Carolina Abecedarian Project

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History of Program/Policy

The Abecedarian study was designed to learn the extent to which an early childhood intervention program might prevent progressive developmental retardation among children born into poverty. Forty years ago, cross-sectional examinations of the cognitive development of children from poor families indicated that their cognitive test scores tended to be within the average range in infancy, but disproportionate declines occurred after that period (Ramey, 1971). A particularly striking cross-sectional graph charted this kind of progressive decline in intellectual test performance among children born to mothers who themselves had low IQs (Heber, Dever, & Conry, 1968). Because at that time no biologically based etiology for most cases of mild retardation had been identified, many scientists believed that early "social deprivation or environmental deprivation" was implicated in the development of this condition. It followed that intervening to improve the intellectual stimulus value of the environment might prevent or ameliorate the disorder.

Largely based on animal research, evidence mounted that early experience supported development in ways that were critical for later functioning (e.g., Hunt, 1961). More to the point, this line of reasoning was supported by human-subject research conducted by Skeels and his colleagues(1938) in which one group of infants reared within institutions showed dramatic gains in developmental abilities when they were given the kinds of affectionate attention and handling not experienced by others from the same orphanage. Gray, Ramsey, and Klaus (1982) described how this groundbreaking research was dismissed at the time because of the strong belief that intelligence was a fixed, in-born capacity, not malleable. Starkly contradicting that belief and supporting what Skeels and his colleagues had found was the dramatic boost in intellectual test performance reported by the investigators of the Milwaukee Project (Garber, 1988). This program enrolled children born to mothers with IQs of 75 or lower. One group of infants had intensive early childhood intervention from infancy through their kindergarten year. Contrasted with a comparison group of children born to similar mothers, the treated children displayed approximately a 20-point IQ advantage during the preschool years. Hence there was good reason to believe that intensive early childhood intervention that began very early in the life span might make a dramatic difference in the intellectual development of children at risk.

Finally, a crucial impetus for beginning intervention early in the life span was based on the first experience with Head Start, initially designed as a short-term program for four year olds from poor families that would prepare them for school success. This program was perceived by many to be a failure when an early evaluation found that no lasting benefits were detectable after three years in school (Cicirelli, 1969). The scientific community therefore needed more well-controlled research to learn what kinds of intellectual gains could be achieved if intervention began in early infancy. The Abecedarian study provided a randomized controlled trial designed to address this question.

Two major theoretical positions underlay the study: Ramey, McPhee and Yeates (1982) suggested that "a variation" on General Systems Theory (Bertalanffy, 1975) helps to explain how a child's development is the product of a system of units that interact with one another, that are linked across time, that differ in complexity, that differ in stability and that mutually regulate one another. The young child is an "active organism" that continually adapts in the face of changing demands, and the child herself or himself constitutes some of those demands. Rather than a "true" theory that can predict with precision, this system is a "perspective or paradigm in which the many components of the system interact to produce strong, synergistic effects." (Ramey et al.,1982, p. 353). Bronfenbrenner's Ecological Theories (Bronfenbrenner, 1986) have also influenced the thinking of the Abecedarian investigators in their effort to understand how the particular segment of the population that we undertook to study, children born into poverty, might develop within the various contexts of their families, their child care settings, their schools, and communities.

Description of Program

The Abecedarian study was funded through a Federal Grant from the Mental Retardation and Developmental Disabilities Branch of the National Institutes of Health. Based on the argument that convincing proof that "environmental deprivation" was a major cause of developmental delays or even mild mental retardation, Craig Ramey and Joe Sparling convinced the agency to fund a trial of what could be achieved through intentional education that began in early infancy. Over the years, in addition to major program project grants from NICHD, other funding from the State of North Carolina, the Spencer and Carnegie Foundations, and the Department of Education helped to support the work. Rather than a dramatic manipulation of the early environment, the experimental treatment was designed to be carried out within a natural setting then (and now) being experienced by an increasing number of infants, namely full-time child care. Situated within North Carolina, where the 1970 Census indicated that 20% of the population had incomes below the Federal poverty line, and where the poverty percent for minority individuals was higher still, the study was designed to take advantage of the critical shortage of full-time child care for infants while at the same time providing a well controlled scientific study of the degree to which children's development might be enhanced through early intervention. (The other three Investigators on the original grant were all pediatricians; important research on the health of young children in group care settings was also done within the same child care setting.) The actual cost of mounting the intervention program was significantly subsidized because it was housed within a University of North Carolina research building. Having this facility plus the grant funds that covered the cost of program staff and research personnel meant that the program was essentially free to participants.

The design called for four cohorts of infants to enter the study, each to consist of 28 children for a total of 112. Half were to be given the full-time child care program the other half were untreated controls. The child care program was housed within the Frank Porter Graham Child Development Center (now Institute); the Center's nursery could accommodate 14 infants. The children were admitted in four cohorts between the fall of 1972 and the late summer of 1977.

Prospective families were identified by local agencies serving pregnant women and young children, primarily prenatal clinics or the Department of Social Services. Professionals at these sites acquainted women with the possibility of enrolling in the study; those who expressed interest were then identified to study personnel who set up home visits to score the study's High Risk Index that contained such sociodemographic factors as parental education, family income, use of welfare funds, evidence of academic failure in other family members, and other indications of problems within the family

(Ramey & Smith, 1977). Those who appeared qualified then came into the Center for further interviewing and a full scale IQ test following which a final determination of eligibility was made.

In all, 123 families were invited to enroll; 89% eventually did so. More families declined the early child care program than declined the control group - not every family sought full time child care for its infant. Table 1 describes the families who enrolled in the program and whose child, if in the treated group, attended for any length of time.

Parents were invited to enroll in the study with the understanding that they had a 50:50 chance of being in the treatment or an untreated control group. The infant might begin attending the Center as young as six weeks of age. Ultimately, 109 families, to whom 111 children were born, accepted their random assignments (one set of identical twins, one sibling pair). This group comprises the base sample for the study with 57 of the children randomly assigned to the treated group and 54 in the control group. All families were low income, most were female headed households, and 98% of the sample was African American. Approximately half the mothers were teenagers (defined as less than 20 years old, range of 13-44 years). Children could begin attending the Center as young as 6 weeks of age; the mean age at entry was 4.4 months, with a range of 6 weeks to 6 months at entry age.

A curriculum, developed by Joseph Sparling and Isabel Lewis was individually implemented for each baby. In describing the development of this curriculum an early grant application noted that the underlying assumption was not that “sensory deprivation (was) the major cause of developmental retardation…but rather that the child received vague or competing sensory messages which (were) useless to him at the moment.”

Thus, the developers saw their task as "(1) designing an organized resource bank of unambiguous experiences or activities and (2) making each activity available to the child at a time and in a way that she can successfully use and master it." These activities were designed to enhance perceptual-motor, cognitive, language, and social development. They involved simple, age-appropriate, adult-child interactions such as talking to an infant, showing toys or pictures, and offering infants a chance to react to sights or sounds in the environment. As children grew, the educational content became more conceptual and skill-based. Language development was especially emphasized. However, children always had freedom to choose activities, and the emphasis on individual development was paramount throughout. These materials were given the name Learningames and were eventually published in two volumes: one covered games for children up to 36 months of age (Sparling & Lewis, 1979) and the second contained games for three and four year old children (Sparling & Lewis, 1984). Updated versions of this curriculum are now available (e.g., Sparling & Lewis, 2007)

In addition to providing children with an intentional curriculum that was applied throughout the day as the infants were receptive, the center had other noteworthy features. Coincidentally with the psychological and educational stimulation that went on, the health of the children in the group care was carefully monitored and a large body of research, especially on communicable upper respiratory disease, grew out of the study. The children had primary pediatric care on site, with a full time Nurse Practitioner, a medical aide based at the center and several pediatricians also involved. A second feature of the treatment program was its proactive nature; station wagons equipped with child safety seats went throughout the neighborhoods to collect the treated infants, toddlers and preschoolers and took them home again in the evenings.

The mean age of the infants at treatment entry was 4.4 months (the range was 6 weeks to 6 months). The Center operated full days, five days per week, year round except for vacation and holiday closings. The children were provided a warm, secure and contingently stimulating environment in which each had an individualized program of learning activities. The Children had breakfast, lunch and a snack during the day as well.

To control for the possibility that any developmental gains seen in the treated children were actually because they had better nutrition at the Center, children in the control group were offered free iron-fortified formula for the first 15 months of life, the period of most rapid brain growth. An additional (and very popular) incentive for families in the control group was free disposable diapers until the child was trained.

A standard protocol of individual assessments was used for the children in both groups, administered by a person independent of the design or provision of the treatment program. To ensure that the child care staff did not teach children how to do the tasks from the standardized instruments, parents were required to be present on all testing occasions. Caregivers were not allowed to accompany children. Appointments and transportation, if necessary for these assessments were made by the evaluators, not the child care providers. Infants were assessed using the Bayley Scales (Bayley, 1969) at 3, 6, 9, 12, and 18 months of age, with the Stanford Binet Form LM (1962 version; Terman & Merrill, 1972) at 24, 36, and 48 months, with the McCarthy Scales (McCarthy, 1972) at 30, 42, and 54 months, and with the age appropriate version of the Wechsler Preschool and Primary Scale of Intelligence (Wechsler, 1967) at 60 months. In addition, studies of mother-infant interaction were carried out on a regular basis in an effort to learn if this kind of full time treatment had discernable effects of how the children related to their mothers. Basic studies on the ways that infants reacted to stimuli were also carried out.

School-age treatment phase. When children were old enough to enter public school (kindergarten at age 5), the children within the preschool treatment and control groups were re-randomized by matching pairs within groups as closely as possible on their 48 month Stanford-Binet score and then randomly assigning one of each pair to a school-age treatment or control group. Figure 1 depicts the study model for the preschool and school-age phases of the work.

Those assigned to treatment during the school-age phase had the services of a Home School Resource Teacher (HST) for the first three years he or she attended public school (Kindergarten to grade 2, unless retained at some point). The HST made alternating visits to the child's classroom and home. At school she consulted with the teacher to learn which concepts were being taught and to identify areas where the child might need extra help. She then designed custom learning activities for parents to use at home to help the child grasp the concept. These were designed to be fun, so that children and parents would enjoy the time devoted to their use, but they also taught basic concepts underlying reading and mathematics. Activity packets were delivered to the home on alternating weeks. HSTs were also expected to function as advocates for families within the community, to help them secure any services they might need such as help with housing, child care, health care, and the like. The variety of activities they carried out is impressive, ranging from securing emergency food to setting up play dates and accompanying a socially isolated child and his custodial grandmother to the play ground where he could spend extra time with children his own age.

Major Findings

Short-term effects: Preschool finding and elementary school findings: Figure 2 shows the test results for infants through age 5. The infants in the treated and control groups appeared to be at the same developmental level in early infancy, but began to diverge by six months of age. By 18 months of age, those in the treatment group scored significantly higher on tests of infant-toddler development. Thereafter, during the remaining preschool years, the treated group maintained a significant advantage over the control group in standardized intellectual test scores (Ramey & Campbell, 1984). As Figure 2 shows, however, the control group showed a gradual rise in score after the age of thee years, a trend likely related to the fact that the children in this group were beginning to attend other preschool programs in the area (Burchinal, Lee, & Ramey, 1989).

Six children were lost to early attrition because of death (4), an undiscovered biological condition that rendered the child ineligible (1), or permanent withdrawal (1). Nine children moved away from the area prior to age 4 and another withdrew from participation, thus they had no 48-month IQ and could not be given a school-age assignment. In all, 96 children were given school-age assignments and could potentially contribute data for an analysis of school-age findings. However, further mobility among participants resulted in there being only 90 who contributed IQ data and 88 with academic test scores at the treatment endpoint (age 8).

After the children entered public school, standardized tests of reading and mathematics achievement were administered in the fall and spring of each of the first three years. Children were also administered the Wechsler Intelligence Scale for Children –Revised (Wechsler, 1978) at age 6-1/2 and 8 years. At this point, data were analyzed according to the four group assignment of the children. The school age phase of treatment appeared to have no effect on intellectual test score performance. A multivariate analysis of variance for repeated measures tested the effect of preschool and school-age intervention on the three Wechsler IQ data points (age 5, 6-1/2, and 8 years), plus the interaction between the two phases. The results showed a significant difference for preschool treatment across this time period, but no effect for the school-age phase and no interaction. A linear trend downward (approximately a 2-point IQ drop from age 5 to age 8) was seen in both groups. Since this trend was consistent across the groups, it does not represent a fade out of the preschool treatment effect. (Ramey & Campbell, 1991).

For the first two y ears, fall and spring achievement tests were the Peabody Individual Achievement Tests (Dunn & Markwardt, 1970), for the third year, the Woodcock-Johnson Tests Psycho-educational Battery, Part 2, Tests of Academic Achievement was substituted (WJ; Woodcock & Johnson, 1977). These tests were individually administered to the children at their respective schools, but by project staff. During those years, the local schools also administered standardized tests of reading and mathematics and these scores were released by parents to the study. Figures 3 and 4 show the "endpoint" results for the four school-age groups, that is, how they scored on the WJ at the end of three years in school. These scores are age-referenced rather than grade referenced, since not all children had completed second grade after three years in school. As can be seen in the figures, there is a linear trend for the reading scores such that the scores increase perfectly as a function of the number of years of intervention, that is, those with 8 years of intervention outscore those with 5 years only, while those with 5 years outscore those with three years only, who in turn outscore those with no intervention at all. The same linear trend is apparent for mathematics but as the Figure 4 shows, it is not as striking as the trend for reading.

Adaptation to school was assessed through teacher ratings on the Classroom Behavior Inventory (Schaefer, Edgerton, & Aaronson, 1977). These data are somewhat ambiguous with respect to the children's behavior and adjustment within their classrooms. Based on the ratings obtained from teachers in the spring of the child's third year in school, no strong trends are seen within the data. Ratings of Verbal Intelligence tend to increase as a function of years of treatment, that is, children with more years of treatment tended to be rated by teachers as appearing to be brighter. No such trend is seen for ratings of positive social behavior (Considerateness minus Hostility). Data based on the first three cohorts of children who entered primary school indicated that teachers perceived students who had been in the preschool treatment group (disregarding school-age assignments) to be more physically and verbally aggressive than students who had been preschool controls (Haskins, 1985). This trend did not replicate when subsequent cohorts of children from the Abecedarian and its related study, CARE, entered school (Burchinal, Campbell, & Bryant, 1995)

Longer term effects: Early and middle adolescent follow-up studies were conducted after students had attended public school for seven year(age 12) and again, after 10 years (age 15). The first of these occurred after children should have completed elementary school at sixth grade (this study having occurred prior to the shift to a middle school system). The second took place after they should have finished ninth grade, what was then the transition point to the senior high school. For both of these follow-up studies the analyses were based on the four-group assignment model, comparing outcomes as a function of preschool treatment, school-age treatment and the interaction between the two.

For the age 12 follow-up, data are available for 90 children who had received a school-age assignment. In addition, all available children earlier lost to attrition were invited to take part and 11 did so.

Intellectual test data were analyzed longitudinally for all available cases with complete data (n = 83) using multivariate analysis of variance for repeated measures with the factors being preschool treatment, school-age treatment, age at testing, and age x treatment interactions. Separate intellectual growth curves were estimated for the four treatment groups. When averaged across ages, preschool treatment, but not school-age treatment had a significant effect on intellectual test scores. All groups showed linear change across time, with a decline from infancy scores to those at age 12. The preschool treated group maintained its advantage at all points, but showed more linear change than the preschool control group, whereas the preschool control group had a more variable pattern of change over time with an upward inflection after age four, and the same overall decline after age 8.

Academic scores in reading, written language, and knowledge showed linear trends to increase as the number of years of intervention increased, and significant preschool treatment effects, but no significant effect for school-age, and no preschool by school-age interactions. In this round of analyses mother's IQ was entered as a covariate to learn if it affected age 12 intellectual and academic outcomes independently of treatment. While holding this powerful predictor of child outcomes constant slightly strengthened the preschool treatment effect, essentially it seems to have affected child outcomes in the same way across treatment groups.

The age-15 follow-up took place after the participants had completed 10 years in school, post-9th grade if they were never retained. For this round of data collection, 92 of the 93 who had some form of school-age treatment took part, plus 12 of the individuals in the early attrition group who lacked a school-age group assignment. The intellectual and academic outcomes at age 15 were essentially the same as at age 12. Higher IQ scores over time were related to preschool treatment (those with either 8 or 5 years of treatment always outscored those with only 3 years or none – $F(1,80) = 8.92$, $p < .004$). The linear decline already detected persisted at the same rate in both early childhood groups. Academic test scores for both WJ Reading and Mathematics Clusters showed significant linear trends and significant preschool treatment effects.

Preschool treatment was associated with fewer grade retention up through age 15. Overall, 31.2% of those with preschool treatment were retained at some point. The rate for those in the preschool control group was 54.5%, a statistically significant difference (Chi Square (1, $N = 93$) = 5.10, $p = .02$). Likewise, those with preschool treatment were less likely to be identified as needing some form of special services (special help for speech and language delays, learning disabilities, or behavior problems). Those who had been in the preschool control group were significantly more likely to be identified (Chi Square (1, $N = 93$) = 5.47, $p = .02$). The group least likely to be seen as needing special services was that having five years of preschool intervention. Being in the most intensely treated group (8 years in all) made it more, not less, likely that a student would be given special services. Evidently, the HST advocated for the student to be given extra help. However, for those who were in the preschool control group, having an HST did not seem to make a difference in their being given special services (Campbell & Ramey, 1995).

At age 12 and age 15 students were asked to complete Harter's scholastic competence rating scales (Harter, 1982; 1988). A longitudinal analysis of these scores showed a significant preschool by school-age interaction such that the group that had three years of treatment in the primary grades scored highest on this measure and, paradoxically, the group having the full 8 years of treatment scored lower than the group with five years only, despite actually having the highest standardized scores on academic measures. Speculatively, the characteristics of the local public schools may have contributed to this outcome: being located in a university town, local public schools were highly competitive, and "average" performance on standardized tests were generally well above national averages. Thus the students with most intensive intervention may have expected more of themselves and, in this context, tended to down rate themselves (Campbell, Pungello, & Miller-Johnson, 2002).

Young adult findings: The most recent Abecedarian data are those collected from study participants as young adults, age 21. At this stage of young adulthood data were available on high school graduation, post-secondary education, job histories, marital status, parenthood, and evidences of social maladjustment such as breaking the law and drug use. These data were collected as close to the 21st birthday as possible, the goal being to assess participants within plus or minus 30 days of their birth date.

At age 21, 105 of the original 111 infants were still living and eligible for follow-up. Of these, all were located and 104 took part (one declined), giving an overall retention rate of 93.7% of the original infant participants, and 99% of those eligible at this age. The decision was made at this point to adopt an "intent-to-treat" model in which each participant was classified according to his or her original preschool group assignment rather than the 4-group model that took preschool and school-age treatment status into account. This had two advantages: it increased the number of cases that could contribute data and it also constituted the most stringent test of the treatment by including as treated all cases so assigned regardless of early attrition.

Data collection at this point consisted of standardized tests: the Wechsler Adult Intelligence Scale-Revised (WAIS; Wechsler, 1981) and the Woodcock-Johnson Broad reading and math scores (WJ, Woodcock & Johnson, 1989). An interview covered life history to this point, and a battery of self-report psychological scales measured other constructs. These included the Youth Risk Behavior Survey (Center for Disease Control, 1992) which covers a variety of behaviors associated with injury or illness in young adults (violence, tobacco use, alcohol and other controlled substance use and abuse). Another was the Brief Symptom Inventory (BSI; Derogatis, 1993). a 53-item version of the Symptom Checklist 90 (Derogatis, 1975), a screening measure of mental health.

Long-term intellectual test score findings. Intellectual and academic findings from the Abecedarian young adult follow up are most fully explained in Campbell, Pungello, Miller-Johnson, Burchinal, and Ramey (2001). Tested in isolation, intellectual test scores for Abecedarian participants showed that those who with preschool treatment scored significantly higher on Full Scale IQ, F (1, 100) = 5.71, $p < .05$, and Verbal IQ, F (1, 100) = 5.21, $p < .05$. There was no treatment effect for Performance IQ. Main effects for gender were not found, but the preschool group by gender interaction approached significance for the Verbal IQ score ($p < .10$). Treated females scored about eight points higher than untreated females while scores for males differed by less than one point across treatment and control conditions. Given that most other early intervention programs where long-term comparisons were possible have found that significant treatment/control differences in intellectual test performance were not seen beyond a few years in primary school (Lazar, Darlington, Murray, Royce & Snipper, 1982), the persistence of a treatment effect on IQ scores into young adulthood was not expected.

Figure 5 shows the longitudinal function for intellectual test scores from ages 3 to 21 years. These data were analyzed using HLM. The polynomial regression model included a term for treatment as a between-subject predictor, a term representing which childhood cognitive test was administered (i.e., the Stanford-Binet administered when the children were 3 and 4 years of age or the Wechsler scales thereafter), linear and quadratic age terms to examine patterns and rates of change over time, a term that represented time of assessment (i.e., younger than age 6 versus older than age 6), and this term's interactions with linear and quadratic age to allow the rate of change to differ between the time period in which children received early treatment and the post-treatment period. The full analysis model included all main effects and all two- and three-way interactions among treatment group, timing of assessment, and the linear and quadratic age terms. The model was simplified when higher order interactions were not significant.

Children who received the early educational treatment achieved higher overall IQ scores than children in the control group. Across all subjects, IQ scores showed a linear decline over time. Finally, a significant main effect was found for the test administered, indicating that children tended to score higher on the Stanford-Binet than on the Wechsler scales.

These main effects were qualified by significant higher-order interactions. The magnitude of the difference between the treatment and control groups varied as a function of time of assessment (i.e., during treatment versus after treatment). Although the magnitude was greater while treated children were still receiving the intervention, the treatment difference was significant both during the preschool period and in the follow-up period. A significant two-way interaction indicated that, across all subjects, more curvature existed during the preschool period than in the post-preschool period. Finally, these two-way interactions were qualified by a significant three-way interaction found for treatment group by time of assessment by linear age. The difference between treated and control groups in linear decline was greater during the preschool period than during the follow-up period, but the groups demonstrated a parallel linear decline in IQ scores during the period after treatment.

Adjusted means and treatment/control effect sizes for cognitive test scores are given in Table 2. Two effect sizes were calculated. The first used the pooled sample standard deviation (*SD* = 6.30), given the truncated nature of the sample (compared to the population on which the Wechsler scales were standardized). A more conservative estimate of the effect size was also calculated using the standard deviation of the Wechsler IQ tests (*SD* = 15). According to Cohen (1988), an effect size of .20 is considered “small” but may be meaningful, an effect size of .50 is “medium”, and one of .80 is “large” (p. 40). As Table 2 shows, even the more conservative estimates are in the range considered educationally meaningful, and both estimates for early childhood treatment period are considered large.

Academic Achievement scores. Analyzed across the four test points, individuals who received the early educational treatment achieved higher reading scores than those in the control group, F (1, 187) = 8.34, p = .004. Across all subjects, from age 8 to 21 years, reading scores were characterized by generally flat levels of change over time (See Figure 6). The treatment and control groups maintained their positions relative to national norms across time, making progress at roughly the same rate.

With respect to math achievement, a significant main effect was found for treatment group, F (1, 187) = 6.02, p = .015, indicating that children who received the early educational treatment achieved higher math scores than those in the control group. In addition, significant linear (F (1, 104) = 79.15, p = .0001) and quadratic (F (1, 187) = 9.39, p = .0025) main effects were found (Figure 7). Across both groups, math scores from age 8 to age 21 were characterized by linear and quadratic change, but the rate and pattern of change were equivalent for both. Both experienced a relatively steeper decline in standardized math scores from age 8 to age 12, compared to a more gradual decline in standardized math scores from age 12 to age 21.

Effect sizes were calculated, based on the age 15 test results, for reading and math. Two effect sizes were calculated, one using the pooled sample standard deviation (reading SD = 4.85; math SD = 6.41), and a more conservative estimate calculated using the standard deviation of the Woodcock-Johnson (reading and math SD = 15). Educators consider effect sizes of .25 or greater to have practical significance (Cohen, 1988). Using the pooled standard deviation of the sample, the effect sizes were large for both reading (1.40) and math (.86). Those based on the test standard deviation are within the range considered moderate (.45 for reading and .37 for math).

Four-group differences in young adult academic scores. To learn if school-age treatment effects persisted over time, academic achievement was examined reverting to the four-group analysis models earlier used during the school-age phase and adolescent follow-up studies (testing for preschool effects, school-age effects, and the interaction of preschool by school-age). Using this model means a loss of power because only data from those individuals who were randomly assigned to one of the four school-age groups can be included, hence 95 instead of the full 104 individuals contribute data (the intent-to-treat rule was again applied, hence the models included 3 cases who were assigned but not actually treated in the school-age phase). Using four-group model, at age 21 neither of the aggregate WJ scores, Broad Reading or Broad Mathematics, showed statistically significant preschool effects, school-age effects, or preschool by school age treatment interactions. However, disaggregating the WJ scores into their component subtests revealed trends toward preschool treatment effects for Letter-Word Identification, F (1, 91) = 2.88, p <. 10, and Calculation, F (1,91) = 3.58, $p < .10$. Effect sizes were calculated by subtracting the mean of the CC group from that of each of the other groups and dividing the remainder in each instance by the standard deviation of the CC group. Judging by the effect sizes thus obtained, the Abecedarian treatment influenced reading achievement more strongly than mathematics achievement. Through age 21, large to medium effect sizes for the full 8 years of treatment were found for reading (ranging from 1.04 at age 8 to .79 at age 21). The effect size for preschool treatment alone varied from .75 at age 8 to .28 at age 21. In contrast, effect sizes for school-age treatment alone (CE group) ranged from .28 at age 8 to .11 at 21, all in the small range or less. For mathematics, effect sizes for the full 8 years of treatment ranged from .64 to .42, whereas those for preschool treatment alone ranged from .27 at age 8 to .73 at age 21. Effect sizes for school-age treatment alone ranged from .11 at age 8 to .26 at age 21 (Campbell, Ramey, Pungello, Sparling, & Miller-Johnson, 2002).

Educational attainment. The most important outcome insofar as education was concerned was that young adults with preschool treatment were almost three times as likely to attend a 4-year college or university than the preschool control group (35.9 % for treated compared to 13.7 % f or the control group, X^2 (1, N = 104) = 6.78, $p < .01$. Irrespective of college attendance, those treated in preschool completed significantly more years of education by age 21 than did preschool controls, F (1, 99) = 5.00 $p < .05$. Although there was not a significant main effect for gender, the interaction of treatment x gender was significant, F (1, 99) = 4.19, $p < .05$. Females with preschool treatment earned 1.2 more years of education than females without. In contrast, treated and untreated males earned almost identical amounts of education, differing only by 0.1 years.

Skilled employment. Individuals in the preschool treated and control groups did not differ significantly in the percent employed but did differ significantly in the level of employment they reported. Based on Hollingshead (Hollingshead, undated) scores of 4 or higher, young adults with preschool treatment were more likely to be engaged in skilled jobs: 47% of treated individuals compared with 27% of the controls, X^2 (1, N =

100) = 4.50, $p < .05$. Electrician is one example of a job rated 4 on the Hollingshead scale.

Parenthood. Few of the individuals in the study sample had married by age 21, (five females, two males, one of whom was by then separated). However, 46 had become parents by that age, four of whom were among the 7 who had married. Within this sample, females tended to have more children than males, F (1, 103) = 3.09, $p < .10$. In all, 40 children had been born to females compared to 24 reported by males. Among those who did have children by age 21, preschool treatment was associated with a significant delay in the average age at first birth. The mean age at the birth of a first child was 19.1 years, *SD* = 2.1 years, for the preschool treatment group compared with 17.7 years, *SD* = 1.5 years, for preschool controls, F (1, 41) = 5.26, $p < .05$. However, the youngest parent in both groups was 15 years old when she or he reported having a child. Defining a teen parent as one aged 19 or younger when a first child was born, preschool treatment was associated with a significant reduction in teen parenthood (26% of those treated compared with 45% of controls had children as teens), X^2 (1, N = 104) = 3.96, $p < .05$.

Social adjustment. Indices of social adjustment included self-reported use of legal and illegal substances, substance abuse, violence, and crime. Marijuana use within the past 30 days was significantly less among the treated individuals. Eighteen percent cited some level of usage during that period, compared to 39% of controls, X^2 (1, N = 102) = 5.83, $p < .05$. Use of any other kind of recreational drug was rarely acknowledged within this sample (cocaine use was denied by 99 of the 102 individuals who completed the Risk Survey). Moderate alcohol use was commonly acknowledged, but comparable among those with and without preschool treatment. Of more importance, a tendency existed for those with preschool treatment to be less likely to describe themselves as regular smokers – 39% of the treated group compared with 55% of the control.

Unlike the Perry Preschool study which has consistently reported preschool-treatment related reductions in criminal involvement for its study sample, no such reduction was found in the Abecedarian study. Responding to the questions about convictions for misdemeanors or felonies on the young adult interview, few admitted such experiences. One female from the treatment group reported a misdemeanor conviction compared to 4 in the control group. No female in either group reported a felony conviction. For males, the number reporting misdemeanor convictions was the same for both groups (N = 5), whereas six control group males and four treated group males reported felony convictions. These differences are not statistically significant.

Mental Health. Because research indicates a higher incidence of depressive symptoms among the poor (Gilman, Kawachi, Fitzmaurice, & Buka, 2003), Abecedarian investigators examined the extent to which having early childhood educational intervention might had been associated with a reduced incidence of depressive symptoms. Using early intervention and the intellectual stimulus quality of the early childhood home environment as predictors, a series of multiple regression with missing data imputed were estimated to see if these factors predicted falling above the clinical cut score for Depressive Symptoms on the BSI. For this dichotomous outcome, neither predicted falling within that range. However, when the full range of scores on the Depression scale was the outcome, having had early childhood treatment led to endorsement of fewer Depression items. In addition, early treatment appeared to moderate the effect of the early home environment such as endorsement of depressive symptoms did not increase as the quality of the early home environment decreased. Thus, treated individuals appear to have been buffered to some extent against the effects of the early home environment on later depressive symptoms (McLaughlin, Campbell, Pungello, & Skinner, 2007).

Cost-benefit Analysis. Economists external to the program have calculated cost-benefit ratios for the Abecedarian program. A complete explanation of the method they used is given in Masse and Barnett (2002). In brief, costs were estimated on the basis of records kept by the University and the program operators; benefits were estimated in seven categories: (1) earnings and fringe benefits of participants; (2) earnings and fringe benefits of future generations; (3) maternal earnings; (4) elementary and secondary education cost-savings; (5) improved health; (6) higher education costs; and (7) welfare use.

Total cost of the program (in 2002 dollars) was estimated at $67,000 per child.[1] Given that treated children were more likely to attend college, an increased cost of higher education was estimated at $8,128. On the other hand, due to increased educational attainment, the benefits of increased lifetime income were estimated to be $37,522. In addition, the program was estimated to increase the earnings of future generations (i.e., children of the participants) by $5,700 due to such factors as enhanced cognitive functioning and achievement, greater educational attainment, and timing and spacing of when the children were born. An estimated benefit of $68,278 was found due to increased earning of the mothers of the program participants. Having their children receive free, high-quality care from infancy through age 5 allowed the mothers to make

[1] In this analyses, discount rates of 3%, 5%, and 7% were used. In each case, the project demonstrated benefits; analyses from the 3% rate are presented here.

greater progress in terms of educational and occupational success. Cost savings were also found for K-12 schooling in the forms of reduced special education placements and fewer grade retentions resulting in an estimated benefit of $8,836. Due to the reduced smoking rates, an estimated benefit of $17,781 resulted. Finally, an estimated benefit of $196 was found for reduced costs from welfare administration. All totaled, the estimated benefits per child were calculated at $158,278 giving an estimated benefit-cost ratio of 2.5:1 (Barnett & Masse, in press). Quoted from Pungello, Campbell, and Barnett (2006).

Future Research Directions

Currently, data are being collected from the Abecedarian study participants when they attain age 30. Data collection should be complete by the first of the year 2008. At this stage, the study will concentrate on the educational attainments and economic circumstances of the participants to learn if the better educational attainment and increased likelihood of going to college seen at age 21 have translated into better, more self-sufficient lives. The primary method of data collection at this age is an extensive interview covering the life experiences of the individuals to this point. Data are also being collected on children aged 3 and older born to the study participants, to learn if intergenerational effects are detectable. Children will be given age appropriate measures of readiness of skills in reading and math and parents will describe their social adjustment. Parenting efficacy is also being measured among those of the sample who are parents. We have also collected limited young adult data on participants in a second, closely related randomized trial of early childhood educational intervention, the Carolina Approach to Response Education (Project CARE). This study was begun immediately after the youngest Abecedarian participants graduated from the infant program. CARE offered one group of participants five full years of educational intervention within a child care setting except that in this case, the infant's caregiver made regular visits to the home to demonstrate the curriculum to parents and encourage them to use the Learningames at home. In addition, CARE had a second treatment model that consisted of home visits only, such that those children did not have center-based educational intervention but rather home-based, parent-provided exposure to the same kinds of stimulating early childhood experiences that the children who attended the center-based program had. At this time, the young adult findings CARE are being submitted for publication.

Implications for Policy

The findings from the Abecedarian study speak most directly to the importance of early childhood education as a way to improve the chance that children from poor families will achieve in school and go on to higher education. That significantly more of those with early childhood treatment did go to a four-year college or University indicates that development of their learning potential was enhanced. Moreover, data collected from the parents of the Abecedarian participant when the adolescent was fifteen years of age indicated that those mothers who had the benefit of the five years of stable, quality child care made more gains in their own lives as reflected in attaining more years of education themselves and also in having higher level jobs at that point. The data at that point suggested that the worst case scenario was to be a teen mother who did not have the benefit of the child care program. This group of mothers was least likely to have made gains on their own.

Specific recommendations would be, first, to recognize that money spent on early childhood programs for poor children is money well spent in that it increases the likelihood that children born into poverty may make more educational gains and hopefully, enhance their own economic capital.

Second, Abecedarian data clearly suggest that the more powerful and enduring effects from its two phases of intervention were due to the five years educational intervention from infancy to kindergarten entry. Effects of the school-age learning supports, while evident in the short term, were never as strong as those from the preschool program alone, and were not discernable in young adulthood in the absence of the preschool program having come before.

Third, data from Abecedarian parent outcomes suggest that having reliable child care during the preschool years makes a difference in the lives of very young mothers, giving them a better chance to enhance their own development in terms of getting more education and better jobs.

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Table 1

Entry Demographic Characteristics for Families in Abecedarian Study by Preschool Group

	Preschool Group		
	Treated	Control	Total
Demographic Measure	(N = 55)	(N = 54)	(N = 109)
Maternal age (years)			
M	19.6	20.3	19.9
S. D.	3.9	5.8	4.9
Maternal education (years)			
M	10.4	10.0	10.2
S. D.	1.8	1.9	1.8
Maternal Full Scale IQ (WAIS)			
M	85.5	84.2	84.8
S. D.	12.4	10.8	11.6
Percent two-parent family	23	26	24
Percent African American family	96	100	98
Percent male child	51	43	47

Table 2

Cognitive Test Scores Over Time as a Function of Treatment and Age: Adjusted Means and Estimated Effect Sizes

	Adjusted means			Effect size	
Phase	Treated	Control	Difference[a]	Pooled sample d[b]	Test d[c]
Treatment	103.0	92.0	11.0	1.75	.74
Follow-up	94.1	88.6	5.71	.87	.37

Note. The adjusted means given for the treatment phase are those at age 4 (the mid-point of that phase), and the adjusted means given for the follow-up phase are those at age 15 (close to the mid-point of that phase).

[a]Difference refers to the difference between the treatment and control group.

[b]Pooled sample d = the effect sizes calculated using the pooled standard deviation (SD = 6.30).

Figure 1

School-Age Program

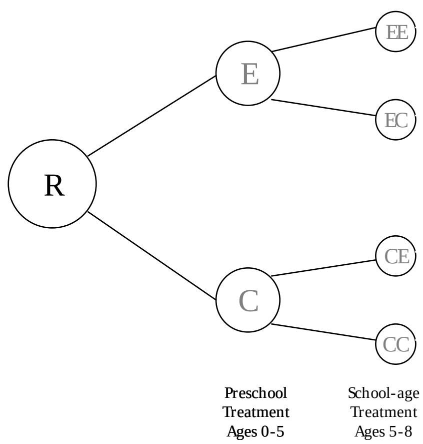


Figure 2

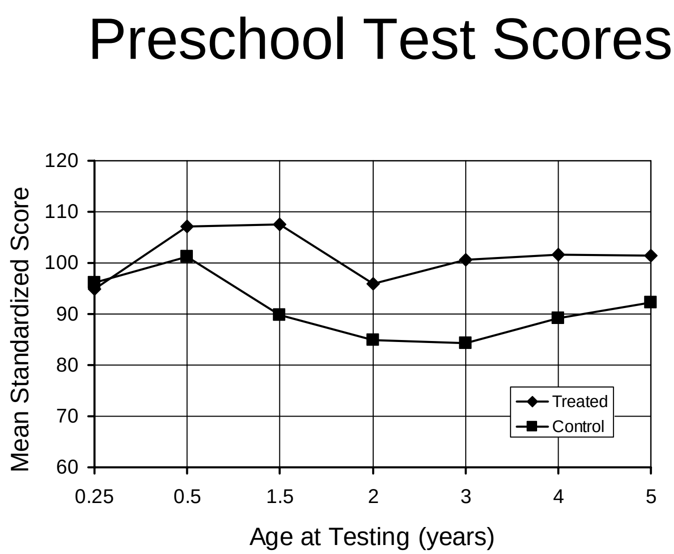

Preschool Test Scores
Mean Standardized Score
120
110
100
90
80
70
60
0.25
0.5
1.5
2
3
4
5
Age at Testing (years)
Treated
Control

Figure 3

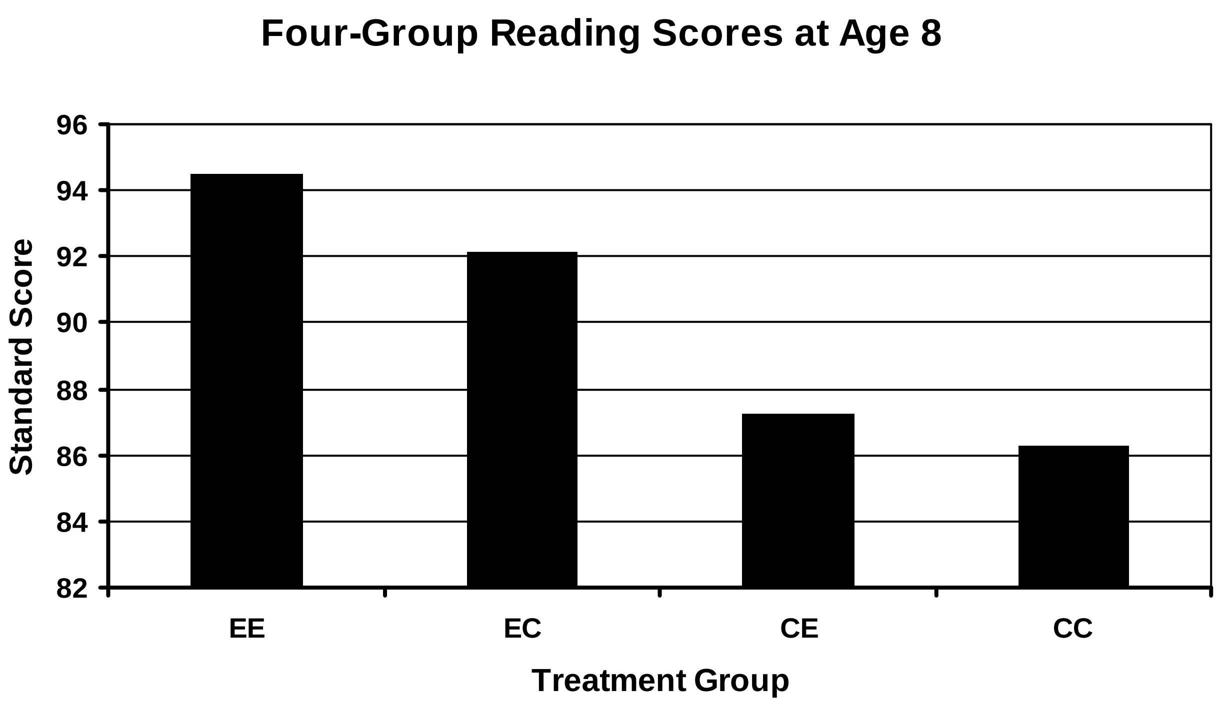

Four-Group Reading Scores at Age 8
96
94
92
90
88
86
84
82
Standard Score
EE
EC
CE
CC
Treatment Group

Figure 4

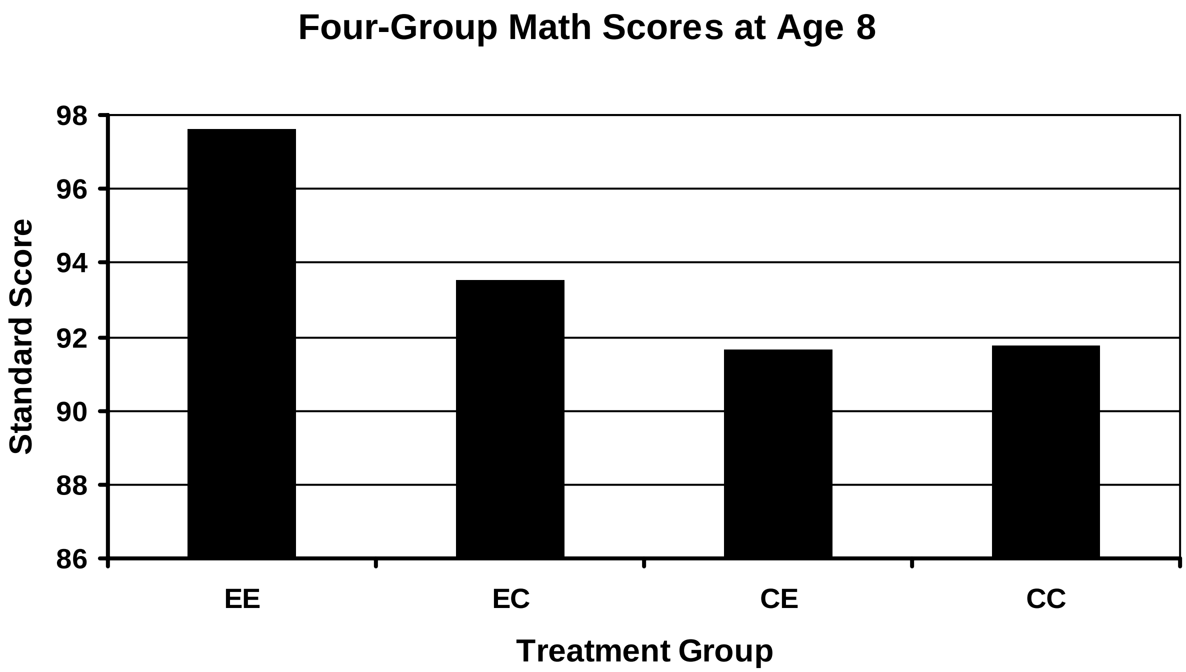

Four-Group Math Scores at Age 8
98
96
94
92
90
88
86
Standard Score
EE
EC
CE
CC
Treatment Group

Figure 5

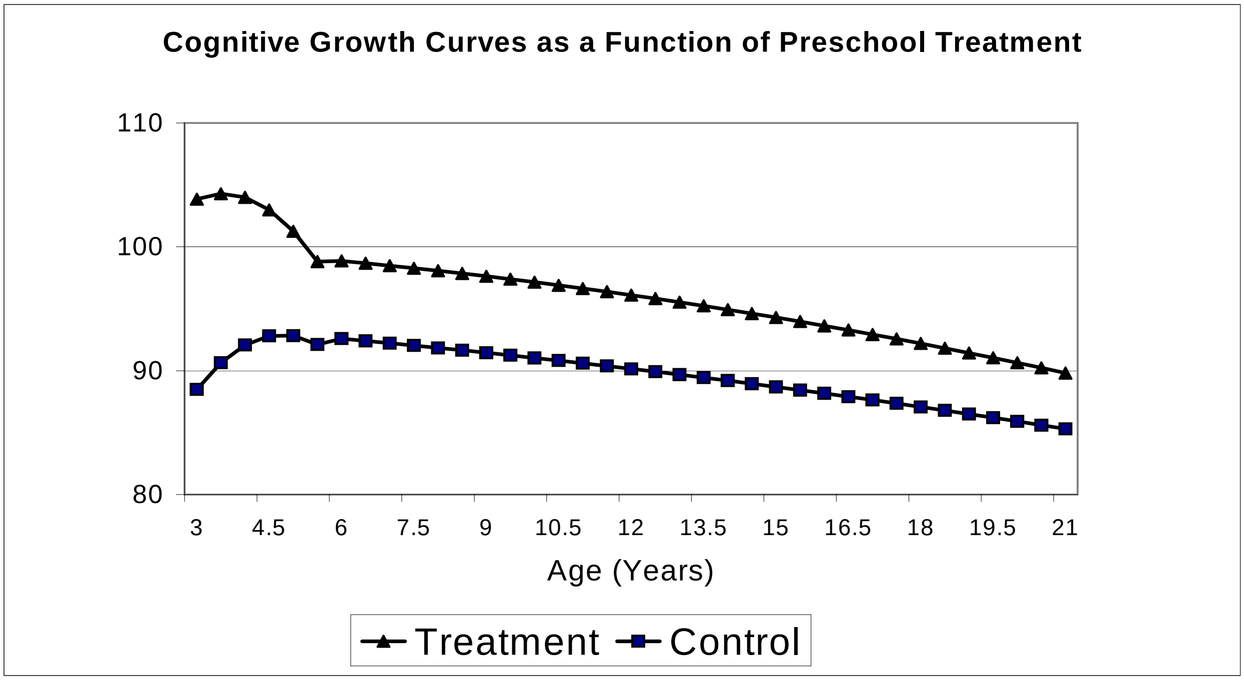

Cognitive Growth Curves as a Function of Preschool Treatment
110
100
90
80
3
4.5
6
7.5
9
10.5
12
13.5
15
16.5
18
19.5
21
Age (Years)
Treatment
Control

Figure 6

Longitudinal Scores for Reading Age 8-21

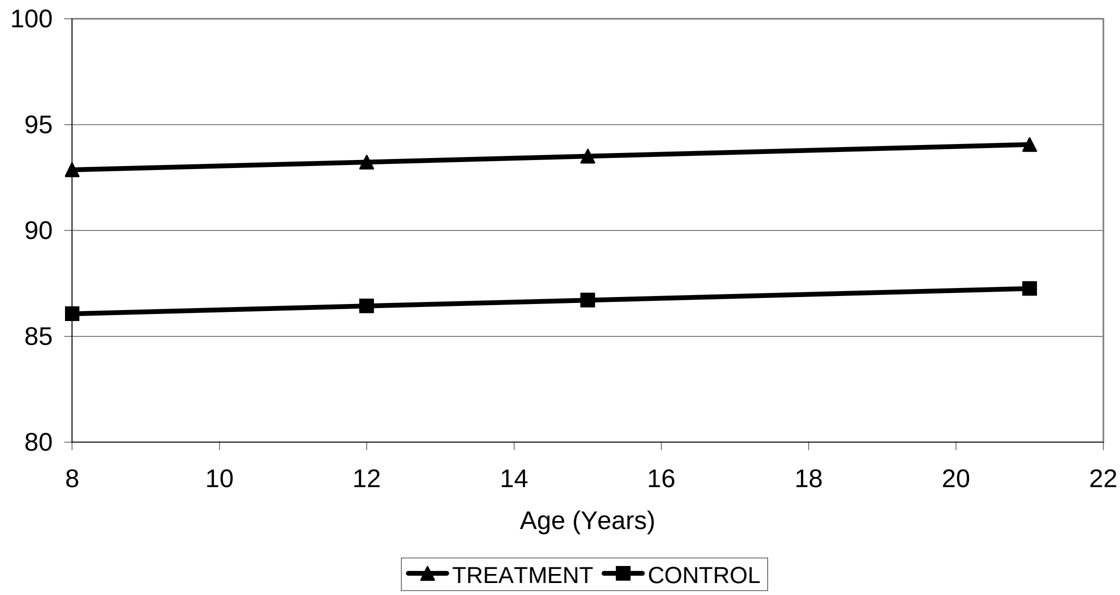
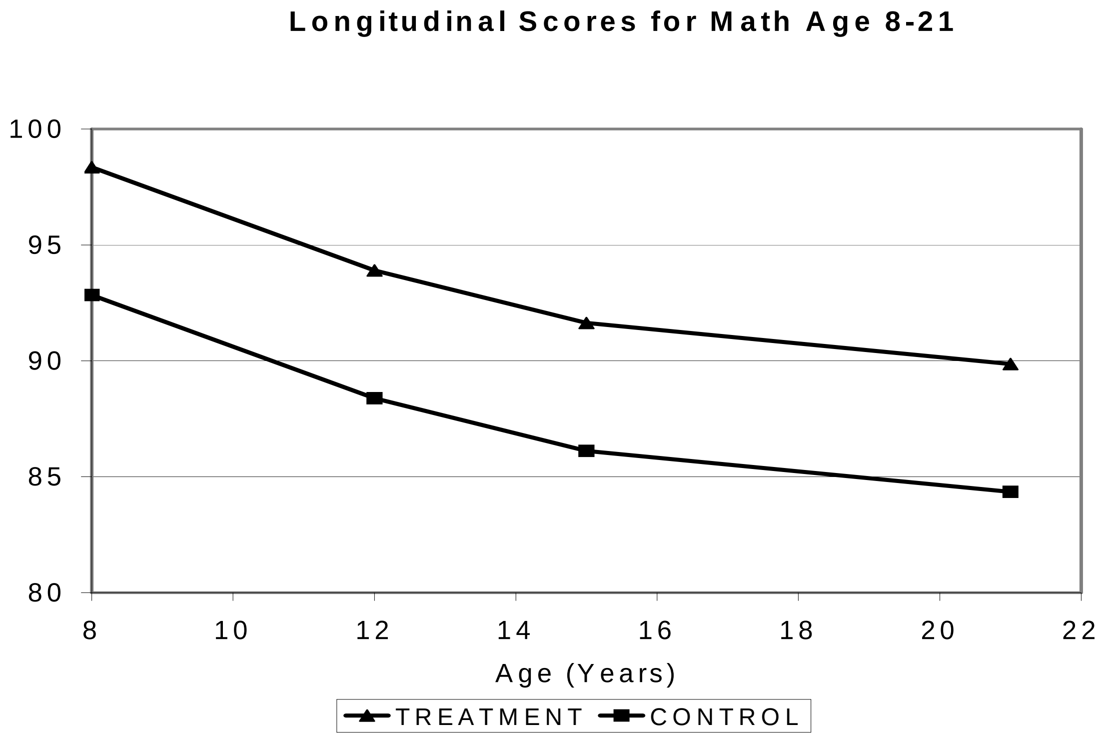


Figure 7


Longitudinal Scores for Math Age 8-21
100
95
90
85
80
8
10
12
14
16
18
20
22
Age (Years)
TREATMENT
CONTROL

Figures 5, 6, and 7