yrs.)	10.45 (1.75)	10.00 (1.89)	10.23 (1.83)
Mean maternal Full Scale IQ	85.49 (12.43)	84.18 (10.78)	84.84 (11.61)
Percent African American	96%	100%	98%

*Numbers in parentheses are SDs.

Subject attrition was low. Eighteen of the original 111 children are considered attrition cases, 15 lost during the preschool years and 3 thereafter. Thus, 93 children may be properly placed in one of the four treatment cells and are eligible to enter the analysis of long-term benefits. The 18 subjects lost to attrition do not differ from the others on any entry-level demographic characteristics.

Abecedarian Treatment

Preschool program. The preschool educational program was provided from infancy until children entered public kindergarten at age 5. The child care center operated full days, year round. The mean age of infants on entry to treatment was 4.4 months. The caregiver to infant ratio was 1:3. An infant curriculum was developed by Sparling and Lewis (1979) especially for this program. The items covered four major domains: cognitive and fine motor development, social and self-help skills, language, and gross motor skills. Sparling (no date) has described the curriculum as "biased toward adult-child transactions involving informational language" (p. 1). Activities were assigned to infants as caregivers and the curriculum staff judged them appropriate.

Caregiver: child ratios gradually increased from 1:3 to 1:6 as children moved from the nursery into toddler and preschool groupings. The center's preschool resembled other high quality programs, with interest centers for art, housekeeping, blocks, fine-motor manipulatives, language, and literacy. Special emphasis was placed on language development and preliteracy skills, with caregivers and teachers being given intensive in-service training in ways to foster sociolinguistic competence in the children (McGinness & Ramey, 1981). The language program, which was made a regular feature of the entire day's program, focused on pragmatic features rather than syntax and

emphasized the contingent and interactive features of adult-child language. In addition, prephonics training (Wallach & Wallach, 1976) was instituted with one cohort of the 4-year-olds to prepare them for reading. This program consisted of brief (up to 10 minutes in length) individual sessions provided twice weekly for 45 weeks (Dorval, Joyce, & Ramey, 1980).

Prior to entering public kindergarten, children were provided a 6-week summer transitional classroom experience. For this special program, extra children from the community were enrolled to make the group larger and more socioeconomically heterogeneous, thereby increasing its contextual similarity to public school.

Parents of treated youngsters served on the day care center's advisory board: they were provided a series of informative programs on parenting topics identified through a survey of their interests, and periodic social events were held at the Center. Since treated children received their primary medical care at the Center, parents also were counseled by the medical staff about child health and development.

Preschool evaluation procedures. Throughout the treatment phase of the study, children in both the treated and control groups were accompanied to the Center by parents for a regular series of psychological evaluations and research studies. Project personnel who administered tests were not involved in the planning or delivery of the treatment, nor were program staff allowed to observe evaluations or given feedback about scores. A variety of widely used, well-standardized intellectual measures with acceptable levels of reliability and validity were administered to the children over the years. At each longitudinal testing occasion, child performance was compared to that of the most up-to-date normative sample available at the start of that particular probe. For infants, this was the *Bayley Scales of Infant Development* (Bayley, 1969). For preschoolers, IQ scores from the *Stanford-Binet Intelligence Scale, Form LM* (Terman & Merrill, 1972) were obtained at 24, 36, and 48 months, and General Cognitive Indices were obtained from the *McCarthy Scales of Children's Abilities* (McCarthy, 1972) at 42 and 54 months.

Preschool outcomes. The treatment endpoint for preschool came at kindergarten entry. Although initially equivalent on early infant scores on the *Bayley Scales of Infant Development* (Bayley, 1969), at every age from 18 months through 54 months, children treated in preschool significantly outscored preschool controls on measures of intellectual development (Ramey & Campbell, 1984).

School-age program. Random assignment to the school-age phase of treatment was done within each wave of children entering school in a given year. Ninety-six of the original 111 children were still in the area and available for assignment, but 3 of the 24 preschool C-group children randomly assigned to the school-age treatment condition (CE) moved from the area and could not be treated as designated, reducing the number of children that may be considered treated-as-assigned in both phases of the study to 93.

Not all children in each of the four preschool cohorts entered school together because entry year was determined by the statewide cutoff date for

school entry, which was attainment of age 5 by October 15. Children thus entered public kindergarten in six waves, beginning in the fall of 1977 and continuing through the fall of 1982. They were assigned to schools according to the district in which they lived, and to classrooms at the discretion of principals. Students in the school district were approximately 80% White and 14% African American, thus the Abecedarian students were part of a minority group within their schools. Efforts were made by all principals to obtain a fair and representative balance of ethnic groups and socioeconomic levels in all classrooms.

The school-age intervention was designed to support children's academic development by increasing and enhancing parent involvement in the educational process. Each treated family was assigned a home/school resource teacher (HST) for the first 3 years their child attended public school. Serving up to 14 families each year, the HST provided parents with home curriculum activities individually designed for each child to reinforce the basic reading and mathematics concepts being taught at school. These supplemental activities were customized based on the classroom teacher's input about concepts and skills the child was then learning. The HST visited the classroom every other week to gain this information and to consult on any other aspects of the child's adjustment to school (e.g., attendance problems, social relationships, and the like). On alternate weeks, the HST delivered new learning activities to the home where she explained and demonstrated them to the parents. Parents were urged to use these activities for at least 15 minutes each day and given calendars to mark showing the extent to which they and the child had done so. Children "earned" books for completing activities.

In addition to educational activities for children, the HSTs provided a liaison between home and school, advocating for the school within the family and the child and family within the school. Most of the participating children attended schools in which a large proportion of the students were from well-educated and relatively affluent homes, reflecting the university community where they lived. In this context, the HSTs saw instances in which classroom teachers displayed insensitivity to the problems of impoverished families, such as expecting parents to have ready access to cars enabling them to come to school on short notice. Similarly, families were sometimes distrustful of teachers' motives when concerns about children's learning styles or classroom adjustment were raised. The HST was often able to allay mistrust on both sides.

The HST also helped families with non-school-related problems that might compromise their ability to support the child's learning, such as a need for medical attention, better housing, employment, adult education, or childcare for younger children. In these instances, the HST functioned much like a social worker, referring families to relevant agencies, providing transportation for parents and children to medical clinics, or assisting parents in completing forms as they attempted to negotiate the bureaucracy involved in securing services. Such efforts were at the individual level, based on needs

assessments, and provided support that enabled several parents to make positive adjustments in their own lives.

School-age evaluation procedures. School-age evaluation procedures included administration of the *Wechsler Preschool and Primary Scale of Intelligence* (WPPSI; Wechsler, 1967) at age 5 and the *Wechsler Intelligence Scale for Children-Revised* (WISC-R; Wechsler, 1974) at 6.5 years. Project personnel administered standardized measures of academic achievement in the fall and spring of each of the first 3 years in school. For the first 2 years, the instrument used for this purpose was the *Peabody Individual Achievement Test* (PIAT; Dunn & Markwardt, 1970). The Reading, Mathematics, and Skills clusters from the *Woodcock-Johnson Psycho-Educational Battery, Part 2: Tests of Academic Achievement* (WJ; Woodcock & Johnson, 1977) were substituted for the PIAT in the third year. In addition, children were observed in their classrooms, and teachers rated each child's classroom adaptation using the *Classroom Behavior Inventory* (CBI; Schaefer, Edgerton, & Aaronson, 1977) each of the first 3 years in school. The school-age treatment endpoint came after 3 years had elapsed. The children were then approximately 8 years old and, if on grade level, had completed second grade. At this point, the WISC-R was again administered, in this instance by examiners with no knowledge of the child's treatment history.

School-age outcomes. At age 8, WISC-R Full Scale IQ scores were available for 90 of the 93 subjects, and WJ academic test scores were available for 88. Analysis of the longitudinal intellectual test data up to the treatment endpoint showed significant positive effects of preschool treatment on intellectual test scores from infancy to age 8. In addition, children treated in preschool scored significantly higher than control children on standardized tests of academic achievement in reading and mathematics after 3 years in school, regardless of whether the comparison was based on age-referenced scores from tests individually administered by project staff or on grade-referenced scores from standardized tests group-administered by the schools to second graders (Ramey & Campbell, 1991). There also was a significantly reduced likelihood that children treated in preschool would be retained in grade during the first 3 years (Horacek, Ramey, Campbell, Hoffmann, & Fletcher, 1987). The analyses indicated that preschool treatment, as opposed to school-age treatment, was more strongly associated with these positive outcomes.

Age 12 follow-up. A follow-up at age 12, after 7 years in public school and 4 years after any treatment had been provided, showed that positive effects of preschool treatment on children's intellectual test performance and on academic tests of reading and mathematics had been maintained into early adolescence (Campbell & Ramey, 1994). This represented a longer maintenance of preschool intervention gains than has typically been reported from previous projects concerned with similar children and families. However, the target children were then in early adolescence, still somewhat under firm parental control and uninvolved in some of the more problematic aspects of local youth culture. Therefore, a second follow-up study was conducted

to monitor the academic progress of the target students as they completed the 10th year in school, a point at which those on grade level should just have completed the ninth grade. That mid-adolescent follow-up study and its results are described below.

The Age 15 Follow-Up Study

Subjects

Attrition to age 15. Of the 93 subjects who received their assigned treatment at school age, 92 took part in the age-15 follow-up. In addition, 12 of the 18 subjects earlier lost to attrition were assessed at age 15. Four subjects were no longer living, and two were ineligible for follow-up: one whose adoptive parents withdrew the child from the study and the biologically handicapped child described above.

Follow-up sample. Table 2 shows the number and gender of subjects originally assigned to the two Abecedarian preschool groups and the four school-age groups compared with the numbers in each group who took part in the age-15 follow-up. In addition, numbers of preschool E- and C-group participants earlier lost to attrition for whom data were collected at age 15 are given.

Follow-Up Procedures

The age-15, follow-up data were collected from all adolescents during the summer after their 10th year in school. The students, if on grade level, had completed ninth grade, the first year of senior high school. They were tested at the child development center by individuals blind with respect to their early intervention history. Parents were interviewed and completed ratings on their adolescents and on themselves.

Table 2
Original Abecedarian Study Sample and Participants In Age 15 Follow-Up

	Preschool treatment				Preschool control			
	Age 15				Age 15			
	Preschool	EE	EC	Attrition	Preschool	CE	CC	Attrition
Original <i>N</i>	57	25	24		54	24 ^a	23	
Age-15 <i>N</i>	48	25	23	5	44	21	23	7
Males	29	12	15	2	23	10	11	2
Females	28	13	8	3	31	11	12	5
% Af. Am.	98				100			

^aThree students randomly assigned to the CE group moved out of the area and did not actually enroll in local schools and thus did not participate in the school-age treatment. They are all represented in the attrition group in this follow-up study.

Language arts teachers were also asked to complete ratings on each student. This academic subject was chosen because it represents the only subject that all students, regardless of grade level, would have been required to take within the past school year. All data are complete with the exception of teacher data. The fact that a number of Abecedarian students lived out of the immediate area and attended school in other districts, plus heavy demands on teacher time, precluded full collection of teacher data.

Because the data collection procedures were extensive, and also to convey to them the degree to which their participation was valued, subjects were reimbursed for taking part in the follow-up. The amount of reimbursement for the students was approximately \$10/hour.

Outcome Measures

The present study describes outcomes in three major domains: intellectual development, academic achievement, and school progress. The instruments and procedures used to measure each are described below.

Intellectual. As it had been on four earlier occasions, the WISC-R (Wechsler, 1974) was administered at the 15-year follow-up. This instrument was normed on a stratified sample of families in which minority students within the relevant age range were included in proportion to their representation in the 1970 United States Census. Test-retest reliability of the instrument was .94 for the Full Scale IQ (Wechsler, 1974). Extensive studies of predictive validity utilizing this and similar instruments have shown essentially the same patterns of prediction for African Americans and Whites (Jensen, 1980; Oakland, 1983). Factor analysis reveals the same WISC-R factor structure in African American and White samples (Kaufman, 1979).

Academic. The WJ was again used to measure scholastic attainment, as it had been at ages 8 and 12. This instrument derives measures of attainment in major academic areas, such as reading and mathematics, by combining scores on two or more subtests to create a cluster score. Age- or grade-referenced percentiles or Standard Scores (with a mean of 100 and *SD* of 15) are obtained by comparing the cluster score earned by the examinee with the average cluster score of the normative sample at a given age or grade level. In this study, age-referenced Standard Scores for reading and mathematics were analyzed.

The reading cluster for the WJ is based on subtests labeled Letter-Word Identification, Word Attack, and Passage Comprehension. A median reliability of .96 was reported for the reading cluster based on reliability studies conducted across the range of its intended use (Woodcock, 1978). The mathematics cluster consists of subtests of Calculation and Applied Problems. A median reliability of .92 was found for this cluster across the range of intended use (Woodcock, 1978).

The norms for the WJ were calibrated to approximate the proportions of White and non-White individuals within each of the 9 census tracts and six classes of occupational status identified during the 1970 census. The technical manual for the test (Woodcock, 1978) does not, however, further

specify what groups made up non-White or in what proportion. The test scores were weighted to make sure that, within each age range covered by the test, the two ethnic categories and all regions and occupational status classes were represented in exact proportion to their occurrence in the United States in 1970.

School progress. The contents of the students' cumulative school records, including those of all special services files, were released by parents to study personnel. From these, notations of retention in grade or assignment to special education were taken, providing the negative indexes of school progress used in this study. Support services in local schools involved two levels of treatment. At the more formal level, referred students went through a diagnostic process leading to their categorization as eligible for special education funding because of learning disability, mental retardation, emotional or behavior disorder, or speech and language delay. For each student diagnosed, an Individualized Education Plan (IEP) was specified. At the second, less formal level, pupils were given learning supports or related services, such as Title 1 or Title 20 reading programs, or assignment to school counseling groups, which did not require a formal diagnosis or an IEP. Some students received no services at either level. Accordingly, when records were reviewed, each student was assigned a code of 2 (special education assignment), 1 (related services), or 0 (no record of either).

Results

Demographic Data

Table 3 gives a summary of the living circumstances of the subjects at birth, age 8, and age 15. At birth, only about one quarter of the children lived with

Table 3
Living Circumstances of Abecedarian Subjects at Three Ages With
Local Population Sample Contrast at Age 15

Family type	Age			
	Birth ^a %	8 Years ^b %	15 Years %	LPS ^c %
Complex	58.2	6.7	11.7	2.1
Multigenerational				
Two-Parent family	25.4	33.3	33.3	60.4
(Intact and step)				
Single parent	10.0	43.3	35.3	37.5
(Mother or father)				
Grandparent(s) alone	0	7.8	7.8	0

^a*N* = 110 subject families. One younger sibling was admitted to the study, randomly assigned to the E group. In this table, this family enters twice. Another family, to whom identical twins were born, enters only once.

^bData are available for only 49 families at age 8.

^c*N* = 48 families.

both biological parents in the parents' own home; over half of them were living with their mothers in multigenerational homes, primarily with grandparents. By age 8 and afterward, about one third of the sample lived in a single-parent household headed by the mother. This is not atypical of the local community, in which 31% of a random sample of the schoolmates of these mid-adolescent students also lived in households headed by their mothers. The greatest contrast was in the living circumstances of the other two thirds. For the random sample of local peers, 60% lived in intact families, either with both their parents or with a parent and stepparent. In contrast, only 29% of the Abecedarian sample lived in two-parent households. Thirteen percent of them still lived in complex, multigenerational households, and an additional 7% lived with grandparents only.

Cognitive and Academic Outcomes

Analytic strategy General linear models were used to analyze the data for the continuous dependent measures such as scores on standardized tests. Repeated measures models were used as applicable (McCall & Appelbaum, 1973). In these analyses, patterns of intellectual development are examined by partitioning the test score variance into between-subjects and within-subject components. The between-subjects score was computed as the mean of repeated assessments of intelligence or academic achievement (i.e., the across-time mean scores). Within-subject scores are computed from orthogonal polynomial contrasts that permit estimates of the magnitude of linear, quadratic, cubic, and higher order patterns of change over time. Age 15 intellectual and achievement test scores were also analyzed in isolation to test the degree to which preschool and school-age treatment/control group differences were maintained to that point. Two models were tested both longitudinally and in isolation: First, the data were tested to see if scores increased as a linear function of the duration of treatment—that is, $EE > EC > CE > CC$. Next, 2 (preschool groups) $\times$ 2 (school-age groups) models were tested to see if mean scores on the dependent variables differed as a function of preschool or school-age treatment.

Intellectual outcomes. Figure 2 gives mean intellectual test scores from age 3 to 15 for the four Abecedarian treatment groups. The preschool IQ data are not usually reported in this manner because the random assignment of children into school-age groups did not actually occur until nearly age 5. However, because some of the analyses described below are based on the four groups, the means have been arrayed in this manner to facilitate understanding of the outcomes. Table 4 gives IQ means averaged across time for the four treatment groups and also summarizes the repeated measures analysis of variance, giving values of F tests for the between-subjects and within-subjects scores.

Analysis of variance for repeated measures indicated that higher IQ scores over time were positively related to the duration of treatment ($F(1,80) = 8.92, p < .004$). In particular, as can be seen in Figure 2, children who received preschool treatment had higher IQ scores over time than children in

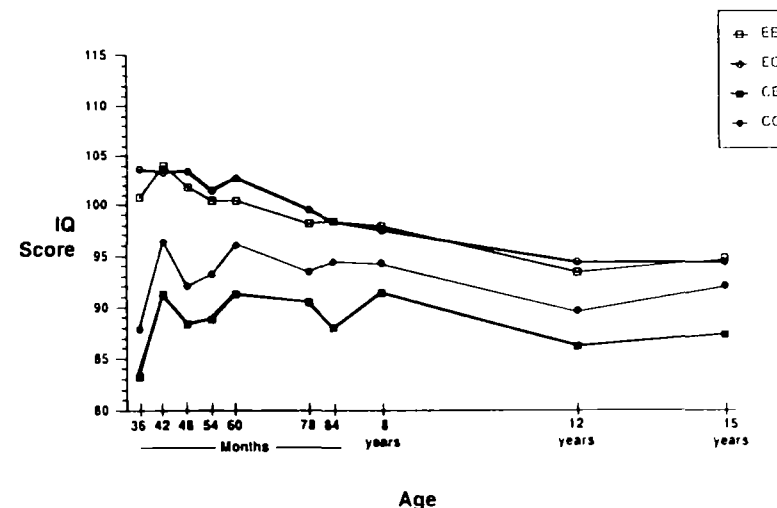


Figure 2. Cognitive test performance from 3 to 15 years as a function of Abecedarian treatment group

the preschool control group. The average IQ score advantage for individuals treated in preschool was 8.8 points, with a range of 16.4 points at age 36 months to 4.5 points at age 8; the final difference, at age 15, was 4.6 points. Effect sizes for IQ differences (the difference in means between treated and untreated subjects, divided by the SD of the untreated group) ranged from 1.22 at age 36 months to .35 at age 15.

For the entire sample, intellectual development was characterized by change over time ($F(9,72) = 7.24, p < .0001$) with a significant linear decline ($F(1,80) = 21.31, p < .0001$) and cubic change ($F(1,80) = 16.87, p < .0001$). However, the patterns of change in IQ differed significantly in relation to the duration of treatment ($F(9,720) = 4.36, p < .0001$). Again, these differences were largely related to preschool intervention. Whereas the children who received preschool treatment were more likely to show declining IQ scores after age 3, the preschool control children displayed modest gains in IQ over time. However, it is important to keep in mind that the average IQ scores of the preschool treatment group always exceeded those of the preschool control group.

When the age-15 Full Scale WISC-R scores were analyzed alone, none of the models (duration-of-treatment or preschool $\times$ school-age estimates) attained the .05 level of significance, although there was a strong trend toward a difference as a function of preschool group assignment, in the expected direction, $F(1,88) = 3.06, p < .08$. Interestingly, the size of the treatment effect on IQ at age 15 ($ES = .35$) is virtually identical to that seen at age 8, the treatment endpoint ($ES = .36$).

Table 4
Parameter Estimates and F Ratios for Preschool, School-Age, and Preschool $\times$ School-Age Group Comparisons for Abecedarian Intellectual Test Scores From Age 3 to 15 Years

	Parameter estimates group				Source of variance		
	EE	EC	CE	CC	PS $F(1,80)$	SA $F(1,80)$	PS $\times$ SA $F(1,80)$
Overall mean IQ	M 99.4 sd 10.7	M 100.2 sd 8.5	M 98.9 sd 10.3	M 93.1 sd 10.5	15.8***	1.3	0.6
Linear change	M -9.01*** sd 9.65	M -10.35*** sd 11.50	M -1.24 sd 14.45	M -1.69 sd 7.91	11.5**	0.1	0.0
Quadratic change	M 3.11* sd 6.04	M 3.22* sd 7.45	M -3.16* sd 5.75	M -1.30 sd 7.95	13.1***	0.4	0.3
Cubic change	M 3.10* sd 6.64	M 2.33 sd 5.34	M 5.67*** sd 6.25	M 5.90*** sd 6.21	5.2*	0.0	0.1
Quartic change	M -0.87 sd 6.23	M -0.59 sd 6.39	M -0.71 sd 6.47	M -1.60 sd 5.05	0.1	0.1	0.2

Note: Higher order terms are not reported because the linear through cubic terms accounted for almost all of the change over time. The change parameters estimate amount of that type of change for the 12-year period, so divide parameter estimate by 12 to get the rate of change per year.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Academic. Benefits of early treatment were more strongly apparent for academic test scores than for IQ test scores. Figure 3 shows mean age-referenced Standard Scores for the WJ Reading Cluster at three ages: 8, 12, and 15 years. Analyzed longitudinally, there were main effects for the duration of treatment hypothesis ($F(1,80) = 10.46, p < .002$) and for preschool group ($F(1,80) = 9.30, p < .003$). There was also a significant change over time, described by a dip in Standard Score at age 12 and recovery at age 15 for three of four groups ($F(2,79) = 14.14, p < .0001$), but there were no time $\times$ treatment history interactions.

The results for mathematics, graphed in Figure 4, paralleled those for reading: Analysis of mathematics Standard Scores showed significant main effects for the duration of treatment hypothesis ($F(1,81) = 5.07, p < .03$) and for preschool group ($F(1,81) = 4.75, p < .04$). There was a significant change over time: All groups decreased in age-referenced Standard Scores from age

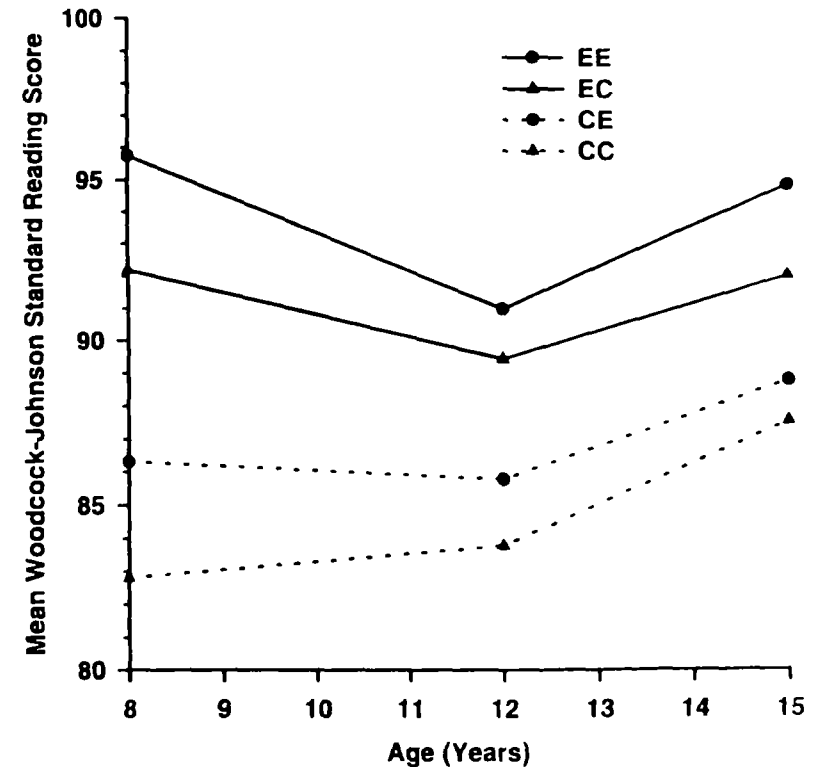


Figure 3. Woodcock-Johnson age-referenced standardized reading scores at ages 8, 12, and 15 years by Abecedarian treatment group

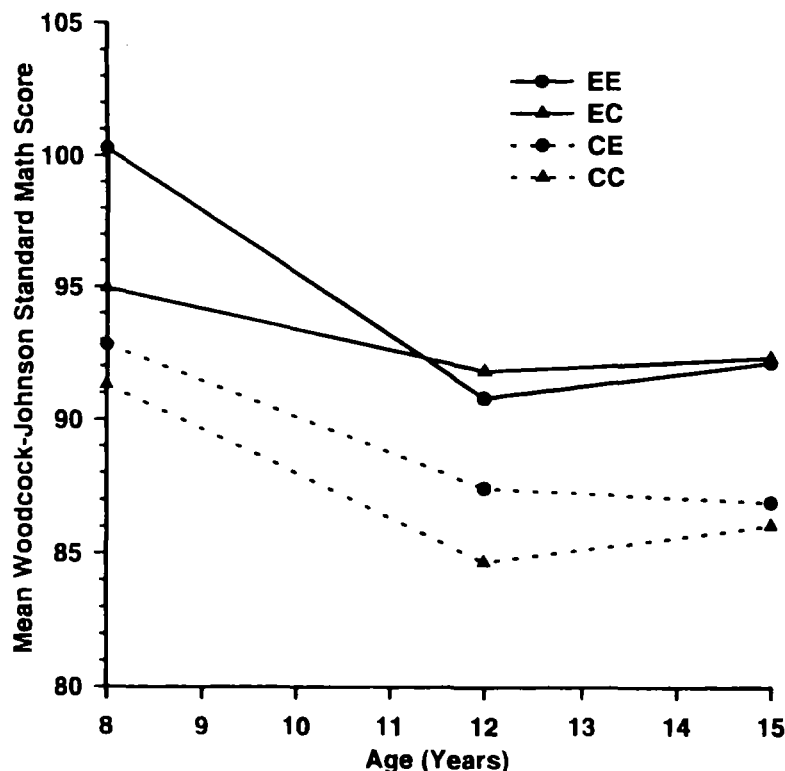


Figure 4. Woodcock-Johnson age-referenced standardized mathematics scores at ages 8, 12, and 15 years by Abecedarian treatment group

8 to 12, then scores remained steady ($F(2,80) = 16.94, p < .0001$). Again, there were no time $\times$ group interactions.

When the age-15 academic test scores were analyzed in isolation, the results indicated that children treated in the preschool years earned significantly higher scores in both reading and mathematics at age 15 ($F(1,88) = 4.22, p < .05$, and $F(1,88) = 4.18, p < .05$, respectively). When child gender, maternal IQ, and the quality of the preschool home environment were added to the models, the treatment effects were strengthened somewhat ($p < .02$ for reading, $p < .03$ for mathematics). In addition to treatment, maternal IQ was significantly related to reading ($F(1,85) = 15.82, p < .0001$) and to mathematics ($F(1,85) = 16.05, p < .0001$), but the effects of gender and the quality of the preschool home environment were not significant for either subject, given the other variables in the model.

School progress. Through 10 years in school, children who had the Abecedarian preschool treatment made better school progress, in terms of fewer retentions in grade and fewer assignments to special education programs, than those in the preschool control group. Figure 5 gives the percentage of each school-age group retained in grade during the first 10 years. Overall 31.2% of preschool E-group children were retained in grade compared to 54.5% of the preschool C group, a statistically significant reduction in rate: chi square_(1, N = 931) = 5.10, $p = .02$.

Assignment to special education varied from 12% in the EC group to 47% in the CE and CC groups, as shown in Figure 6. Again, chi square showed a significant positive difference related to preschool treatment (chi square_(1, N = 931) = 5.47, $p = .02$). Overall, 24.5% of preschool E-group children were placed in special education compared to 47.7% for preschool Cs.

Expanding the category of extra services to include students with records of receiving supplements that did not require formal diagnosis and IEPs showed that the use of such supplements was quite high among all the

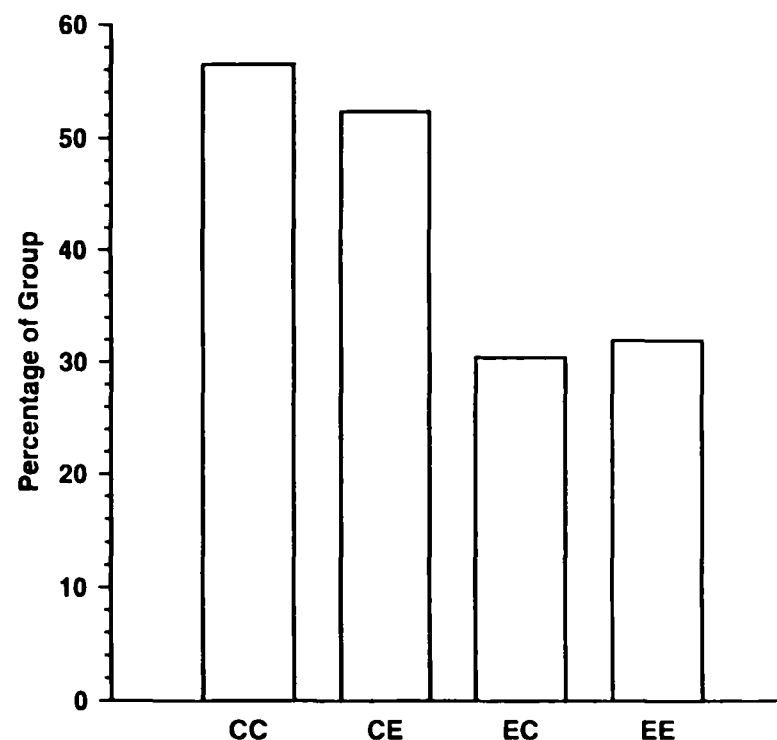


Figure 5. Percentage of Abecedarian treatment groups ever retained in grade through age 15

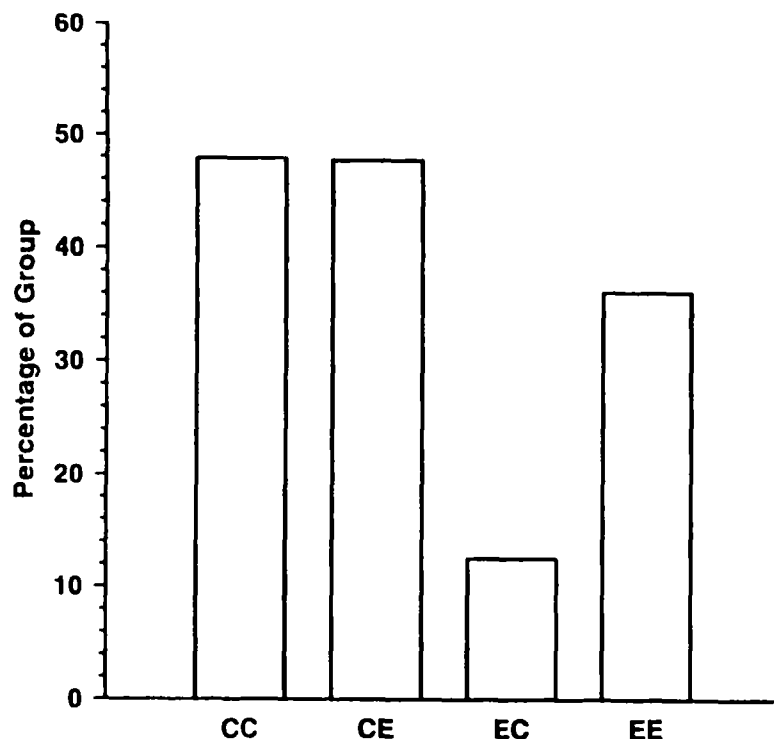


Figure 6. Percentage of Abecedarian treatment groups assigned to special services, grades K-9

Abecedarian groups, ranging from 64% in the EE group to 81% in the CE group, and there were no systematic differences in proportionate rates related to intervention history. Clearly, the school system had made extensive use of supplemental services for these students from low-income families. In contrast, only 6.5% of a randomly identified local comparison group had received such services at either the formal or informal level.

Comparison with other long-term studies. It is of interest to compare the Abecedarian study outcomes with those of similar early childhood programs. Two previous programs are of particular relevance: the Milwaukee Project (Garber, 1988) and the Perry Preschool Project (Schweinhart & Weikart, 1980). All three programs were experiments with children randomly assigned to treatment and control conditions. All three treated children from economically disadvantaged families, primarily African American, but their selection criteria varied somewhat. The Milwaukee study sample was limited to children born to very low-IQ mothers (IQ < 75); the Perry Preschool Project enrolled children aged 3 years or older, with 3-year IQs between 70

and 85 points; the Abecedarian study used a weighted combination of scores reflecting family sociodemographic factors to determine eligibility. Programs varied also. The Perry Preschool provided a half-day center-based educational program for children aged 3 to 5, with family visits in the afternoons. The Milwaukee and Abecedarian programs provided child-focused, full-day educational intervention within a day care/preschool setting, from infancy through age 5. The Milwaukee project continued its educational program through the children's kindergarten year. In contrast, the two phases of the Abecedarian design involved staggered ages of entry (infancy or age 5) and termination of treatment (age 5 or age 8). Mid-adolescent intellectual and academic outcomes are available for all three programs, although the adolescent academic data from the Milwaukee study have not been published.

Table 5 shows means for mid-adolescent IQ scores reported by all three intervention studies. The Milwaukee and Abecedarian programs appear to have had a more enduring impact on the intellectual test performance of treated individuals than did the Perry Preschool Project. Subjects treated in the Perry Preschool no longer showed a significant IQ advantage over controls by age 7. The groups differ by only one IQ point at age 14. In contrast, the children treated in the Milwaukee study consistently outscored controls through age 14. At that time, the last occasion for which scores are available, they maintained a 10-point IQ advantage over their controls. Abecedarian children treated in preschool also outscored controls through age 15, but not as dramatically. To provide a more comparable contrast between the Milwaukee and Abecedarian studies, the treatment/control difference in IQ for Abecedarian participants born to very low-IQ mothers was calculated. Thirteen of the Abecedarian mothers had IQ scores of 70 points or below. It is interesting to note that, when mean IQ scores are compared for the 12 of these Abecedarian subjects (6E, 6C) for whom age-15 child IQ data are

Table 5
Adolescent Mean Intellectual Test Scores for the Abecedarian, Milwaukee, and Perry Preschool Early Educational Programs and Academic Test Scores for the Abecedarian and Perry Preschool Programs

Program	Treated group	Control group	Mean IQ score
Abecedarian ^a	94.98	90.34	
Perry Preschool ^b	81.02	80.71	
Milwaukee ^b	101.06	91.13	
California Achievement Test range of mean percentile scores			
Abecedarian	38-41	28-30	
Perry Preschool	15-17	< 10	

^a= based on the WISC-R.

^b= based on the WISC.

available, the preschool treatment/control difference is 11.7 IQ points, very comparable to the age-14 Milwaukee treatment/control IQ difference.

Both the Abecedarian study and the Perry Preschool Project obtained California Achievement Test (CAT) percentile scores for academic achievement in reading, mathematics, and language at eighth grade. Abecedarian children earned higher average scores than did the Perry Preschool Project subjects: Mean CAT percentile scores ranged between 38 and 41 for Abecedarian preschool experimental subjects; those of the preschool controls were between the 28th and 30th percentile. In contrast, subjects treated in the Perry Preschool Project earned mean academic achievement scores between the 15th and 17th percentiles, and their controls earned scores below the 10th percentile (L. J. Schweinhart, personal communication, May 1993). Thus, for the Abecedarian and Perry Preschool studies, statistically significant academic benefits related to preschool programs were maintained into adolescence, long after treatment had ended. The Milwaukee study reportedly found no treatment/control differences in academic performance by 7 years in school (H. Garber, personal communication, June 1992).

Discussion

We may answer the questions posed in the introduction as follows: (1) Through mid-adolescence, there were different patterns of intellectual development in individuals treated in the Abecedarian preschool program compared to preschool controls; (2) a significant difference in academic test performance was maintained through 10 years in school for both reading and mathematics; (3) there were significantly fewer instances of assignment to special education and retention in grade for those who had preschool treatment; and (4) the more optimal timing for educational intervention was during the preschool years.

The mid-adolescent cognitive and academic benefits associated with the Abecedarian program represent one of the most durable positive effects of an early childhood educational program reported to date. Because assignment to treatment and control conditions was random, it is plausible to conclude that the early educational treatment itself was responsible for the benefits found. The results generalize primarily to African Americans because almost all the Abecedarian subjects were of that ethnic background. This heightens the importance of the results because educational discouragement appears to be an especially serious problem for African-American students. One large study found that, despite beginning first grade at readiness levels equal to those of White children, African-American children fell behind almost immediately (Alexander & Entwisle, 1988). As the present study shows, early failure among this population can be significantly reduced with an intensive preschool program.

Comparing academic test scores across the four Abecedarian treatment groups indicates that the preschool treatment was more strongly associated with the improvement in academic achievement than was the later school-age intervention. Although inspection of the means suggests that, for reading

test scores, a modest, long-lasting benefit was associated with having school-age treatment added to preschool experience, there was no evidence that having the school-age program boosted mathematics performance above the level of gain associated with preschool treatment alone. The mean mathematics scores of the EE and EC groups are virtually identical both at age 12 and age 15. For subjects untreated in preschool, the school-age program alone did not produce lasting improvement in reading or mathematics. The slight advantage in academic scores shown by the CE group compared with the CC group at age 8 is not seen at age 12 or age 15.

We cannot interpret with certainty all the reasons why 5 years of preschool education in a child care setting produced larger and more enduring treatment effects than did 3 years of family-mediated intervention during the primary grades because the design does not permit the effects of duration, timing, or modality of treatment to be definitively disentangled. The design unavoidably confounds duration (8 versus 5 versus 3 years), timing (infancy and early childhood versus the primary school years), and treatment delivery models (direct teaching of the child versus parent-mediated home activities) such that it is impossible to know for certain what factors were responsible for the stronger influence of preschool treatment on intellectual and academic outcomes. There are logical suppositions, however. If the primary factor was simply duration of treatment, then the EE group should outscore all others at all points from age 8 onward. They do not do so, except in the case of reading. Neither IQ scores nor mathematics scores show any advantage for students who had school-age intervention added to preschool intervention. In contrast, there is always a strong academic advantage for students treated in the preschool years over those who lacked such treatment, and, to a lesser extent, there is also an advantage in IQ scores. Thus, the data support the conclusion that 5 years of preschool are almost equally as effective at enhancing child IQ and academic achievement as 5 years of preschool with a 3-year follow-through and definitely more effective than intervention offered only from age 5 to 8. The Abecedarian outcomes may be interpreted as supporting the principle labeled by Kessen (1979) as the *primacy of early experience* because the results suggest that educational intervention very early in the life span had a greater impact than experiences provided later.

It is quite plausible that, compared to the school-age program, enhancing the educational stimulus value of the infant and preschool environment through a full-day, year-round child care program represented a more powerful contrast to the early childhood environments of the preschool control children. After they entered public school, all children were exposed to highly educational environments during the school day, whereas the school-age intervention altered only part of what went on at home. Thus, the school-age treatment was probably less salient within the whole context of the child's day. Certainly, the service delivery model employed in preschool provided more control over the degree to which the children were exposed to the educational opportunities it afforded. In contrast, the supplemental activities delivered through a parent-mediated program could not guarantee

actual delivery of the experiences. However, over 90% of parents reported having completed the activities with their child, and fewer than 2% of the activities were given negative ratings by parents; 83% were given positive ratings, and 16% were neutral (Ramey & Campbell, 1991).

There is other evidence from preschool research suggesting that a child-centered program, rather than a parent-mediated approach, has merit. Project CARE was a study conducted at the child development center immediately following the Abecedarian study. Children in the CARE study were randomly assigned to three conditions. One group had center-based intervention, based on the same curriculum provided for Abecedarian subjects, supplemented by having the day-care teachers also make regular home visits to teach parents how to use the learning activities at home. In a second group, labeled the Family Education group, parents were visited at home weekly, provided with the same materials used in the day-care program and taught to use the activities with their children. Children in this group did not attend the day-care program, although they may have gone to other child care centers. A third group was untreated, but some children may also have attended other child care centers. At the end of the preschool years, children in the Family Education group were not different from untreated controls in cognitive development (Wasik, Ramey, Bryant, & Sparling, 1990). While these findings do not negate the importance of involving families in children's programs, they do imply that early interventionists should not abandon programs in which children themselves are a primary focus.

Even if one concedes that intervention in early childhood had a more powerful effect, it is still necessary to explain the fact that mid-adolescent academic test scores and indexes of school progress (or of not making satisfactory progress) still showed positive effects from an intervention that happened so many years earlier. The most parsimonious explanation appears to be that the early cognitive gains reflected in higher preschool IQ scores were associated with greater mastery of academics from the start, which led, in turn, to better performance thereafter. At least, through age 15, early mastery has continued to be associated with higher scores on tests of reading and mathematics. There does appear to be support for the suggestion by Zigler, Abelson, Trickett, and Seitz (1982) that early academic success is associated with continued success. Academic benefits do not appear to be entirely dependent on continued enhancement of IQ. In this study, IQ differences were less pronounced at age 15 than were academic benefits, and the Perry Preschool study also found mid-adolescent academic benefits in the absence of any demonstration of lasting IQ benefits.

Further analyses now underway will determine what factors, in addition to a general enhancement of the level of general intelligence, were related to the lasting academic gains in the preschool E group. The Abecedarian results, in combination with the results of the Perry Preschool Project and the Milwaukee Project, suggest that the relationship between IQ scores and academic outcomes is not a simple, direct one. Despite maintaining an apparently larger IQ advantage than that of the Abecedarian subjects, children

treated in the Milwaukee study lost their academic edge by adolescence. In contrast, although treatment/control IQ differences eroded quickly in the Perry Preschool study, treated children showed an increasing academic advantage over their controls from fourth to eighth grade (Schweinhart & Weikart, 1980). Similarly, students in the Abecedarian study show a recovery from age 12 to age 15 in reading scores which is not matched by a parallel change in IQ scores. Thus, if students being reared in poverty are to maintain early academic gains related to preschool intervention, it appears that other mediators, in addition to an enhancement of IQ test performance, are likely to be involved.

Woodhead (1988) has speculated that, even in the absence of enduring IQ or achievement test differences, early intervention may change the psychosocial functioning of treated children, leading teachers to perceive them in more positive ways and influencing the teachers' decisions about nominating these children for grade retention or assignment to special classes. To what extent might teacher perceptions of the children or attitudes toward the Abecedarian program have played a role in enhancing the school progress of the Abecedarian students?

The attitudes of elementary school teachers toward the Abecedarian preschool program may have influenced their perceptions of its graduates, but there is little evidence on this point. The elementary school teachers did know which children participated in the Abecedarian study because they were asked to rate the children's classroom behavior and to permit observations of target students in their classrooms. However, it is not clear that teachers could distinguish between children who had been treated in preschool and those who had not, because all of the study participants had the same sorts of data collected within the schools. Teachers whose pupils had the school-age phase of treatment were very much aware of it, because regular meetings between the classroom teacher and the home/school resource teacher were essential to the development of the supplemental curricula for the program.

The most pertinent data that exist relative to teacher perceptions of the students consist of teacher ratings of classroom adaptation made in the first 3 years of school. On the CBI, early elementary teachers showed a marginal trend to rate verbal intelligence higher for children with greater amounts of treatment (Ramey & Campbell, 1991). However, there is also evidence that children treated in the preschool were not necessarily seen as better behaved (Haskins, 1985). We would therefore conclude that the elementary school teachers had no consistently positive bias toward these children, as a group.

Clearly, there were other factors in the homes, schools, and communities of the Abecedarian students and those of the participants in the other studies which influenced outcomes in mid-adolescence. Speculatively, the 20 children treated in the Milwaukee study faced the worst odds in later life, given the intellectual limitations of their mothers and the urban ghetto communities in which they were reared. Despite better IQ test performance, they did not retain an academic edge in their ghetto school environments and homes where parental support for learning may have been weak. Perhaps the

Abecedarian and Perry Preschool students had somewhat more supportive educational settings across this time span, or their families were better able to facilitate their progress, or both. Of the three studies, the Abecedarian population was most heterogeneous with respect to initial parent/child ability levels, which could account for the higher academic test scores earned by its adolescent participants relative to those in the Perry Preschool study.

Policy implications. The long-term results from the Abecedarian Project underscore the need for high quality learning environments for impoverished infants, toddlers, and preschoolers. This study demonstrates that, if such children are given high quality educational experiences during the preschool years, their academic performance and school progress may be significantly enhanced through middle adolescence. The untreated control children, reared within their natural ecology, had high rates of academic failure reflected in more grade retentions and in more assignments to special education. These outcomes are based on a sample of students almost entirely African American in ethnicity, but they may generalize more broadly. The program's essential elements were applied in the Infant Health and Development program provided for almost 1,000 low-birth-weight children at eight sites nationwide. The large sample of infants was ethnically much more heterogeneous than the Abecedarian sample, having large numbers of Whites and Hispanics as well as African Americans. Results through age 3 were comparable to those for Abecedarian subjects for all but the unhealthiest infants (Infant Health and Development Program, 1990; Ramey, Bryant, Wasik, Sparling, Fendt, & LaVange, 1992).

Some of the children in the Abecedarian control group were cared for at home by their mothers; others were cared for by relatives; some attended other community child care programs. Within the preschool control group, exposure to preschool has been shown to facilitate the children's cognitive development (Burchinal, Lee, & Ramey, 1989). These results should not, however, be construed as proof that out-of-home care was the key element. The Abecedarian child care program had a low caregiver:child ratio, and the staff worked intensely and intentionally with each child on a daily basis to ensure that he or she benefited from the activities. It is quite likely that this type of early intellectual enhancement can occur in a variety of settings. Although these results do not definitively support one early child care setting over another, they clearly demonstrate that consistent exposure to early learning experiences has long-term implications. The key factor is likely to be that the environment was appropriately responsive to the needs of the developing child and provided continuing experiences from which enhanced intellectual development and literacy and mathematics skills emerged.

Although the Abecedarian program involved parents in a number of ways, each child also received, in addition, consistent, individualized teaching over a period of years. Parents living in poverty face a number of problems that can interfere with their ability to optimize their children's development (McLoyd, 1990). Although it certainly cannot replace parents, nor does it in any way minimize their importance, a high quality preschool program can

support and supplement parental efforts. The Abecedarian results also support the provision of services to poor children from infancy onward.

Based on the present results, the value of providing only a supplemental program in the primary grades of public school appears doubtful, being, by itself, not associated with greatly enhanced academic outcomes. Even though it is easier to provide supplemental services for children once they are in school, those who plan interventions for poor children should be aware that elementary school programs may have less impact on the children's academic performance than would programs begun earlier in the life span. On the other hand, mean scores for reading were higher in students who had school-age treatment added to preschool treatment. Further research needs to be conducted on the interaction between school-age treatment and child and family factors to learn how they may potentiate one another.

The present study has shown, in a controlled, randomized trial, that greatly improved academic performance is possible for economically disadvantaged African-American children. Extrapolating from long-term outcomes of the Perry Preschool Project, it is the hope of the Abecedarian investigators that the benefits found through mid-adolescence in our sample will eventually be reflected in better life circumstances in adulthood. The investigators are now in the process of collecting data as study participants attain age 21 to assess outcomes across the full developmental span from infancy to young adulthood.

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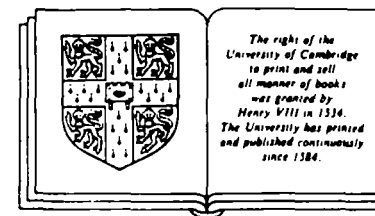
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8 Poverty, early childhood education, and academic competence: The Abecedarian experiment

Craig T. Ramey and Frances A. Campbell

Children from low-resource families are at high risk for academic underachievement as early in their school careers as first grade (Ramey, Stedman, Borders-Patterson, & Mengel, 1978). Low-resource children are at increased risk for retention in grade, for special education placement, (Lazar, Darlington, Murray, Royce, & Snipper, 1982), and for failure to complete high school (Brooks-Gunn & Furstenberg, 1986). Dropping out of school is linked, in turn, to increased rates of juvenile delinquency (Berrueta-Clement, Schweinhart, Barnett, Epstein, & Weikart, 1984), increased likelihood of teenage pregnancy, and intergenerational economic dependency (Furstenberg, 1976).

A crucial mediating factor in successful academic achievement is intellectual competence. Brighter individuals go further in school, have greater economic power (Jencks, 1972), and appear to lead healthier, more prestigious lives. Therefore, it is important to determine the extent to which intellectual competence can be enhanced through systematic interventions for high-risk children from low-resource families.

Early childhood education and family support are theoretically justified (e.g., Hunt, 1961; Ramey, Bryant, Campbell, Sparling, & Wasik, 1989), practical, and increasingly popular methods of intervention. A central theoretical and policy-relevant question is what are the relative effects of different methods of intervention? This chapter describes one long-term research effort

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to address that question – the Carolina Abecedarian Project, a program designed to determine the relative efficacy of multiple interventions intended to enhance the intellectual competence and academic achievement of children from socioeconomically disadvantaged families.

Method

Rationale

In 1972 we began the Abecedarian¹ Project at the Frank Porter Graham Child Development Center of the University of North Carolina. The research program involved investigators from developmental psychology, pediatrics, and early childhood education. The initial phase of the intervention program combined early childhood education, pediatric care, and family support services into an integrated intervention system. The focus of our efforts was on the question of whether these coordinated high-quality services, delivered from early in the child's life, could be instrumental in promoting intellectual competence during the so-called preschool years. Accordingly, in the Abecedarian Project, preschool educational intervention, in a day-care setting, was begun in infancy and provided continuously for the first 5 years of the child's life. A second phase of the intervention, in which parents were systematically supported in assisting their child's educational progress, began when the children entered public school as kindergarteners and continued for three school years. An endpoint evaluation took place when the children had completed these three years; the children were then approximately 8 years old. The primary outcome measures at age 8 included assessments of the children's intellectual development and academic performance as well as parent and teacher judgments concerning social competence.

Design

The design of the preschool study required two initially equivalent groups of high-risk children who subsequently would be treated educationally differently to determine if the treatment produced increased intellectual competence. Therefore, one of the key features of the Abecedarian Project was the random assignment of children to treatment and control groups. This assignment procedure is especially important because studies of educational intervention that treat only volunteers and have no experimentally adequate comparison group cannot determine if intellectual changes are the result of the educational treatment or of some other influence on development. Random assignment

¹ *Abecedarian* means one who learns the fundamentals of something, such as the alphabet.

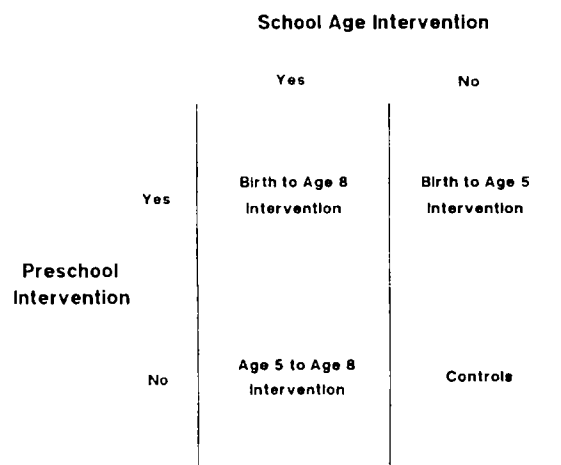


Figure 8.1. Experimental design of the Carolina Abecedarian Project.

is, therefore, a powerful scientific tool to ensure initial group equivalence, which is an essential feature for strong causal inferences.

Because children were randomly assigned to treatment groups at birth, the basis for equating the groups was derived from a combination of family risk factors. These were summarized into a High-Risk Index (Ramey & Smith, 1977). Equated pairs of children were assigned either to the preschool intervention group or to the preschool control group. Four cohorts of approximately 28 children each were admitted to the project between 1972 and 1977.

Before their entry into public school kindergarten, the children within the preschool intervention and control groups were re-randomized by equating pairs of children, within groups, on the basis of their Stanford-Binet IQ scores at 48 months and then assigning one of each pair to a school-age intervention group and the other to a school-age control group. Thus, half of each preschool group received the school-age intervention program. The resulting four-cell design shown in Figure 8.1 permitted a comparison of intellectual and academic outcomes in children who had a total of eight years of intervention, five in preschool and three in early elementary school (preschool plus follow-through), five years of intervention in preschool only (preschool intervention only), three years of school-age intervention only (school-age only), and no educational intervention provided by the Abecedarian Project (control condition).

Recruitment

The High-Risk Index (Table 8.1) that was used to screen families for eligibility included factors previously reported in the literature to be associated with

Table 8.1. High-risk index

Factor	Weight
Mother's educational level (last grade completed)	
6	8
7	7
8	6
9	3
10	2
11	1
12	0
Father's educational level (last grade completed)	
6	8
7	7
8	6
9	3
10	2
11	1
12	0
Family income (per year)	
\$1,000	8
1,001-2,000	7
2,001-3,000	6
3,001-4,000	5
4,001-5,000	4
5,001-6,000	0
Father absent for reasons other than health or death	3
Absence of maternal relatives in local area	3
Siblings of school age one or more grades behind age-appropriate level or with equivalently low scores on school-administered achievement tests	3
Payments received from welfare agencies within past three years	3
Record of father's work indicates unstable or unskilled and semiskilled labor	3
Records of mother's or father's IQ indicate scores of 90 or below	3
Records of sibling's IQ indicates scores of 90 or below	3
Relevant social agencies in the community indicate the family is in need of assistance	3
One or more members of the family has sought counseling or professional help in the past three years	1
Special circumstances not included in any of the above that are likely contributors to cultural or social disadvantage	1

mild mental retardation and academic failure, including low levels of parental education and family income and evidence of retardation or social maladjustment in family members. These factors were preassigned weights according to consensual professional estimates of their psychological importance. A family's total score was the sum of applicable weights earned. A family had to score 11 points or higher on the High-Risk Index to be included in the study.

Prenatal clinics and social service agencies were used to identify families

Table 8.2. *Entry level demographic data for preschool experimental and control families*

Variable	Group		Total (<i>N</i> = 109)
	Experimental (<i>N</i> = 55)	Control (<i>N</i> = 54)	
Mean maternal age (years)	19.56 (3.88)	20.28 (5.77)	19.92 (4.90)
Mean maternal education (years)	10.45 (1.75)	9.98 (1.91)	10.22 (1.84)
Mean maternal full-scale IQ	85.49 (12.43)	84.18 (10.78)	84.84 (11.61)
Percentage intact family	23%	26%	24%
Percentage black	96%	100%	98%

who appeared likely to qualify for the experiment. These families were then visited by a member of the center's staff who explained the project and obtained informed consent for participation. A final determination of eligibility was made after the mother of a prospective project family visited the center. On this occasion, the mother was again interviewed and administered an intelligence test, either the Wechsler Adult Intelligence Scale (Wechsler, 1955) or the Wechsler Intelligence Scale for Children (Wechsler, 1949), depending on her age. Following this second contact, scoring of the High-Risk Index was completed, and enrollment offered or not. Random assignment to groups was completed prior to an infant's 6-week birthday.

Participants

All children in the sample were full-term infants free from conditions known to have genetic or infectious links to mental retardation, but all were from homes with low levels of parental income and education. A total of 122 families were invited to participate in the study; 109 families to whom 111 children were born agreed to participate, accepted their random group assignments, and actually took part. By the beginning of the elementary school phase, attrition due to a wide variety of reasons had reduced the number to 96 children. Of these, 90 had IQ data collected by "blinded" assessors at the end of three years in public school, and 88 had scholastic achievement test data. Using the figure of 90 as the final sample size gives an attrition rate of 18.9%, or 1.46% per year over the 13-year span from entry of the oldest subjects until the youngest reached the 8-year-old endpoint. No systematic effects of attrition have been detected (Martin, Ramey, & Ramey, 1990).

Table 8.2 shows selected demographic characteristics of the mothers in the

study at the time of the child's birth. The mothers tended to be young, to have less than a high school education, and to be single parents. Maternal ages ranged between 13 and 43; approximately one-third of the mothers were 17 years old or younger when their children were born. Maternal IQs ranged from 49 to 124, with the mean falling at approximately 85 in both groups. Ninety-eight percent of all subjects were black, although race was not considered a risk factor on the High-Risk Index. The high proportion of blacks reflects the demographic characteristics of the university town where the study was conducted. Almost no qualified whites could be found within a distance that made daily participation feasible. (Participant families had to live within commuting distance of the center to allow the child potentially to attend the educational Child Development Center program.)

Preschool intervention

As just noted, preschool educational intervention was delivered in a child development center setting, where children were taught by the staff. Treated children attended the Child Development Center until they entered public school kindergarten at age 5. Families were offered and encouraged to participate in parent group sessions on a wide variety of topics related to parenting and family development. Parents also had access to the project's social workers, who provided instrumental, social, and emotional support. This support included direct assistance with such issues as housing and social services as well as personal counseling. Pediatric care was provided by a team of on-site research nurses and pediatricians.

Infants in the preschool intervention group began attending the center as young as 6 weeks of age; mean age at entry was 8.8 weeks. The project's goal for families was to have a warm and friendly, homelike atmosphere that families would find helpful and positive. For children the goal was to provide them with a safe and healthful environment staffed by sensitive and resourceful early childhood educators who would offer high-quality education and emotional support. The infant nursery accommodated 14 babies and was staffed by four caregivers. Curriculum materials to enhance cognitive, language, perceptual-motor, and social development were devised by Sparling and Lewis (1981) for use in this program. Educational experiences were chosen for infants based on the curriculum developers' and teachers' assessments of each child's needs, and the experiences were changed as the infant appeared to be ready for new challenges. These activities were fit into the child's daily schedule as natural events while infants paced themselves through the day. Toddlers likewise had flexible schedules for activities and nap times.

The preschool program became increasingly structured as children became developmentally more mature. The classrooms for 3- and 4-year-olds resembled other high-quality developmentally appropriate preschool programs.

with centers for housekeeping, blocks, water play, books, and art and quiet corners for 1:1 teaching or solitude.

Because a number of theorists have hypothesized that deficits (Blank, 1982; Tough, 1976) or differences (Heath, 1983; Labov, 1970) in the early language environments of disadvantaged children leave them unprepared for success in mainstream public schools, language development was especially emphasized in the preschool program. The focus was on pragmatic features of adult-child language in the context of natural conversations about daily life. Teachers received specific training so that their verbal exchanges with the children would be developmentally appropriate and would elicit prolonged conversations (McGinness & Ramey, 1981; Ramey, McGinness, Cross, Collier, & Barrie-Blackley, 1981). In addition, preliteracy curricula were used with older preschool children (Greenberg & Epstein, 1973; Wallach & Wallach, 1976).

In summary, the preschool educational program was designed to appear playful and spontaneous from the child's viewpoint, yet planful and structured from the adults' perspective. A more detailed description of the preschool program and its biosocial systems theory rationale can be found elsewhere (Ramey, Bryant, Campbell, Sparling, & Wasik, 1988; Ramey, MacPhee, & Yeates, 1982).

To increase confidence that developmental outcomes might be causally attributed to participation in the educational intervention rather than to improved nutrition via meals at the Child Development Center or general family support, some services were provided to participants in the control group. Thus, nutritional supplements were provided to children in the control group and supportive social work services were provided to families in both groups. Because children who attended the center received their primary medical care on-site, control children either received similar care on-site or were enrolled in local clinics developed by the same group of pediatricians. Thus, the main difference between the preschool intervention and control groups was that the intervention group received systematic education at the Child Development Center and the control group did not.

A number of basic scientific questions regarding early development have been addressed as an integral part of the research design. Thus, studies of basic language development (e.g., Gordon, 1984), health (e.g., Henderson, Gilligan, Wait, & Goff, 1988), mother-child interactions (e.g., Ramey, Farran, & Campbell, 1979), children's attachment to parents and day-care teachers (e.g., Farran, Burchinal, Hutaff, & Ramey, 1984), biological vulnerability (Breitmayer & Ramey, 1986), and parental beliefs and values (Campbell, Goldstein, Schaefer, & Ramey, in press) were conducted, to name but a few. However, because the central question being addressed was that of the malleability of intellectual competence, the children's performance on standardized tests of intellectual development provided the primary outcome measure of the effectiveness of the intervention during the preschool years.

The intellectual outcomes from the preschool intervention have been reported in previous scientific publications (e.g., Ramey & Campbell, 1984; Ramey, Yeates, & Short, 1984). On standardized tests of intellectual development the treated children significantly outperformed the control children at every testing occasion after the infancy period through the preschool endpoint assessment. On the McCarthy Scales of Children's Abilities (McCarthy, 1972) administered to children at 54 months of age, which was the preschool endpoint evaluation occasion, the intervention group children's mean General Cognitive Index score was 101, 10 points higher than the control group's mean score of 91 points ($t = 4.00, p < .001$). Moreover, by the age of 4 years, children in the control group were 6 times more likely to score within the mildly retarded range ($IQ < 70$) than were children in the intervention group (Ramey & Campbell, 1984). We made extensive efforts to assure that the intervention group children were not "taught the tests" upon which these outcomes were based. Tests were administered by persons not involved in the planning or delivery of the intervention program. Young children were tested with their parents present, not their teachers. Teachers were not allowed to observe testing procedures and were never given specific feedback about test results. Thus, we are confident that the intellectual results are as free of systematic bias as we know how to make them.

School-age intervention

The Carolina Abecedarian Project is not alone in having demonstrated that children from socioeconomically disadvantaged families, if given high-quality early educational intervention, outperform control children on intelligence tests during the preschool years. However, many investigators have reported also that early group differences in intellectual test scores tend to diminish over time, leading to questions of their durability and control factors (e.g., Baroff, 1974; Lazar et al., 1982). Incidentally, the diminishing of group differences is frequently due to the rising performance of control groups rather than to a fade-out effect of performance by the experimental groups. Generally, positive effects on later academic outcomes have been found for high-quality programs with sound experimental designs (Lazar et al., 1982).

In order to investigate the form, duration, and mechanisms of preschool intellectual effects, we designed a second phase of intervention to be applied to half the preschool intervention group and half the preschool control group. This design permitted an examination of the questions of the extent to which early gains might be maintained in elementary school with and without a follow-through program and of what could be accomplished, relatively speaking, through early elementary school intervention in conjunction with regular education. Half the preschool control group, educationally untreated in either phase, provided a basis for estimating the expected outcome for local high-

risk children under typical conditions in a highly resourceful and socially aware school system and a standard for comparison of the effectiveness of the three treatment conditions.

The rationale for the school-age intervention was that high-risk children might learn more slowly than average and thus would benefit from increased exposure to and tutoring in basic concepts in two key academic subjects: reading and mathematics. In addition, it was expected that the children would profit from having their parents become more directly involved in their educational program. The intervention program during the primary grades thus consisted of providing the children with extra exposure to academic concepts by having their parents engage in specific supplemental educational activities at home. Materials for this supplemental curriculum were developed by master-level home/school resource teachers. These resource teachers also provided emotional and social support to parents and consultation to classroom teachers.

To guarantee that the supplemental materials were of high quality and to enhance the program's credibility with classroom teachers, graduate-level teachers with backgrounds in primary education were recruited for the positions of Home/School Resource Teachers. The Home/School Teachers thus were qualified to act as consultants to classroom teachers when problems arose. Typically, a Home/School Resource Teacher worked each year with 12 children, their families, and their classroom teachers.

After meeting with the classroom teacher to learn which concepts were currently being taught in school, the Home/School Resource Teacher designed attractive, enjoyable and compatible home activities. The resource teacher then discussed these activities with the family, explained their purpose and their relationship to classroom activities, demonstrated their use, and encouraged parents to use them with their children on a regular basis. We hypothesized that regular visits by a professional educator who had specific knowledge about the child's classroom opportunities and performance, and who demonstrated *specific materials and procedures*, would lead high-risk parents to have a clearer idea of how to help their children. It was also expected that this process might lead the parent to take a more substantive interest in and to place greater value on the child's academic accomplishments. Another important goal of the Home/School Resource Program was to facilitate communication and establish trust between the high-risk family and the school system. In the Home/School Resource Teacher's dual role, working between home and school, the educator became an advocate for the family within the school system and for the school within the family.

A brief summary of the implementation data of the Home/School Resource Program is presented in Table 8.3. The Home/School Teacher met every other week with the parent, usually in the home but occasionally at the parent's workplace or some other location. The Home/School Teacher

Table 8.3. *Summary of Home/School Resource Program contacts by years*

	Year 1	Year 2	Year 3
1. Grade level	kindergarten	grade 1	grade 2
2. Number of children treated	46	46	45
3. Mean school visits	18.3	17.6	13.9
4. Mean home visits	15.4	14.2	12.5
5. Mean total contacts ^a	42.4	40.3	35.0
6. Ratings of parental acceptance of activities			
Positive	84%	82%	83%
Neutral	15%	16%	16%
Negative	1%	1%	0%

^aIncludes all telephone calls, special visits to home, and "other" contacts for each family.

conveyed any special messages from the classroom teacher regarding the child's academic achievements or behavior in class and introduced the new activities. Family life and adult issues were also discussed. Mothers sometimes revealed personal problems and sought advice. Accordingly, Home/School Teachers helped families with situations that, unattended, might have made it difficult or impossible for parents to devote energy to their child's school progress. Parents were helped to find jobs and decent housing as well as to secure appropriate social services to which they were entitled. In one case, a Home/School Resource Teacher arranged for a custodial grandparent to take adult literacy classes so that the child and his guardian learned to read at the same time.

In a typical year, approximately 60 different learning activities were designed for each child. These activities were maintained in research notebooks to document the curriculum. Many of these activities were original games created by Home/School Resource Teachers. In addition, ready-made activities to give practice in handwriting, phonics, and math concepts and facts were provided. Parents always were asked for feedback on these activities, including how much time they had spent doing them during the previous two weeks. The average amount of time parents reported working with their children on the activities was about 15 minutes a day.

The activities were generally popular with parents and well received. Most parents reported high levels of success and satisfaction in using them. Overall the parents participated enthusiastically and frequently; at the project's end the parents reported that they had found it a very positive experience and would have liked to continue to participate if the program had lasted longer.

During summers the school-age intervention group children participated in special programs. These activities included day camps, special tutoring in reading and mathematics, and organized field trips that were planned by the Home/School Resource Teachers.

Throughout the program the opinions and ideas of parents were solicited, and the parents' contribution to their child's development was emphasized. Parents were encouraged and assisted in their role as advocates for their children's welfare and development.

Results

Intellectual competence

Because level of intellectual functioning is a central issue for this educational experiment, IQ scores constituted an outcome of major interest. Figure 8.2 depicts average longitudinal preschool scores on tests of intellectual development for the preschool intervention and control groups across the range of child ages from 6 to 96 months. The early intervention significantly enhanced IQ performance. Multivariate analysis of variance for repeated measures showed that the scores of the preschool intervention group were consistently higher than those of the control group, particularly after the first year of life. Children in both groups showed some decline from above-average performance in infancy to age 8, but the control group declined significantly more than the intervention group, which was at national average at age 8. The control group initially showed a steeper decline followed by an increase in mean IQ scores after the 36-month assessment occasion until age 8 years. In contrast, the intervention group had a more even profile of higher IQ scores over the time span after infancy.²

To determine whether there were detectable intellectual effects during the second phase of intervention, scores on the Wechsler Preschool and Primary Scale of Intelligence (WPPSI) (Wechsler, 1967) at 60 months, and the Wechsler Intelligence Scale for Children-Revised (WISC-R) (Wechsler, 1974) at 78 and 96 months, were examined. Although scores on the McCarthy Scales of Children's Abilities administered to the children at 84 months were also available and were included in the full longitudinal analysis reported earlier, they were not included here to minimize possible artifacts due to differences between instruments in this more limited analysis. The means and standard deviations for the Wechsler test scores earned by the four school-age groups are given in Table 8.4.

The analysis model was a 2(Preschool Groups) $\times$ 2(School-Age Groups)

2 For the longitudinal set of intelligence test scores, repeated measures multivariate analysis of variance showed a significant between subjects effect for Group ($F_{(1,83)} = 17.93, p < .0001$), a multivariate effect for time ($F_{(1,83)} = 18.88, p < .0001$), and a Group $\times$ Time interaction ($F_{(1,83)} = 6.86, p < .0004$). Significant linear ($F_{(1,83)} = 38.31, p < .0001$), and cubic ($F_{(1,83)} = 31.00, p < .0001$) trends were observed across the two groups. There were Group $\times$ Time interactions in tests of the quadratic ($F_{(1,83)} = 9.54, p < .002$) and cubic terms ($F_{(1,83)} = 9.58, p < .003$).

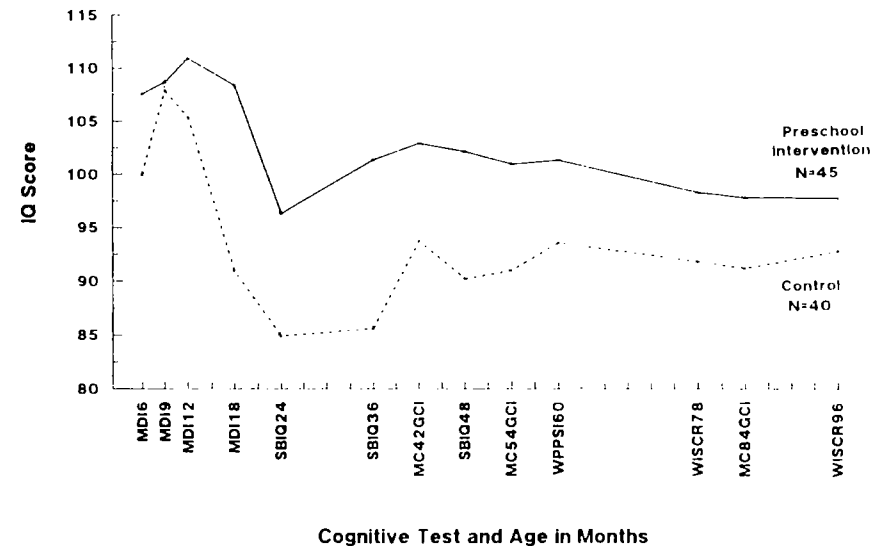


Figure 8.2 Intellectual competence results from the experimental phase of the Carolina Abecedarian Project.

$\times$ Time multivariate analysis of variance for repeated measures because no directional a priori hypotheses were stated concerning the durability of IQ performance as a function of intervention history. (Complete Wechsler test data exists at all three ages for 87 children.) Planned contrasts showed a significant difference between the preschool groups on mean IQ scores across the three occasions $F_{(1,83)} = 6.90, p < .01$. There was no significant effect for school-age group, and no significant Group $\times$ Time interaction. The results did show a significant multivariate effect for time $F_{(2,82)} = 4.51, p < .02$, which accounts for the approximately 2-IQ-point drop from age 5 to age 8 when averaged across all groups. Thus, for the 60-, 78-, and 96-month subset of scores, children who had preschool intervention scored significantly higher than those who did not. The difference was persistent across the first three years of public school with no evidence for a preschool fade-out effect. However, educational intervention that began during the primary grades was not associated with positive effects on IQ performance.

Academic achievement

Even more than scores on standardized intelligence tests, academic outcomes during the primary grades represent a critical test of the practical success of the educational interventions. Achievement in two basic subjects, reading and mathematics, was considered most important because they had been the

Table 8.4. Mean Wechsler full-scale, verbal, and performance IQ scores at 60, 78, and 96 months by school-age group

Group	N		60-month	N	78-month	N	96-month
			WPPSI Mean IQ (SD)		WISC-R Mean IQ (SD)		WISC-R Mean IQ (SD)
Control	23	Full scale	94.48 (13.83)	22	92.77 (11.47)	22	95.09 (12.69)
		Verbal	94.00 (13.09)		93.23 (10.46)		93.09 (13.01)
		Performance	96.04 (13.82)		94.04 (14.47)		98.09 (13.76)
School-age only	21	Full scale	92.76 (13.75)	21	91.71 (12.32)	20	91.40 (12.13)
		Verbal	93.62 (14.40)		93.95 (11.61)		92.10 (13.25)
		Performance	93.29 (12.79)		90.67 (13.40)		91.95 (12.29)
Preschool only	24	Full scale	102.50 (7.25)	22	98.86 (8.71)	23	97.78 (10.43)
		Verbal	103.46 (9.30)		99.36 (12.92)		96.91 (10.49)
		Performance	100.96 (7.38)		93.68 (12.89)		99.61 (12.21)
Preschool plus follow-through	25	Full scale	100.40 (13.69)	25	98.08 (14.86)	25	97.88 (13.09)
		Verbal	101.92 (13.25)		97.76 (16.43)		98.80 (13.28)
		Performance	98.56 (13.81)		94.76 (17.90)		97.60 (13.03)

primary focus of the Home/School intervention program, and they are the skills to which teachers and school administrators pay particular attention. Both age-referenced and grade-referenced measures were used to compare academic outcomes among the four experimental groups. The age-referenced measure held years of exposure to school constant when children were tested and consisted of age-referenced standard scores for reading and mathematics on the Woodcock-Johnson Psychoeducational Battery, Part 2: Tests of Achievement (Woodcock & Johnson, 1977), which was individually administered to all children by project staff at the end of three years in school. The grade-constant measures were either actual or projected³ reading and math-

3. Between 1980 and 1983, the state of North Carolina administered the criterion-referenced Prescriptive Reading Inventory and the Diagnostic Mathematics Inventory to children completing second grade; from these instruments, the test manufacturer projected California

Table 8.5. Means and standard deviations of age-referenced Woodcock-Johnson standard scores and percentiles and grade-referenced California Achievement Test standard scores and percentiles for reading and mathematics achievement by group

Group	Woodcock-Johnson			California Achievement Test		
	N	Standard score	Percentile	N	Standard score	Percentile
<i>Reading</i>						
Control	20	82.80 (12.43)	19.10 (18.66)	19	92.00 (9.64)	32.32 (21.15)
School-age only	20	86.30 (11.14)	23.25 (20.49)	19	95.37 (10.51)	40.05 (21.99)
Preschool only	23	92.17 (13.69)	34.87 (27.62)	21	96.24 (10.88)	42.57 (21.89)
Preschool plus follow-through	24	95.75 (12.87)	41.46 (27.75)	24	102.08 (12.90)	53.25 (26.33)
<i>Mathematics</i>						
Control	20	91.20 (14.16)	32.60 (28.18)	19	96.63 (11.55)	43.11 (25.29)
School-age only	20	92.80 (14.89)	37.20 (29.12)	19	99.37 (12.12)	50.32 (23.56)
Preschool only	23	94.96 (11.07)	39.09 (24.67)	21	106.81 (14.71)	63.14 (26.73)
Preschool plus follow-through	25	100.28 (13.11)	51.16 (28.69)	25	105.36 (13.88)	60.60 (27.06)

ematics scores from the California Achievement Test (California Achievement Test, 1978), which was group administered by school system personnel to all pupils at the end of second grade. The California Achievement Test scores became part of each child's permanent record and were released to the project investigators by the children's parents. Children not retained in kindergarten or first grade had both measures administered the same year; retainers of either year had the California Achievement Test after four, not three, years' exposure to school. Both instruments yielded age-referenced or grade-referenced percentiles or age-referenced or grade-referenced standard scores with means of 100 and standard deviations of 15.

Table 8.5 gives the age-referenced means and standard deviations for standard scores for reading and mathematics and percentiles earned by the four groups of high-risk children on the Woodcock-Johnson assessment at

Achievement Test percentile ranks that were reported along with other scores for each child. From 1984 on, the California Achievement Test itself was administered to children completing second grade.

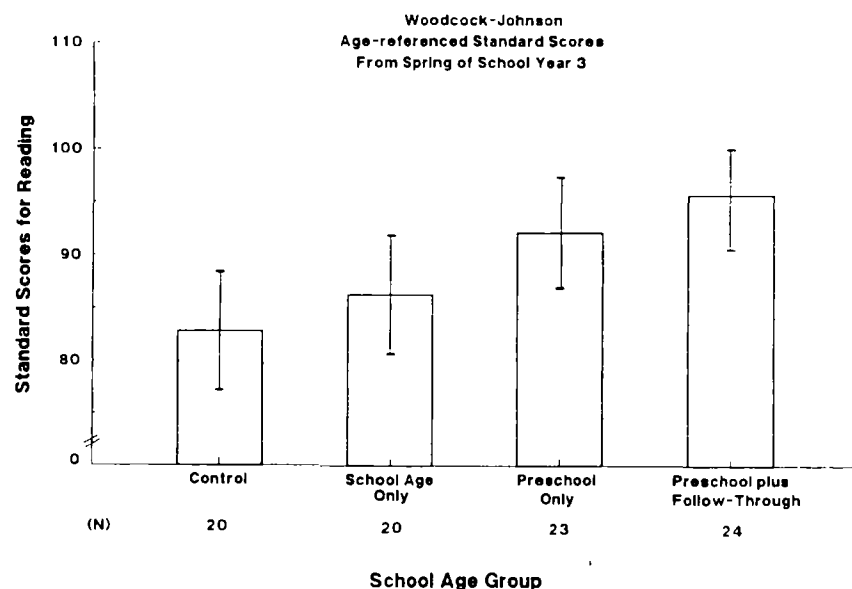


Figure 8.3. Means and standard errors of the mean for age-referenced reading achievement by group. Linear trend $F_{(1,79)} = 11.09$, $p = .001$.

the end of three years in school and their grade-referenced standard scores and percentiles from the California Achievement Test at the end of second grade. The standard score results for age-referenced performance are presented graphically in Figures 8.3 and 8.4. The grade-referenced achievement data are presented in Figures 8.5 and 8.6 for reading and mathematics respectively. The smaller group sizes resulting from the change to a four-group design for the school-age phase of the Abecedarian study led to the use of a different statistical strategy for examining academic achievement outcomes in order to maximize statistical power. A hierarchical order of scores was hypothesized, that is, a linear trend with academic achievement scores hypothesized to vary positively across the four experimental groups from low to high as the length of educational intervention increased. The first analysis of academic achievement outcomes consisted of a multivariate procedure in which this model was tested across all four sets of standard scores. The results showed a significant multivariate trend across groups for the grand mean of the four sets of scores ($F_{(4,76)} = 3.32$, $p < .02$). Separate univariate analyses were then conducted for each individual set of achievement scores.

The test for the Woodcock-Johnson reading scores showed that, with exposure to school constant, there was an overall linear trend in the means related to treatment amount ($F_{(1,79)} = 11.09$, $p < .001$). The same finding held for the Woodcock-Johnson mathematics scores; performance increased

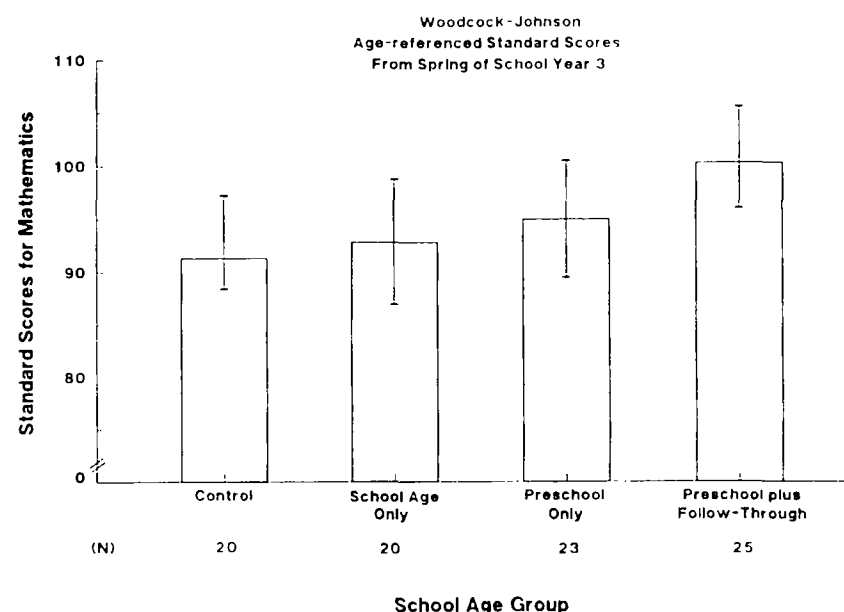


Figure 8.4. Means and standard errors of the mean for age-referenced mathematics achievement by group. Linear trend $F_{(1,79)} = 4.05$, $p = .05$.

as a function of the amount of intervention ($F_{(1,79)} = 4.05$, $p < .05$). Similarly, the univariate test of the California Achievement Test standard scores for reading revealed a significant linear trend as years of educational intervention increased ($F_{(1,79)} = 8.18$, $p < .005$) and so did the California Achievement Test standard scores for mathematics, ($F_{(1,79)} = 7.13$, $p < .009$). Thus, all four sets of academic achievement measures showed a significant trend for the mean scores to increase as a linear function of the amount of educational intervention.

Our conclusion with respect to scholastic achievement is that the hypothesized trend across groups from lowest to highest scores as a function of increasing amounts of intervention is seen for both reading and mathematics achievement whether one examines the outcomes holding child exposure to school or grade level constant. The average percentile rank on Woodcock-Johnson reading scores ranged from a low of the 19th percentile for the control group to a high of the 41st percentile for the preschool plus follow-through group. On the California Achievement Test for reading the comparable percentile ranks were 32 and 53.

With respect to mathematics achievement, the control group scored at the 33rd percentile on the Woodcock-Johnson test, and the most intensively treated group scored slightly above national average at the 51st percentile.

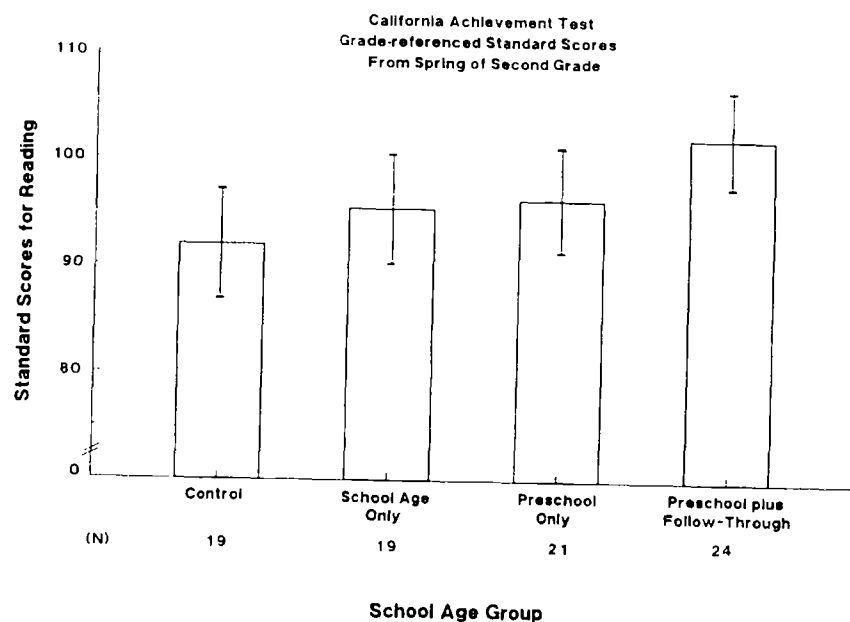


Figure 8.5. Means and standard errors of the mean for grade-referenced reading achievement by group. Linear trend $F_{1,76} = 8.18, p = .005$.

Similarly, on the California Achievement Test for mathematics, the control group was at the 43rd percentile while the preschool intervention plus follow-through group was the highest scoring group, at the 61st percentile.

The mean standard scores and percentiles both indicated that the children in this study scored slightly higher on mathematics than on reading. The findings also indicate that preschool intervention plus follow-through can result in groups of very high-risk children scoring at or above the national average at the end of the primary grades on tests that are either individually administered or group administered.

Retention in grade

In the elementary schools attended by Abecedarian children, the most likely response when a child had serious academic difficulty was retention in grade, especially in the early years. As a result, many of the high-risk children in the study were held back at some point during the first three years. Figure 8.7 shows the percentage of children in each treatment group retained in grade across the first three years in public school. Previously reported by Horacek, Ramey, Campbell, Hoffmann, and Fletcher (1987), these data show that the control group high-risk children overall fared much worse than the

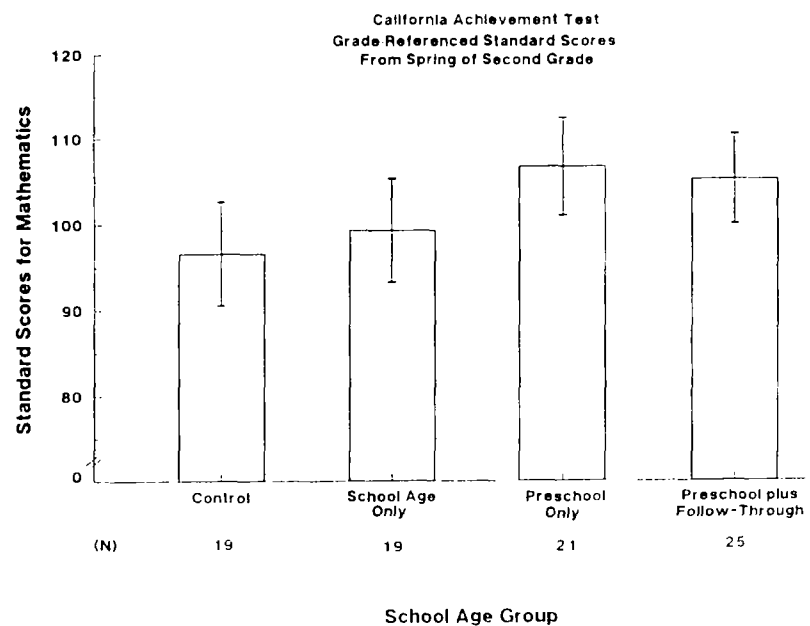


Figure 8.6. Means and standard errors of the mean for grade-referenced mathematics achievement by group. Linear trend $F_{1,76} = 7.3, p = .009$.

local systemwide average for retentions in the early grades, confirming the high-risk status of this sample, which was determined at birth.

Comparing the grade-retention rate among the high-risk groups in Figure 8.7, we found that the highest failure rate occurs in the control group and the lowest rate in the preschool plus follow-through group. In fact, the rate for the preschool plus follow-through group is very similar to that for the local population base rate of 13%. The group that received the school-age intervention only had a somewhat more favorable experience than the control group but less favorable than the group that received the more intensive and prolonged preschool intervention alone. Thus, the failure rate exhibits a decreasing pattern with increase in duration and intensity of intervention. A statistical test for this pattern of association was undertaken with the Spearman Rank Correlation statistic for ordered categorical data (Landis, Heymann, & Koch, 1978). Its result ($X^2 = 6.49, 1 df, r_s = -0.27$) was significant ($p = 0.01$). Also, specific tests were undertaken for each of the components of the intervention with the Mantel-Haenszel statistic (Mantel, 1963). With this method the preschool intervention was found to have the stronger effect ($X^2 = 4.78, 1 df, p = 0.03$), with the school-age effect being nonsignificant ($X^2 = 1.71, 1 df, p = 0.19$) but still in the positive direction.

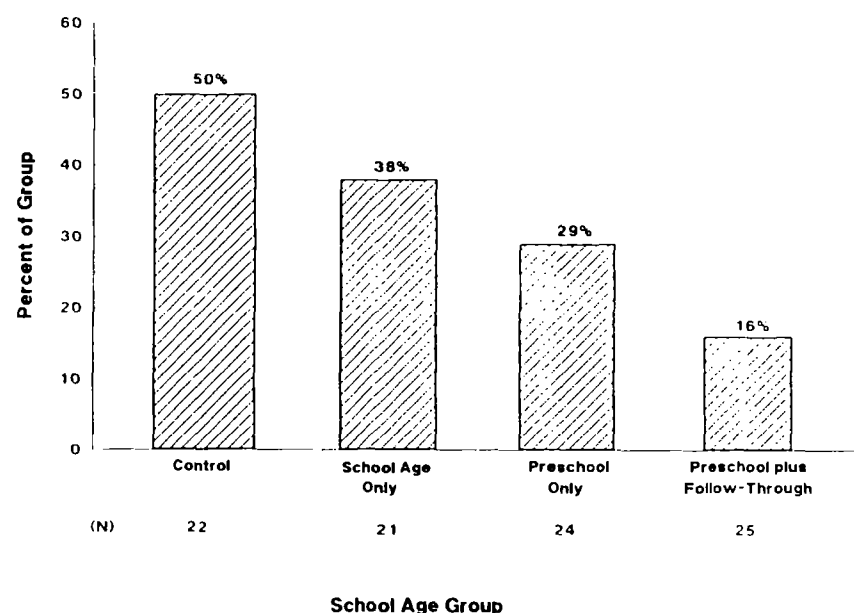


Figure 8.7. Percent of school-age intervention groups retained in grades kindergarten, 1, or 2.

Teacher ratings of classroom behavior

One measure of social adaptation to the classroom was obtained by having teachers rate the children's behavior in each of the first three years in elementary school using the Classroom Behavior Inventory (CBI) developed by Schaefer, Edgerton, and Aaronson (1977). This inventory contains 10 scales designed to measure three factors: Considerateness versus Hostility, Academic Competence, and Introversion versus Extraversion.

To learn whether the varying degrees of intervention experienced by the high-risk children had any effect upon teacher perceptions of the children's adaptation to the classroom, teacher ratings made in the spring of the third year in school were analyzed. The analysis strategy was to test for a linear trend across intervention groups as was done with the academic achievement scores. Ratings on three scales, representing the three dimensions of positive school adaptation, were analyzed. For the bipolar dimensions, Considerateness versus Hostility and Extraversion versus Introversion, the scales describing the considerateness and extraversion poles were chosen for analysis, and a scale labeled Verbal Intelligence represented the teachers' ratings of Academic Competence.

Means for these ratings across groups are given in Table 8.6. The academic

Table 8.6. Means and standard deviations of teacher ratings on selected classroom behavior inventory scales and mean *t*-scores from parent ratings on the child behavior checklist for four experimental groups

Group	Preschool plus follow-through Mean (SD)	Preschool only Mean (SD)	School-age only Mean (SD)	Control Mean (SD)
<i>Teacher ratings on Classroom Behavior Inventory</i>				
	N = 24	N = 23	N = 20	N = 20
Verbal intelligence	13.63 (3.95)	13.26 (3.82)	12.15 (4.03)	11.80 (3.83)
Considerateness	15.17 (4.56)	14.70 (4.53)	17.00 (3.97)	16.45 (3.69)
Extraversion	19.58 (3.69)	18.22 (3.55)	19.20 (3.82)	19.40 (3.52)
<i>Parent ratings on Child Behavior Checklist</i>				
	N = 22	N = 21	N = 20	N = 23
Activities <i>t</i> -scores	47.68 (6.65)	48.33 (5.69)	45.25 (7.85)	45.87 (7.29)
Social <i>t</i> -scores	49.82 (4.65)	48.33 (6.56)	45.45 (7.69)	49.35 (7.34)
Academic <i>t</i> -scores	43.14 (11.06)	45.38 (9.61)	42.65 (8.73)	40.70 (9.10)
Total problem <i>t</i> -scores	56.68 (12.05)	56.62 (8.01)	57.20 (11.95)	58.22 (9.61)

competence scores showed a marginally significant positive linear trend across intervention groups as a function of the number of years of intervention ($F_{(1,83)} = 3.09, p = .08$). Thus, children who had greater amounts of educational intervention were perceived as more competent than children who had lesser amounts of intervention. There was not a linear relationship between teachers' ratings of extraversion and considerateness as a function of increasing amount of intervention.

Parent ratings of child behavior. Parents completed the Child Behavior Checklist (Achenbach & Edelbrock, 1979) after the children had completed three years in public school. This instrument provides ratings of the child's adjustment or adaptation in four categories: range of activities, social adjustment, academic progress, and problem behaviors. Ratings in each category may be expressed as *t*-scores with a normative sample mean of 50 and a standard deviation of 10. Analysis showed no statistically significant relationship between the amount of intervention and parents' descriptions of the children's

behavior as measured by their responses to the Child Behavior Checklist. Applying the same linear model already described to Child Behavior Checklist *t*-scores, no significant linear trends were found across the four groups. Moreover, all mean *t*-scores were within normal limits indicating that for the primary school years these children as groups were not seen by their parents as at high risk for behavior problems.

Comparison with other preschool intervention programs

The Perry Preschool Project and the Milwaukee Project. It is instructive to compare the outcomes of the Abecedarian program with those of other intervention programs. Two other programs are particularly relevant because of their previous impact on public policy and because they are different from the Abecedarian program in important and systematic ways. The first, the Perry Preschool Project, was targeted, beginning in 1962, at 128 socioeconomically disadvantaged urban 3- and 4-year-olds who had pretest IQs between 70 and 90. Approximately half were assigned to receive a 2½-hour per day preschool education program coupled with a weekly family education home-visit program (Schweinhart & Weikart, 1989). Thus, this program was less intensive than the Abecedarian program and was remedial in nature rather than preventive. The other half of the sample served as completely untreated control subjects.

The second program, the Milwaukee Project, began in 1966, was set in an urban ghetto area, and provided intensive early intervention in an educational day-care setting for 17 socioeconomically disadvantaged children, beginning in early infancy. The children's mothers participated in an intensive family education and employment program. The sample children's development was compared to that of 18 completely untreated control children. In addition, the Milwaukee program required that the children admitted have mothers with IQs of 75 points or lower (Garber, 1988). Thus, the Milwaukee Project was preventive in nature and focused on a more intellectually restricted high-risk sample than the Abecedarian Project.

All three programs found significant differences between treated and untreated children's IQs at age 5. The Milwaukee study, however, reported much greater differences in IQ levels at age 5 between treated (mean = 120) and untreated children (mean = 94), a difference of 26 IQ points, compared with a difference of 11 points for children in the Perry Preschool Project (mean = 94 for treated and 83 for controls) and 8 points for Abecedarian Project 5-year-olds (mean = 101 for treated and 93 for controls). Similarly, the Milwaukee Project reported much larger group differences in IQ at age 8 for treated (mean = 103) and control subjects (mean = 83), approximately 20 points (Garber, 1988), than existed between Abecedarian preschool intervention (mean = 98) and control subjects (mean = 93) (approximately 5

points). By age 8, children in the Perry Preschool Project did not differ in IQ as a function of preschool intervention (mean = 88) in comparison to controls (mean = 87).

The three preschool programs varied in intensity, in duration, and also in the children's ages at entry into the programs. However, from the intellectual competence outcomes of the three studies taken together, one would infer that intervention for disadvantaged children is more effective and lasts longer if it begins in early infancy and is very intensive. Although IQ gains were demonstrated when intervention began at age 3, the gains were better maintained and treated children scored at significantly higher IQ levels in those programs that began intervention in infancy.

It is difficult to explain the discrepancy in the amount of difference between treated and untreated subjects in the Milwaukee and Abecedarian studies. The programs were comparable with respect to length of preschool intervention provided; both began in infancy, and both provided full-day programs for treated children. Recent re-analyses of the Abecedarian preschool data by Martin, Ramey, and Ramey (1990) have suggested that one reason for the apparent difference in outcomes for the two projects lies in the restriction of the Milwaukee sample to children with very low maternal IQs. Examining the differences in IQ between educationally treated and untreated Abecedarian children whose mothers had IQs within the retarded range (IQ < 70), Martin, Ramey, and Ramey (1990) found a difference of 21 points on the General Cognitive Index of the McCarthy Scales of Children's Abilities when children were 4½ years of age. This result is consistent with the results from the Milwaukee Project's difference of 26 points at age 5 and raises important questions about differential response to treatment by subgroups of poverty-level children. When, in the present study, the 96-month IQs for a continuing-to-participate subset of these children were compared, there was a difference between treated and untreated children of 13 points on the WISC-R full-scale IQ. The remaining 6 children of retarded mothers in the preschool intervention group had a mean IQ of 93.67 (*SD* = 7.00) at 96 months whereas the 5 such remaining children in the control group had a mean IQ of 80.20 (*SD* = 16.24). Because the numbers of subjects who actually had retarded mothers was so small, this finding, even though statistically significant, must be interpreted with caution, but it does suggest that had the initial groups of subjects in the Milwaukee Project and the Abecedarian study been more comparable with respect to maternal IQ level, the overall relative discrepancy between treated and control children's intellectual test performance might have been more similar in the two studies. Put another way, it appears that high-risk children of low-IQ mothers may be particularly responsive to intensive, high-quality preschool intervention and particularly vulnerable without it.

In none of the three longitudinal studies did the intellectual test scores of children in the preschool control groups display the trend usually reported

from cross-sectional studies of disadvantaged children, that is, a gradual and continuing trend downward as child age increases (Heber, Dever, & Conry, 1968). The Abecedarian longitudinal data for the preschool control group indicated a rather sharp drop from above average in tested intellectual level after the infancy period, followed by a gradual recovery toward national average at age 8 years. A slight rise in test performance when control children entered public school has been found in the present study, in the Milwaukee Project, and in the Perry Preschool Project. Thus, the introduction of systematic education is associated with increased intellectual competence in high-risk children.

The rise in intellectual competence for the Abecedarian control children actually began after the age of 3 years, before school entry (see Figure 8.2). Of particular importance is the fact that after the age of 3 years, many of the high-risk control children entered other preschools and day-care centers and thus also had the benefit of some preschool education (Burchinal, Lee, & Ramey, 1989). An active Head Start program and other high-quality preschools with scholarships for low-income children were available to and used by many Abecedarian control group preschoolers. From reports of the historically earlier Perry Preschool Project and the Milwaukee Project it does not seem that such programs were available to their control group subjects during the preschool years, which may account for the beginning of the rise in their control children's intellectual competence coincident with the onset of public school in their projects and for the earlier rise in the Abecedarian Project's control group. Neither were the Perry or Milwaukee control subjects provided with nutritional supplements or family supports. Thus, the results from the Abecedarian Project may be particularly conservative given the preschool services provided to its control subjects by the project and by the control group's participation in other preschool programs, particularly after the age of 3.

Scholastic achievement outcomes. When scholastic achievement is compared, all three studies reported significant effects of intervention on achievement test scores. Direct comparison of the three programs is difficult because of differences in the way outcomes are reported: The Milwaukee Project and the Abecedarian Project report outcomes in terms of standard scores and percentiles, but the Perry Preschool Project gives scholastic outcomes in terms of percentage of test items passed. It is possible to compare the significance levels of reported group differences for tests on reading and mathematics. The results, however, are based upon different test instruments and different procedures of data collection: The Perry Preschool program used California Achievement Test scores individually administered by project personnel; the Milwaukee study used Metropolitan Achievement Test scores administered

by the city; and the Abecedarian scores are based upon school-administered statewide standardized tests. The results are shown in Table 8.7.

Both the Abecedarian study and the Perry Preschool Project report end-of-second-grade preschool experimental versus control group differences. The Milwaukee p value is derived from an F test of the group differences in achievement data summed across the first four years of school. With these caveats, the generalization is that the Abecedarian preschool intervention group differed significantly from its control group in both reading and mathematics at the end of second grade. The Milwaukee experimental and control groups differed significantly in mathematics across four years but not in reading (Garber, 1988, p. 267), and the Perry Preschool experimental children differed marginally significantly ($p < .10$) on mathematics but not on reading at the end of second grade (Weikart, Bond, & McNeil, 1978, p. 49).

From data presented by Garber (1988), it is possible to compare post-second grade reading and mathematics percentile ranks for children in the Abecedarian and Milwaukee studies. (Comparable data are not available for the Perry Preschool Project to our knowledge.) These figures, given in Table 8.8, show that Abecedarian children who had preschool educational intervention earned higher percentile scores in both subjects than did the experimental group Milwaukee Project children. Differences existed, however, not only in the instruments upon which these percentile scores are based but also in the experimental procedures, which makes it difficult to know the best way to compare percentile scores across the two studies. For example, Abecedarian children, with one exception, entered public school kindergarten at age 5, whereas Milwaukee experimental children remained in their preschool program that year and entered public school as first graders. Milwaukee experimental group children had a summer tutorial in reading and mathematics after they had completed first grade. Not all treated Abecedarian children had summer tutorial programs, only those in the school-age intervention groups. Thus, it is difficult to know whether it is more relevant to compare the Milwaukee experimental group children with the Abecedarian preschool only group or with the Abecedarian preschool plus follow-through group. However, inspection of the Abecedarian California Achievement Test percentiles and the Metropolitan Achievement Test results reported by Garber (1988) shows that Abecedarian children earned higher percentile scores no matter which comparison is made.

On standardized tests of reading achievement at the end of second grade, children in the Abecedarian preschool only intervention group earned a mean score at the 43rd percentile, and those in the preschool plus follow-through group scored at the 53rd percentile, compared to the 25th percentile scored by children in the Milwaukee experimental group. In mathematics, the Abecedarian preschool only children scored at the 63rd percentile, and those in the preschool plus follow-through group scored at the 61st percentile, com-

Table 8.7. Reported significance levels for treatment/control differences in reading and mathematics achievement in early elementary school in three early intervention studies

Study	Subject	
	Reading	Mathematics
Abecedarian ^a	Preschool intervention > control $p = .03$ School-age intervention > control $p = .08$	Preschool intervention > control $p = .01$ School-age intervention > control $p = NS$
Perry Preschool ^b	Experimental > control $p = NS$	Experimental > control $p = .08$
Milwaukee ^c	Experimental > control $p = NS$	Experimental > control $p = < .05$

^aBased on a 2(preschool groups) 2(school-age groups) ANOVA on post-second grade California Achievement Test percentile scores.

^bBased on Group $\times$ Sex $\times$ Wave analysis of variance of California Achievement Test subtest raw scores.

^cBased on total subject percentile scores from the Metropolitan Achievement Test across years 1-4.

Table 8.8. Comparison of third school year academic achievement percentile ranks for Abecedarian and Milwaukee Project children

Subject	Group				
	Abecedarian ^a preschool plus follow-through	Abecedarian preschool only	Milwaukee ^b experimental	Abecedarian control	Milwaukee control
Reading	41.5	34.9	25.1	19.1	15.6
Math	51.2	39.1	22.6	32.6	10.4

^aAbecedarian scores are age-referenced percentiles from the Woodcock-Johnson Psychoeducational Battery, Part 2 (Woodcock & Johnson, 1977).

^bMilwaukee scores are percentiles from the Metropolitan Achievement Test, as reported in Heber (1988).

pared to the 22nd percentile for Milwaukee children. Thus, the higher IQ test scores earned by the experimental group children in the Milwaukee Project, relative to those in the Abecedarian study, were not associated with a comparable superiority in scholastic achievement.

It is difficult to interpret these Milwaukee-Abecedarian relative differences in scholastic achievement with confidence because the children were in dissimilar school systems. Garber (1988) described the neighborhood schools where his experimental group children would have been enrolled as "obviously poor" (p. 256), and he arranged to have most of the children enrolled in schools with better records of success. Nevertheless, the schools were still in the inner city. In contrast, the Abecedarian children were in a university town with a predominantly upper middle-class, highly educated population, which was reflected in classroom composition and academic expectations. The level of academic competition faced by Abecedarian children in their classrooms was high and persistent. Abecedarian children entered schools in which the typical child was intellectually about 15 IQ points above the national norm, and thus their classrooms were likely to have been stimulating and cognitively challenging. The public schools in Chapel Hill, North Carolina, also provided many resources for all pupils having academic difficulties. Because of such confounding factors, specific differences in academic outcomes between the two studies cannot be interpreted with full confidence. Clearly, this is an area where additional research is essential if the mechanisms of program impact are to be understood scientifically.

The Consortium for Longitudinal Studies. Having treated the relative outcomes from the Perry Preschool Project, the Milwaukee Project, and the Abecedarian Project in some detail, it is of interest also to compare the Abecedarian outcomes with those from the Consortium for Longitudinal Studies (Lazar et

al., 1982), which summarized the long-term effects of early education from 11 different projects. The Perry Preschool Project was one of these programs and one of the four projects given special emphasis as "more nearly randomized designs" (see Lazar et al., 1982, pp. 21, 41, for a fuller description).

A major conclusion of the consortium was that "early education significantly improved the ability of low-income children to meet their school's requirements for adequate performance, as reflected in reduced rates of assignment to special education and retention in grade" (Lazar et al., 1982, p. 55). "For the projects which reported random assignment to groups... 29.4% of the Control group children were placed in special education classes compared to only 5.3% of the program group children" (p.33). "For the projects with more nearly randomized designs, the median grade-retention rate was 25.8% in the program group compared to 36.6% for the Control group" (p.34).

The Abecedarian results with respect to retention in grade support this basic conclusion and show a somewhat stronger effect by reducing the likelihood that a child would be retained in the first three years of school from 50% for the control groups to 16% for the preschool plus follow-through group, 29% for the preschool only group, and 38% for the school-age only group. No statistical differences were found for special education placement by the Abecedarian endpoint evaluation, however. The total number of placements was small (10) and fairly evenly distributed across the four groups so there is very low statistical power to detect differences given the small numbers of children placed in special education (11%). It remains to be seen whether longer term follow up of the subjects, comparable to that of the consortium's, will tend to confirm the consortium finding of fewer rather than more placements as a result of preschool intervention. One caveat, however, is that the more affluent Chapel Hill school system, with its relatively advantaged pupils, may make referrals to special classes using different criteria from those that were used in the consortium's historically earlier studies, which were predominantly set in poor, inner-city areas. Further, the ABC Home/School Teachers were advocates for special education where that seemed to offer children additional and needed resources. Only additional time will reveal the impact of such forces.

We cannot yet compare the long-term Abecedarian effects of preschool intervention on intellectual competence assessed by IQ tests with those obtained in the consortium projects because not all of the Abecedarian children are yet of comparable age to those reported by Lazar et al. (1982). Based on its 11 studies, the consortium concluded that the effects of early intervention persisted for at least the first three or four years after the early intervention program ceased, but that longer term follow-ups, when children were 10 to 17 years of age, suggested that earlier differences eventually eroded. We are currently following up the subjects to learn if our endpoint group differences persist through age 12.

The consortium also found across all studies that "program graduates in general performed better than their controls [on school-administered academic achievement tests]" (Lazar et al., 1982, p. 56). The Abecedarian results support these basic conclusions from the consortium with respect to academic achievement in both reading and mathematics. Finally, the Abecedarian and consortium results complement one another with respect to differential effects on children with different backgrounds. Whereas both sets of results indicate a broad positive intellectual and scholastic response to preschool programs with respect to such variables as the child's gender, maternal education, and composition of home, the Abecedarian Project does indicate that economically disadvantaged children of low-IQ mothers may be especially responsive to this form of intervention (Martin, Ramey, & Ramey, 1990). This finding could have obvious implications for future selection criteria for high-risk infants.

Timing of intervention

These data allow us to speculate about optimal timing of interventions for disadvantaged children. Insofar as positive effects on intellectual development and academic accomplishment are concerned, the outcomes suggest that earlier and longer treatments have a more powerful influence on IQ and scholastic success than special treatment begun at school entrance and continued through the primary grades.

The higher levels of intellectual competence demonstrated by Abecedarian children receiving preschool intervention seems a likely explanation for their better achievement in early elementary school, particularly in light of the higher teacher ratings of academic competence for children receiving intervention. If, however, the differences in academic accomplishment were attributable primarily to the supplemental curriculum provided in the school-age intervention, then after three years' exposure to public school the follow-through only children should have performed at about the same level as those in the preschool plus follow-through group, for they attended the same schools and both groups had the benefit of a special and intensive school-age intervention for all three years. This was not the case for reading, however. Children in the preschool plus follow-through group significantly outscored school-age only children in reading, being about 7 standard score points higher on the Woodcock-Johnson reading assessments.

A second interesting comparison is of the relative academic achievements for children who had preschool intervention alone and for those who had school-age intervention alone. Whether one examines Woodcock-Johnson or California Achievement Test mean scores for these two groups, the scores always favor the preschool intervention group. Individual *t* tests indicate that none of these differences attain the .05 level of significance. It is important

to remember, however, that the school-age program did have consistently beneficial effects, as shown by the significant linear relationship found between the number of years of educational intervention and scholastic accomplishment.

Conclusions

The Abecedarian experiment and several other carefully designed interventions demonstrate that early educational intervention can significantly benefit children at high risk for academic failure. Early childhood education can enhance intellectual growth and improve later school performance. Taken together with results from similar experiments with disadvantaged children, our results suggest that educational intervention should begin early in the life span and continue at least into the primary grades. Children who appear to benefit most are those born to low-IQ, impoverished mothers. To put it another way, those children who need intervention the most appear to benefit the most.

Intensive intervention during early elementary school in the form of supplemental academic experience at home does undergird increased scholastic achievement but, by itself, appears to be less effective than preschool intervention as a preventive measure against intellectual lags and school failure. We are continuing to pursue questions about the long-term effects of the interventions, the factors associated with such effects, and the processes and mechanisms undergirding the development of disadvantaged children. Follow-up studies of the Abecedarian subjects at age 12 and age 15 are underway to learn to what extent the effects of the earlier interventions might still be apparent at later ages. This follow up also will permit us to examine psychosocial mechanisms at the levels of the child, family, and school that might plausibly sustain or diminish school performance.

One fact is clear: Disadvantaged children face enormous odds even in high-quality, affluent, and socially aware public school systems. Children from low-resource families require intensive and long-lasting educational efforts if they are to reach their full academic potential (see Ramey & Ramey, 1990, for an elaboration of this point relevant to public policy). In our opinion, the primary task for public policy makers is to develop sufficiently supportive mechanisms to maximize the availability of effective and innovative programs. Short and inexpensive programs are not likely to have much practical educational impact.

As a nation, we are now armed with more useful knowledge about the amelioration of the devastating consequences of poverty than ever before. The challenge is to find the leadership and the motivation to convince the public that intergenerational poverty and undereducation is a preventable disease that the United States cannot afford.

Summary

The effectiveness of three forms of educational intervention for high-risk children from low-income families is reported from a longitudinal randomized experiment. The intervention included a preschool plus follow-through program, a preschool only program, a school-age only program, and an educational control condition. Positive effects of intervention are reported on children's intellectual competence, academic achievement in reading and mathematics, and reduction of retention in grade. No significant differences were found in parents' perceptions of problem behaviors, which were of low frequency in all groups. The positive effects of intervention on outcomes are proportional to the amount of intervention. For example, 50% of control children were retained in the primary grades in comparison to 38% of school-age only children, 29% of preschool only children, and 16% of preschool plus follow-through children. Results from the Abecedarian Project are compared and contrasted with results from the Perry Preschool Project, the Milwaukee Project, and the Consortium for Longitudinal Studies. These comparisons suggest that more intensive and longer lasting programs are associated with greater positive educational impact for high-risk students. We conclude that practically significant educational gains will require systematic and intensive interventions even in affluent, progressive, and resourceful school systems.

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