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**Preschool Education, Educational Attainment, and Crime Prevention:
Contributions of Cognitive and Non-Cognitive Skills**

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ABSTRACT

We investigated the extent to which cognitive and noncognitive skills accounted for the measured links between participation in preschool intervention and high school completion, highest grade completed, and incarceration history in early adulthood. Using data from the Chicago Longitudinal Study, an on-going 20-year investigation of the effects of the school-based Child-Parent Center early intervention program for over 1,500 children, we assessed the contribution of a variety of cognitive and noncognitive measures to the estimated effect of preschool. The cognitive measures included school readiness, achievement test scores up to age 14, and remedial education while noncognitive skills were represented by measures of social adjustment, motivation, educational expectations, problem behavior, and juvenile arrest.

Regression analysis indicated that when assessed separately, cognitive factors explained 42% of the effect of preschool on high school completion, 37% on highest grade completed, and 23% on incarceration history by age 24 while the measures of noncognitive factors explained 36%, 45%, and 59% of the effect of preschool in these outcomes, respectively. Together, the large set of cognitive and noncognitive factors explained 46%, 51%, and 59% of the main effect of preschool participation on these outcomes. Cognitive skills were more important for explaining educational attainment while noncognitive skills made greater value-added contributions to incarceration history. As one of very few studies investigating the differential contributions of cognitive and noncognitive skills to preschool effects, our findings support the important role of test scores, school performance, and social and motivational factors in explaining the effect of enriched preschool on economically important indicators of well-being.

INTRODUCTION

A number of studies in recent years report high rates of return to investments in high quality preschool programs, especially for children from low-income families. Temple and Reynolds (2006) and Rolnick and Grunewald (2003) discuss this literature. Enriched preschool programs, which broadly include home visitation programs by nurses and educational daycare as well as preschool education programs for 3- and 4- year olds, have demonstrated significant long-term effects in terms of reduced need for school remediation, higher educational attainment, greater economic well-being, and reduced crime (e.g., Barnett and Masse, 2006; Nores, Barnett, Belfield, and Schweinhart, 2005; Reynolds, Temple, Robertson and Mann, 2002; and Currie, 2001). Results of cost-benefit analyses of early childhood programs suggest benefit-cost ratios in the range of 4 to 10 or even higher.

Economists conducting research on early childhood interventions focus on two lines of inquiry. First, they have investigated the timing of human capital investments and have concluded that certain types of early investments are likely to have greater rates of return than later investments. When discussing the cumulative process of skill formation and the relative importance of early human capital investments, Heckman (2000) argues that “skill begets skill.”

Second, and consistent with objective of this paper, economists and developmental researchers are investigating the pathways through which early investments in education lead to higher educational attainment and general well-being in adulthood. Historically, early interventions were designed to provide educational enrichment to children with special needs or to children from economically-disadvantaged families (Ramey & Ramey, 1992). The major goal was to enhance cognitive skills, as measured by achievement tests or language assessments. As

described in Consortium for Longitudinal Studies (1983) and Campbell et al. (2002), early studies demonstrated that participation in intervention was linked to higher cognitive skills at school entry. The cognitive advantage created by participation in intervention was then found to account for longer-term effects on school achievement and need for school remedial services. Later research on the well-known Perry Preschool Program suggests that participation in preschool intervention caused lower rates of delinquency and crime and improved economic well-being in adulthood. Through path analysis, Perry researchers have consistently found that these results are primarily due to the process of cognitive advantage (Berrueta-Clement et al., 1984; Schweinhart et al., 2000; 2005). Noncognitive skills such as motivation and social adjustment contributed only as a consequence of the initial cognitive advantage.

More recent studies have tested a wider array of cognitive and noncognitive factors that explain early intervention effects. In the first empirical test of alternative explanations for the long-term effects of preschool intervention, Reynolds, Ou, & Topitzes (2004), using structural modeling with data in the Chicago Longitudinal Study, found that while cognitive advantage, measured by kindergarten achievement test scores, independently accounted for about a quarter of the total effect of preschool on educational attainment and juvenile arrest, family behavior and school support factors each accounted for similar proportions of the total effect of preschool. Social adjustment and motivation factors, which are most closely linked to noncognitive skills, accounted for very little of the total effect of preschool, especially on educational attainment.

Nevertheless, Heckman (2000) and Heckman and Masterov (2004) argue that the longer-term effects of the Perry Preschool Program and other successful early interventions are due primarily to the effect of the interventions on noncognitive skills. To strengthen their argument that noncognitive abilities are an important determinant of adult outcomes, Heckman,

Stixrud, and Urzua (2006) examine a wider array of cognitive and noncognitive factors that are associated with educational attainment and other adult outcomes such as crime or earnings. Using data from the National Longitudinal Survey of Youth (NLSY), Heckman et al. estimate the relative importance of cognitive abilities as measured by an Armed Forces Qualifications Test score and noncognitive abilities as represented by a measure of local control and a measure of self-esteem. They argue that cognitive and noncognitive abilities both are important in explaining a large number of economic outcomes in adulthood, although their relative importance varies according to outcomes and individual characteristics. Heckman et al. suggest that the findings regarding noncognitive abilities in particular have important policy implications because they believe that these abilities can be greatly affected by early childhood interventions.

The research in this paper builds upon the Heckman et al. (2006) study in two ways. First, we employ a larger number of both cognitive and noncognitive measures which are measured at different points in time. We use achievement test scores, need for remedial education, and a comprehensive set of noncognitive factors, including social and emotional learning, motivation, and attitudes. Second, because we use a longitudinal data set that was designed to study the impact of an early childhood intervention, we are able to examine the effects of early intervention of the wide array of cognitive and noncognitive skills and then see how these skills are related to educational attainment and crime. While Reynolds, Ou and Topitzes (2004) investigated several competing hypotheses of preschool effects in the Chicago Longitudinal Study (CLS), several limitations restrict interpretations. First, measures of social adjustment and motivation were restricted to classroom social adjustment as rated by teachers and self-perceptions of school commitment. Second, the temporal order of influences, based on established theory, was presumed to be from cognitive to noncognitive and not the reverse.

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Moreover, the outcomes of educational attainment and crime were measured no later than age 20, leaving open the question of whether identified paths continued to be influential for early adult well-being.

In this paper, we use data from the Chicago Longitudinal Study (CLS, 2005) to investigate the importance of many measures of cognitive and noncognitive skills that have been hypothesized to account for the effects of preschool participation. The CLS has followed a cohort of children born to families living in high-poverty neighborhoods in Chicago between 1979 and 1980. In this quasi-experimental study, almost a thousand children participated in the Child-Parent Center early education program and a matched group of children from randomly selected schools participated in full-day kindergarten programs, which was the usual educational treatment at the time for low-income children. The study has collected a rich set of cognitive and noncognitive measures beginning in kindergarten and continuing on a yearly basis up to age 15 from teachers, parents, children, and from standardized tests of reading and math skills given annually by the school district. These data are an unusually rich source of information of the various skills students acquire as they progress through school. As the students in the CLS have reached adulthood, a number of important student outcomes have been collected including measures of educational attainment and criminal behavior. These data are well-suited for examining the pathways through which participation in an enriched program of preschool intervention affects early adult outcomes. Our study investigates the effects of preschool participation on various cognitive and noncognitive skills and suggests the relative importance of these skills in determining educational attainment and crime.

We consider cognitive abilities as represented by test scores but also by special education placement for specific learning disabilities and by grade retention. The achievement

test scores include school readiness scores on the Iowa Tests of Basic Skills (ITBS), word analysis and math achievement at the end of kindergarten, and reading comprehension and math achievement up to eighth grade. Children's noncognitive skills are defined as the social, emotional, and attitudinal aspects of learning and development. Through self-assessments and ratings by teachers and parents between third and tenth grades, we included school commitment, achievement motivation, expectations for educational attainment, classroom social adjustment, problem behaviors in schools and official juvenile arrest. Other related skills and assets were not assessed in the study, including school and community attributes, peer influences, and family socialization and parenting behavior. However, parent involvement in children's education was used to test the robustness of the effects on cognitive and noncognitive factors. See Reynolds and Temple (2005) for additional perspectives on contributing factors.

METHODS

Sample and Data

The study sample was drawn from the Chicago Longitudinal Study (CLS, 2005), an ongoing investigation of a panel of low-income minority (93% African American; 7% Hispanic/Latino) children growing up in high-poverty neighborhoods in Chicago. The original sample (N=1,539) included 989 children who attended the CPC preschool program and 550 children who participated in alternative public programs, all of whom entered matriculated kindergarten in the Chicago Public Schools in 1986.

Data were collected since birth from various sources, such as study participants, parents, teachers, and administrative records from schools and other agencies (Reynolds, 2000). Educational data were gathered from elementary, secondary, and post-secondary schools attended by participants. Administrative records of county-level adult arrest and incarceration

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histories were collected from four states in the Midwest. Incarceration records were obtained from state departments of corrections and county level court data. The sample size for the present study included 1,368 participants for whom educational attainment (892 program and 480 comparison cases) and 1,413 participants with known incarceration status (913 program and 500 comparison cases). Recovery rates for the adult outcomes were roughly 90% for the program and comparison group with no suggestion of differential or selective attrition.

CPC Program Description

Since the CPC program is fully described in previous reports (Reynolds, 2000; Reynolds et al., 2004), we provide a summary of the main features. Located in or close to elementary schools in the Chicago public school system, the preschool program provides educational and family-support services to children beginning at age 3 or 4. Within a structure of comprehensive services similar to Head Start, the acquisition of basic skills in language arts and math is emphasized through relatively structured but diverse learning experiences that include teacher-directed, whole-class instruction, small-group and individualized activities, and frequent field trips. Literacy experiences involving word analysis, oral communication, and listening skills are highlighted. All teachers in the half-day preschool program have bachelor's degrees and are certified in early childhood education. Classes include 17 children and 2 staff members (teacher and aide). Each center is run by a head teacher, and a parent resource teacher implements the parent room activities in cooperation with the school-community representative. After a half- or full-day kindergarten, school-age services also are provided up to third grade in the elementary schools. Consequently, we include such participation as a covariate in the analysis. Since the comparison group had all-day kindergarten, this component of the program is not assessed.

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Families in CPC neighborhoods participated at a high rate (over 80%) which helps ensure that findings are representative of eligible children rather than sample selective.

A. Adult Outcomes.

Two types of educational and social outcomes are examined in this paper for the students in the Chicago Longitudinal Study. These include educational attainment by age 24 and adult incarceration status from ages 18 to 24.

Educational Attainment. Two measures of educational attainment were used: high school completion and highest grade completed. High school completion is a dichotomous variable indicating whether youths completed their secondary education with an official diploma or were awarded a General Education Development (GED) credential by August 2004 (N=1,372). Highest grade completed is an ordinal criterion ranging from 7 to 16 (N=1,368). Participants who obtained a GED were assigned a value of 12 while college attendance was coded depending on the number of credits earned. Thirty credits were treated as one year of college attendance.

Adult crime. Crime was measured through a dichotomous indicator: any incarceration or jail. The adult incarceration sample (N=1,413) includes all participants who completed the CLS adult survey, whose criminal arrest or incarceration records were available, or who were verified as residents of Illinois after age 18 based on various administrative sources. Most incarcerated cases served their sentence in state correctional institutions. Participants who were in jail less than 30 days were not coded as incarcerated.

B. Participation in early preschool intervention.

Child-Center Program Participation. CPC program participation was measured through two dichotomous measures: *preschool participation* and *follow-on participation*. Follow-on participation indicates whether the student received school-age services, primarily consisting of

small class sizes in special classes offered in the Child-Parent Centers. Because the focus of the present study is to examine the relationship between preschool participation and student outcomes, this additional participation in the grade school years is included in the analysis as a covariate.

C. Cognitive and noncognitive skills.

Cognitive Skills/School Achievement

Entering kindergarten cognitive readiness (age 5) was measured by the Iowa Test of Basic Skills (ITBS; Hieronymus, Lindquist, & Hoover, 1980). The test measures a broad array of readiness skills, including listening, word analysis, vocabulary, language, and mathematics. Each subscale has approximately 30 pictorial items. Internal consistency reliability was .94.

Word analysis in kindergarten was measured by the ITBS scale at age six. The scale consists of 35 items evaluating prereading skills, such as letter-sound recognition and rhyming. *The math subtest scale in kindergarten* included 33 items assessing numbering, classification, and quantification. Internal consistency reliability was .87 for word analysis, and .82 for math test. Research has confirmed the measure's predictive validity for later achievement (Reynolds, 1991, 2000).

ITBS reading and math scores at age 12 and 14 were also included as measures of school achievement. At age 12, the ITBS reading comprehension subtest includes 54 items on interpreting test passages. The mathematics total subtest contains 101 items on computation, concepts, and problem-solving skills. Both subtests have high reliability (KR-20s > .90). At age 14, the ITBS reading scale in a continuous measure comprised of 58 items that emphasized understanding of text passages (alpha = .92). The math test contained 117 items assessing

conceptual domains, computation, and problem solving. The reliability was .95 (Reynolds, 2000).

Grade retention reflects all individuals who ever repeated a grade between ages 6 and 14. *Any learning disability special education placement* reflects all individuals who received special education due to learning disability between ages 7 and 18. Children who were made to repeat a grade typically did so because of poor academic performance, and so grade retention and special education placement are used here as additional ways of measuring cognitive abilities.

Non-cognitive skills

Classroom adjustment was measured on a six-item scale rated by teachers from first grade through sixth grade (ages 7 to 12). The scale asks teachers to rate children from poor/not at all (1) to excellent/very much (5) on items including “concentrates on work,” “follows direction,” “is self-confident,” “participates in group discussion,” “gets along well with others,” and “takes responsibility for actions” (alpha = .91). Three composite measures were created from the annual scores: average of ages 7 to 9 (grades 1 to 3), average of ages 10 to 12 (grades 4 to 6), and average of ages 9 to 12 (grades 3 to 6).

Perceived competence was measured through a self-concept scale including task persistence on a 10 to 12-item (slightly different from year to year) scale coded from strongly disagree (1) to strongly agree (4). Average of internal consistency of the scale is .75. Examples of the items are like “my classmates like me”, “I get along well with others”, “I am smart”, and “I try hard in school”. The scores were transformed into *z*-scores first, and 2 average scores were used: average of ages 9 and 10 and average of ages 9 to 12.

Intrinsic motivation to learn between ages 9 and 12 was measured through student ratings on 14 items, such as “I get bored in school”, “learning is fun”, and “I like to learn things”. Items

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vary year by year. A total score for each year was calculated by summing the ratings for all available items. The total scores were then transformed into Z-scores, and averaged across ages 9 through 12.

Troublemaking behavior between ages 9 and 12 was measured through student ratings on 4 items (“I get in trouble at school”, “I get in trouble at home”, “I follow class rules”, and “I fight at school”) related to their behavior at school and home. Each item was measured on a three-point scale (1= not much, 2= some, 3= a lot) in ages 9 and 10 and a four-point scale (from 1 = strongly agree to 4 = strongly disagree) in ages 11 and 12. A total score for each year was calculated by summing the ratings for all four items. The total scores were then transformed into Z-scores, and averaged across ages 9 through 12.

Acting out behaviors between ages 12 and 13 were measured through a teacher-rated 6-item scale from the Teacher-Child Rating Scale (T-CRS), including “disruptive in class”, “fidgety, difficulty sitting still”, “disturbs others while they are working”, “constantly seeks attention”, “overly aggressive to peers (fights)”, and “deviant, obstinate, stubborn. The internal reliability was .94. The continuous measure was recoded into a dichotomous variable indicating if one is 1 standard deviation above average score.

Assertive social skills between ages 12 and 13 was measured through a teacher-rated 5-item T-CRS scale, including “defends own views under group pressure”, “comfortable as leader”, “participates in class discussions”, “expresses ideas willingly”, and “questions rules that seem unfair/unclear”. The internal reliability was .87.

Teachers rated participants on *peer social skills* on a 5-item T-CRS scale (e.g. “has many friends”, “is friendly towards peers,” and “well liked my classmates”) at age 12 (alpha = .93) and

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age 13 ($\alpha = .92$). The scale ranged from not at all (1) to very well (5). The average score was used.

Task orientation between ages 12 and 13 also was measured through a 5-item T-CRS scale, including “completes work”, “well organized”, “functions well even with distractions”, “works well without supervision”, and “a self-starter”. The internal reliability was .93.

Student expectations is a dichotomous variable indicating whether students expected to go to college or not. This measure is based on the item, “How far in school do you think you will get?” from student survey at age 10. If students were missing at age 10, an age 16 response on the same item was used.

School commitment was measured through a 12-item scale rated by students at ages 11, 12, and 16. Same items were included in the scale (e.g., “I try hard in school”, “I like school”, “I give up when school work gets hard”). Two items were asked only at age 16 (10th grade): “I learn a lot at school” and “there are many things about school I don’t like”. The items were rated on a four-point scale coded from strongly disagree (1) to strongly agree (4) ($\alpha = .74$ for age 11, $\alpha = .78$ for age 12, $\alpha = .79$ for age 16). The average score of ages 11 and 12 was used, and if one was missing from both, the score at age 16 was used. Overall, the scores ranged from 25 to 64.5 with a higher score indicating greater motivation.

Any juvenile arrest codes participants 1 if they had an official delinquency petition before age 18; otherwise they were coded 0. Data came from administrative records of the Cook County Juvenile Court in Illinois and in a few other locations.

Parent involvement between ages 7 and 12 measures the frequency of parent participation in school from grades 1 through 6. Teachers rated “parent’s participation in school activities” from poor/not at all (1) to excellent/much (5). The total scale ranges from 0 to 6, reflecting the number

of times that parents were given "average or better" ratings (average or better is a score of 3 or higher; Min. = 0, Max. = 5) for parent involvement.

D. Additional covariates.

A number of dichotomous sociodemographic measures were included in all analyses as covariates, including race/ethnicity, gender, maternal education, free lunch eligibility, single parent status, teen parent status, family size, public aid receipt (TANF/AFDC), and status of child welfare case history by child's age 4. For several explanatory variables, participants with missing values were imputed through multiple imputation procedures using the EM algorithm, and a dummy variable equal to one when these data are missing is included as an additional control in the regression analyses. Only one outcome variable, kindergarten cognitive school readiness, had a significant number of cases imputed. Intercorrelations among variables as well as program and comparison group mean differences were similar before and after imputation suggesting missing data was relatively unsystematic in the study sample.

RESULTS

Descriptive Statistics

Table 1 presents the descriptive statistics of the key measures described in the previous section. We employ Iowa Test of Basic Skills (ITBS) test scores at various ages. We have test score information available at both kindergarten entry and at the end of kindergarten. We also focus on later test scores for math and reading for students aged 12 and 14. These ages generally correspond to grades 6 and 8. Table 1 also shows the means and other statistics for the large number of noncognitive measures we employ in our analysis. At the bottom of the table, the descriptive statistics for educational attainment and crime are presented. Approximately 75% of

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the sample either graduated from high school or received the GED as of age 24. Almost a quarter of the sample had spent more than 30 days in jail.

Table 2 shows the unadjusted means on cognitive skills/school achievement and noncognitive skills by groups. There are significant differences between the preschool group and the comparison group on all measures of cognitive skills/school achievement. The preschool group has higher test scores than the comparison group. The preschool group also has lower rates of grade retention and special education placement for learning disability than the comparison group. In terms of noncognitive skills, the group differences are significant for most of the measures except perceived competence, intrinsic motivation to learn and student expectations of attending college. The preschool group has higher scores on classroom adjustment, assertive social skills, peer social skills, task orientation, and school commitment than the comparison group, and has fewer troublemaking behavior and lower rates of acting out and delinquency than the comparison group.

Program Estimates for Cognitive and Noncognitive Skills

We first estimate examine the relationship between preschool participation and the accumulation of cognitive and noncognitive abilities measured in the years after preschool. Tables 3 and 4 show these results. In the quasi-experimental design of the CLS, preschool children were matched with very similar children from equally poor (actually, slightly poorer) neighborhoods that did not contain the Child-Parent Center intervention sites. The comparability of these groups been extensively examined in previous studies and no evidence of selection bias has been found (e.g., Temple and Reynolds, 2006 and Reynolds and Temple,

1995). As a result, we interpret the results in Tables 3 and 4 as suggesting the causal effects of preschool participation on the cognitive and noncognitive abilities.

Table 3 reports the effect of preschool participation on 9 different cognitive outcomes. Seven OLS regressions were employed for the continuous test scores measures, and two probit regressions were run to analyze the outcomes of any retention and any special education placement. For all the regressions reported in this paper, specifications accounting for within-site intervention correlations in errors are not shown because the within-site correlations are low and the results with robust standard errors differ little from the OLS results. In Table 3, the adjusted group means show the mean level of the cognitive outcome for the preschool group and the non-preschool group, controlling for 12 or 13 socio-demographic variables listed in the note to the table. The p-value reported for the estimated marginal effects of preschool indicates that all group differences are significant at the 5% level or below. Most of these results are similar to those reported in previous studies of the CLS such as Reynolds et al. (2005) and Reynolds and Temple (1995), but some differences may exist due to the fact that some of the socio-demographic control variables have only been recently added to the study. Temple and Reynolds (2006) discuss some of the new information on family backgrounds that have been added to the CLS in recent years as more administrative data have become available.

In Table 3, the effects of the preschool program on test scores suggest that preschool participants have scores that are 3 to 5 points higher than non-participants. This roughly corresponds to roughly a 5 or 6 month difference in kindergarten and a 4 or 5 month difference as of grade 8. Students who participated in the preschool program have almost a 6 percent point reduction in the probability of being made to repeat a grade. Preschool participants have a 3

percentage point reduction in the probability of being placed in special education, which corresponds to almost a one-third reduction in this probability (from 9.5% to 6.3%).

The findings that preschool participation can affect academic performance is not surprising because the preschool is an educational intervention with a focus on early literacy activities. In Table 4, however, we examine the effect of preschool on over a dozen measures of non-cognitive abilities. Table 4 reports the results of 15 separate regressions. Twelve of the outcomes are continuous and were measured using OLS, while the remaining dichotomous measures were analyzed using probit analysis. The effects of preschool participation on these non-cognitive skills are not as strong overall as the academic results reported in Table 3. However, many of the effects of preschool on these skills are significant at the 10% level or below. Importantly, teacher ratings of classroom adjustment for ages 7-9 appear to be significantly affected by preschool participation. Other strong effects were found for peer social skills, school commitment, delinquency, and parental involvement. Note that all signs on the estimated effects of preschool are in the expected direction. Taken as a whole, the results in Table 4 suggest that a program of enriched preschool participation for children from disadvantaged families has an effect on a wide range of non-cognitive abilities observed over both the early and later years of schooling. In the tables that follow, the role of both the cognitive and non-cognitive skills in determining important adult outcomes of educational attainment and crime will be examined.

Initial Contributions of Cognitive and Noncognitive Skills

Since CPC preschool participation is significantly associated with adult well-being, we use a hierarchical regression approach to estimate the contributions of cognitive and noncognitive skills to effect of preschool. A key metric in this approach is the percentage

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reduction in the estimated main effect of preschool associated with a particular indicator or set of indicators of cognitive/noncognitive skills. A cognitive/noncognitive indicator would completely account for the preschool effect if after inclusion, the preschool coefficient was reduced close to 100% or at a minimum the included cognitive/noncognitive skill would change the preschool coefficient from statistically significant to nonsignificant.

Table 5 shows the estimated effects of preschool participation before and after inclusion of cognitive and noncognitive skills hypothesized to account for the observed effect. As shown in the first row of Table 5, preschool participants had an adjusted rate of high school completion that was 8.7 percentage points higher than the comparison group. The preschool group also completed about a third of a year more of schooling, and had a 5 percentage point lower rate of adult incarceration.

The second and third blocks of Table 5 show the marginal effect of preschool after including cognitive and non cognitive skill indicators one at a time. Inclusion of variables one at a time provides a relative index of variable contributions without the construct confounding of simultaneous entry of all variables. Among cognitive skills, ITBS reading and math achievement at age 14 were associated with the largest reductions in the main effect of preschool on the three adult outcomes. This indicates they accounted for the largest share of the preschool main effect. Grade retention and special education for learning disabilities were generally associated with the smallest reductions in main effect, indicating they alone contributed the least to the explanation of preschool effects.

Among noncognitive skills, school commitment and juvenile arrest were associated with the largest reduction in preschool main effects. School commitment accounted for the largest share of the effect on high school completion while juvenile arrest accounted for the largest share

of effects on highest grade completed and incarceration. Teacher ratings of classroom adjustment by third grade and self-reports of trouble making behavior by age 12 accounted for the smallest reduction in the main effect of preschool on high school completion whereas peer social skills and classroom adjustment accounted for the smallest reduction in effects on highest grade completed and incarceration, respectively.

Value-Added Contributions of Cognitive and Noncognitive Skills

As shown in Table 6, we estimated the independent effects of cognitive skills on the relation between CPC preschool and adult outcomes controlling for noncognitive skills as well as the independent effects of noncognitive skills controlling for cognitive skills. Within each skill area, the sequential effects of different indicators also were assessed based the temporal order of measurement.

Cognitive skills. In the first block of Table 6, each cognitive indicator contributed to the explanation of preschool effects. Note that inclusion of only kindergarten achievement measures did not substantially reduce the size of the preschool coefficient. The largest reduction in effects occurred when all five cognitive measures were included in the model. For example, the set of cognitive indicators accounted for 42% of the main effect of preschool participation on high school completion, 37% of the main effect on highest grade completed, and 23% of the main effect of incarceration.

Noncognitive skills. Similarly, the full set of noncognitive skills accounted for the largest reduction in the size of the preschool coefficient. For example, the noncognitive skills accounted for 36% of the main effect of preschool on high school completion, 45% of the main effect on highest grade completed, and 59% of the main effect on incarceration. Not surprisingly, juvenile

arrest status explained the largest percentage of the preschool main effect, especially for adult incarceration.

Table 6, block 4 also shows that cognitive skills uniquely contributed to preschool effects on high school completion and highest grade completed above and beyond the influence of noncognitive skills. In contrast, the set of noncognitive skills contributed most to the explanation of the preschool effect on incarceration history (see block 3). Noncognitive skills made smaller unique contributions to educational attainment.

Together, the set of cognitive and noncognitive skills accounted for roughly one-half of the direct main effect of preschool on adult outcomes, including 46% of the effect on high school completion, 51% of the effect on highest grade completed, and 59% of the effect on incarceration.

In summary, both cognitive and noncognitive skills accounted for sizable shares of the link between preschool participation and adult outcomes. The inclusion of both sets of skills in the model made the largest contribution to the explanation of main effects. Nevertheless, 40 to 50% of the estimated direct effect of preschool was left unaccounted for by cognitive and noncognitive skills.

CONCLUSION

A number of studies in recent years have demonstrated that high-quality early intervention programs have long lasting effects into adulthood. Understanding how early education can produce long lasting benefits in terms of educational attainment, income, and other economic outcomes is an important area of current study. Heckman et al. (2006) and Heckman (2000) argue that the effects of early education on cognitive abilities only represents a small

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portion of the overall effects of early education, and suggest that more research should be conducted on the effects of early education on noncognitive abilities.

Using data from an ongoing investigation of the effects of preschool intervention for a large sample of children from low-income urban families, we find that participation in an enriched preschool program generates increases in both cognitive and noncognitive abilities throughout the school years. A strength of our study is the availability of a large number of noncognitive and cognitive measures obtained at different points in time. We find that while noncognitive skills are important for educational attainment, these abilities are especially important in explaining criminal activity as measured by incarceration history. Given the large benefits to society of policies that can reduce crime, it appears that high-quality preschool intervention can be an effective tool in the fight against crime by not only increasing educational attainment but also addressing deficits in noncognitive skills that are correlated with criminal activity.

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Table 1 Descriptive Statistics for Explanatory and Outcome Measures

	N	Min.	Max.	Mean	SD
<i>Cognitive skills/school achievement</i>					
ITBS kindergarten cognitive readiness (age 5)	1539	28.0	83.00	47.40	8.81
ITBS kindergarten word analysis skills (age 6)	1531	19.0	99.00	63.75	13.31
ITBS Kindergarten math scores (age 6)	1531	27.00	96.00	62.28	13.60
ITBS reading scores (age 12)	1209	62.00	173.00	123.86	17.68
ITBS math scores (age 12)	1204	74.00	180.00	128.79	16.56
ITBS reading scores (age 14)	1344	77.00	212.00	144.73	21.76
ITBS math scores (age 14)	1343	82.00	225.00	147.32	18.34
Any grade retention (ages 6-14), %	1377	0	1	.28	.45
Any learning disability special edu (ages 7-18), %	1377	0	1	.09	.29
<i>Noncognitive skills</i>					
Classroom adjustment (ages 7-9; teacher rating)	1429	7.0	30.0	19.11	4.83
Classroom adjustment (ages 10-12; teacher rating)	1224	6.0	30.0	18.72	4.89
Classroom adjustment (ages 9-12; teacher rating)	1348	6.0	30.0	18.78	4.57
Perceived competence (ages 9-10; student rating)	1227	-3.604	2.857	.00	1.0
Perceived competence (ages 9-12; student rating)	1332	-3.620	3.350	.00	1.0
Intrinsic Motivation to Learn (ages 9-12)	1332	-3.21	1.74	.00	.77
Troublemaking behavior (ages 9-12; self report)	1331	-1.73	2.65	.02	.79
Acting out behavior (ages 12-13; teacher report)	1058	0.0	1.0	.17	.37
TCRS Assertive social skills (ages 12-13)	1058	5.00	25.00	15.46	4.36
TCRS Peer social skills (ages 12-13)	1058	5.00	25.00	16.69	4.72
TCRS Task orientation (ages 12-13)	1058	5.00	25.00	14.37	5.20
Student expects to go to college (ages 10-15)	1163	.00	1.00	.81	.40
School commitment (ages 11-15; student rating)	1228	25.00	64.50	50.67	5.68
Any official delinquency by age 18, %	1406	.00	1.00	.21	.41
Parent participation in school average or above (ages 7-12; teacher rating)	1447	0	6	1.96	1.49
<i>Outcome Measures</i>					
High school completion by age 24, %	1372	0	1	.74	.44
Highest grade completed by age 24	1368	3	16	11.86	1.64
Any incarceration by age 24, %	1413	0	1	.23	.42

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Table 2 Unadjusted Means of Cognitive and Noncognitive Skills by CPC Preschool Participation

	Total mean (N = 1,539)	Preschool group (N = 989)	Comparison group (N= 550)	p-value
<i>Cognitive skills/school achievement</i>				
ITBS kindergarten cognitive readiness (age 5)	47.40	49.14	44.26	.000
ITBS kindergarten word analysis skills (age 6)	63.75	65.87	59.91	.000
ITBS Kindergarten math scores (age 6)	62.28	64.15	58.86	.000
ITBS reading scores (age 12)	123.86	125.42	120.78	.000
ITBS math scores (age 12)	128.79	130.41	125.57	.000
ITBS reading scores (age 14)	144.73	147.05	140.31	.000
ITBS math scores (age 14)	147.32	149.24	143.68	.000
Any retention (ages 6-14), %	28.34	24.58	35.33	.000
Any learning disability special edu (ages 7-18), %	9.08	7.04	12.86	.001
<i>Noncognitive skills</i>				
Classroom adjustment (ages 7-9)	19.11	19.58	18.26	.000
Classroom adjustment (ages 10-12)	18.72	19.08	18.07	.001
Classroom adjustment (ages 9-12)	18.78	19.11	18.16	.000
Perceived competence (ages 9-10)	0.00	.040	-.08	.056
Perceived competence (ages 9-12)	0.00	.037	-.069	.067
Intrinsic Motivation to Learn (ages 9-12)	.004	.0188	-.0239	.337
Troublemaking behavior (ages 9-12)	.022	-.019	.100	.009
TCRS Acting out behavior (ages 12-13)	16.82	15.04	20.28	.037
TCRS Assertive social skills (ages 12-13)	15.46	15.67	15.04	.025
TCRS Peer social skills (ages 12-13)	16.69	16.97	16.14	.006
TCRS Task orientation (ages 12-13)	14.37	14.73	13.68	.002
Student expects to go to college (ages 10-15)	80.57	82.08	77.61	.072
School commitment (ages 11-15)	50.67	51.06	49.93	.001
Any official delinquency, %	20.91	17.89	26.47	.000
Parent participation average or above (ages 7-12)	1.96	2.12	1.65	.000

Note. Sample sizes are from the original study sample. Sample sizes for high school completion, highest grade completed, and incarceration were, respectively, 1,372 (892 and 480), 1,368 (889 and 479), and 1,413 (913 and 500).

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Table 3 Adjusted Program Group Means and Marginal Effects for Cognitive Outcomes

<i>Indicator</i>	Preschool group	Comparison group	Marginal effect	<i>p</i> -value	Effect size
ITBS kindergarten cognitive readiness (age 5)	49.09	44.34	4.75	.000	0.539
ITBS kindergarten word analysis skills (age 6)	65.83	59.99	5.84	.000	0.439
ITBS Kindergarten math scores (age 6)	64.16	58.84	5.32	.000	0.391
ITBS reading scores (age 12)	124.78	122.06	2.72	.015	0.153
ITBS math scores (age 12)	129.84	126.70	3.14	.003	0.189
ITBS reading scores (age 14)	146.41	141.53	4.88	.000	0.224
ITBS math scores (age 14)	148.66	144.79	3.87	.000	0.211
Any retention (ages 6-14), %	21.8	27.40	-5.6	.026	0.178
Any learning disability special edu (ages 7-18), %	6.3	9.50	-3.2	.048	0.220

Note. Adjusted for gender, race, single parent status, maternal education, mother was a teen parent, number of children, TANF, free lunch, mother unemployment, income60, missing of individual indicators, child welfare history by age 4, and follow-on participation. Kindergarten achievements were not adjusted for follow-on participation.

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Table 4 Adjusted Program Group Means and Marginal Effects for NonCognitive Outcomes

<i>Indicator</i>	Preschool group	Comparison group	Marginal effects	<i>p</i> -value	Effect size
Classroom adjustment (ages 7-9)	19.41	18.56	.85	.002	0.176
Classroom adjustment (ages 10-12)	18.91	18.39	.52	.088	0.106
Classroom adjustment (ages 9-12)	18.91	18.53	.38	.153	0.083
Perceived competence (ages 9-10)	.025	-.047	.072	.276	0.072
Perceived competence (ages 9-12)	.035	-.066	.101	.109	0.101
Intrinsic Motivation to Learn (ages 9-12)	.014	-.014	.028	.574	0.036
Troublemaking behavior (ages 9-12)	-.011	.086	-.097	.044	0.122
Acting out behavior (ages 12-13)	14.09	18.69	-4.6	.083	0.187
Assertive social skills (ages 12-13)	15.64	15.11	.53	.086	0.121
Peer social skills (ages 12-13)	16.92	16.24	.68	.043	0.144
Task orientation (ages 12-13)	14.60	13.93	.67	.055	0.128
If student report of expect college (ages 10-15)	81.73	80.23	1.5	.588	0.055
School commitment (ages 11-15)	51.01	50.01	1.00	.007	0.176
Any delinquency, %	14.57	21.57	-7.0	.003	0.268
Parent participation average or above (ages 7-12)	2.04	1.80	.24	.005	0.161

Note. Adjusted for gender, race, single parent status, maternal education, mother was a teen parent, number of children, TANF, free lunch, mother unemployment, income60, missing of individual indicators, child welfare history by age 4, and follow-on participation.

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Table 5 Estimated Effects of CPC Preschool Participation after Including Cognitive and Noncognitive Skills One at a Time

Entered variables	High school completion		Highest grade completed		Incarceration	
	<i>Marginal effect</i>	<i>p-value</i>	<i>Coeff.</i>	<i>p-value</i>	<i>Marginal effect</i>	<i>p-value</i>
CPC Preschool participation (main effect)	.0869	.001	.3245	.001	-.0501	.033
Cognitive skills						
ITBS kindergarten cognitive readiness (age 5)	.0699	.011	.2540	.010	-.0396	.102
ITBS kindergarten word analysis skills (age 6)	.0652	.016	.2321	.016	-.0435	.068
ITBS Kindergarten math scores (age 6)	.0716	.008	.2675	.006	-.0424	.075
ITBS reading scores (age 12)	.0523	.082	.2263	.030	-.0402	.111
ITBS math scores (age 12)	.0515	.086	.2025	.048	-.0399	.113
ITBS reading scores (age 14)	.0502	.080	.1933	.047	-.0321	.183
ITBS math scores (age 14)	.0481	.093	.1941	.045	-.0363	.134
Any retention (ages 6-14), %	.0625	.027	.2654	.007	-.0485	.044
Any learning disability special edu (ages 7-18), %	.0665	.019	.2852	.004	-.0495	.040
Non-cognitive						
Classroom adjustment (ages 7-9)	.0748	.007	.2795	.003	-.0513	.033
Troublemaking behavior (ages 9-12)	.0739	.01	.2846	.005	-.0387	.102
Peer social skills (ages 12-13)	.0701	.033	.3045	.009	-.0336	.208
School commitment (ages 11-15)	.0603	.042	.2601	.013	-.0300	.213
Any delinquency, %	.0669	.016	.2552	.008	-.0212	.374
Parent participation average or above (ages 7-12)	.0680	.013	.2756	.004	-.0430	.068

Note. Coefficients are the estimated preschool effect after including one and only one indicator of cognitive or noncognitive skills.

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Table 6 Hierarchical Estimates of Effects of CPC Preschool Participation by Skills Area and Sequentially Across Skill Area

	High school completion		Highest grade completed		Incarceration	
	Coeff.	Marginal effect	Coeff.	Coeff.	Marginal effect	
CPC Preschool participation (main effect)	.2754*	-.0869	.3245*	-.1966*	-.0501	
Cognitive Skills						
ITBS kindergarten word analysis skills (age 6)	.2100*	.0652	.2321*	-.1731	-.0435	
+ ITBS Kindergarten math scores (age 6)	.2076*	.0645	.2281*	-.1628	-.0409	
+ Retention and learning disability special education	.1710	.0530	.2214*	-.1800	-.0429	
+ ITBS reading scores (age 14)	.1648	.0508	.2056*	-.1648	-.0386	
Non-cognitive Skills						
Classroom adjustment (ages 7-9)	.2440*	.0748	.2795*	-.2096*	-.0513	
+ Troublemaking behavior (ages 9-12)	.2445*	.0746	.2651*	-.2070	-.0470	
+ School commitment and Peer social skills	.21002	.0647	.2283	-.17135	-.0363	
+ Any delinquency, %	.1818	.0557	.1783	-.1019	-.0207	
All Cognitive measures	.1648	.0508	.2056*	-.1648	-.0386	
+ Classroom adjustment (ages 7-9)	.2017*	.0621	.2381*	-.2139*	-.0503	
+ Troublemaking behavior (ages 9-12)	.2401*	.0733	.2597*	-.2078	-.0469	
+ School commitment and Peer social skills	.1800	.0546	.2017	-.1668	-.0350	
+ Any delinquency, %	.1562	.0471	.1595	-.1023	-.0207	
+ Parent participation average or above (ages 7-12)	.1483	.0446	.1528	-.0988	-.0200	
All non-cognitive measures	.1818	.0557	.1783	-.1019	-.0207	
+ ITBS kindergarten word analysis skills (age 6)	.1732	.0529	.1681	-.1059	-.0216	
+ ITBS Kindergarten math scores (age 6)	.1780	.0544	.1772	-.1053	-.0215	
+ Retention and learning disability special education	.1670	.0508	.1664	-.1105	-.0224	
+ ITBS reading scores (age 14)	.1562	.0471	.1595	-.1023	-.0207	
+ Parent participation average or above (ages 7-12)	.1483	.0446	.1528	-.0988	-.0200	

* p < .05

Appendix. Coefficients of Explanatory Variables in the Cognitive, NonCognitive, and Combined Models

	High school completion	Highest grade completed	Incarceration
	Coeff.	Coeff.	Coeff.
Cognitive only			
Preschool participation	.1648	.2057*	-.1648
School-age participation	-.0078	-.0675	.0988
ITBS kindergarten word analysis skills (age 6)	.0053	.0048	.0056
ITBS Kindergarten math scores (age 6)	-.0054	-.0082*	.0018
Any retention (ages 6-14), %	-.3067*	-.3927*	-.0043
Any learning disability special edu (ages 7-18), %	-.0944	-.1787	-.0652
ITBS reading scores (age 14)	.0135*	.0198*	-.0133*
Non-cognitive only			
Preschool participation	.1818	.1783	-.1019
School-age participation	.0088	.0115	.1530
Classroom adjustment (ages 7-9)	.0508*	.0837*	.0075
Troublemaking behavior (ages 9-12)	.0574	.0054	.2203*
School commitment (ages 11-15)	.0153	.0251*	-.0197
Peer social skills (ages 12-13)	.0365*	.0352*	-.0198
Any delinquency, %	-.4797*	-.8021*	.9436*
Cognitive and non-cognitive			
Preschool participation	.1483	.1528	-.0988
School-age participation	-.0657	-.0501	.1481
ITBS kindergarten word analysis skills (age 6)	.0027	.0013	.0025
ITBS Kindergarten math scores (age 6)	-.0058	-.0083	.0002
Any retention (ages 6-14), %	-.2594*	-.3273*	-.0450
Any learning disability special edu (ages 7-18), %	-.1944	-.1723	-.0920

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	High school completion	Highest grade completed	Incarceration
	Coeff.	Coeff.	Coeff.
ITBS reading scores (age 14)	.0096*	.0101*	-.0041
Classroom adjustment (ages 7-9)	.0099	.0465*	.0135
Troublemaking behavior (ages 9-12)	.0613	.0134	.2162*
School commitment (ages 11-15)	.0090	.0195*	-.0186
Peer social skills (ages 12-13)	.0322*	.0311*	-.0185
Any delinquency, %	-.4364*	-.7239*	.9214*
Parent participation average or above (ages 7-12)	.0829*	.0682	-.0290

* p < .05