How Does the Fast Track Intervention Prevent Adverse Outcomes in Young Adulthood?

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Abstract

Numerous studies have shown that childhood interventions can foster improved outcomes in adulthood. Less well understood is precisely how – that is, through which developmental pathways – these interventions work. This study assesses mechanisms by which the Fast Track project (*n*=891), a randomized intervention in the early 1990s for high-risk children in four communities (Durham, NC; Nashville, TN; rural PA; and Seattle, WA), reduced delinquency, arrests, and health and mental health service utilization in adolescence through young adulthood (ages 12–20). A decomposition of treatment effects indicates that about a third of Fast Track's impact on later crime outcomes can be accounted for by improvements in social and self-regulation skills during childhood (ages 6–11), such as prosocial behavior, emotion regulation and problem solving. These skills proved less valuable for the prevention of mental and physical health problems.

Considerable research demonstrates that early childhood interventions targeting children, schools, or families can improve outcomes much later in life (e.g. Battistich, Schaps, & Wilson, 2004; Campbell et al., 2014; Ludwig & Phillips, 2008; Olds et al., 1998; Schweinhart et al. 2005). Less is known, however, about the mechanisms through which interventions yield positive long-term outcomes (Heckman, Pinto, & Savelyev, 2013; Dodge, Godwin, & Conduct Problems Prevention Research Group (CPPRG), 2013). It is not enough merely to know whether a childhood program is effective in its goals. How specifically do participants grow or change in response to the intervention, and which changes are especially valuable in producing long-term outcomes? Most early childhood interventions attempt to change characteristics of a child directly, anticipating that these changes will mediate long-term outcomes indirectly. Making policy decisions about scale-up

or dissemination of a program requires detailed knowledge about the pathways of prevention, and understanding these pathways informs theories of child development.

This study seeks to identify the mechanisms through which Fast Track, a childhood intervention for high-risk, aggressive, first-grade children carried out in the 1990s in four communities across the United States, prevented harmful outcomes in adolescence and young adulthood. Fast Track provided children academic tutoring and lessons in social skills and self-control. Fast Track has been evaluated through a randomized controlled trial that has demonstrated positive impact on antisocial outcomes through age 25 (CPPRG, 2015). A decomposition of Fast Track's treatment effects can illuminate the relative importance of enhancing different types of personal capabilities for decreasing the likelihood of later criminal behavior or health and mental health problems. Sen (1999, p. 87) defines capabilities as the various combinations of functioning (beings and doings) that a person can achieve. In this study, we use the terms *capability, skill*, and *competency* interchangeably and focus on their malleable rather than stable aspects.

In the first stage of this study, we analyze a heterogeneous set of capability measures taken from the elementary school years to generate three latent capabilities affected by the Fast Track intervention. We contribute conceptually to our general understanding of multidimensional skill development in childhood by employing an a priori classification of child capabilities into three categories – academic, intrapersonal, and interpersonal – so as to identify broader developmental mechanisms that could not be observed in prior studies, which often relied heavily on individual constructs and measures (Almlund, Duckworth, Heckman, & Kautz, 2011). Intrapersonal capabilities refer to an individual's capacity to regulate their internal emotions, thoughts, and behaviors.

Next, we take estimates of the average treatment effects on arrest, delinquency, and health outcomes, and decompose them into parts: treatment effects attributable to enhanced academic skills, intrapersonal skills, or interpersonal skills, and treatment effects resulting from unmeasured mechanisms. The results of this study therefore permit a discussion of which programmatic components of intervention proved most effective in reducing arrests, delinquency and health service utilization.

This study also offers a methodological contribution by contrasting two approaches to modeling mediation. We compare results from a traditional structural equation modeling (SEM) approach with results from a three-stage treatment effect decomposition approach employed by economists (Heckman et al., 2013). We note advantages and limitations of these two methods for identifying mechanisms of effective policy interventions.

The Fast Track study

The Fast Track intervention was developed and implemented in the early 1990s in four communities (Durham, NC; Nashville, TN; rural PA; and Seattle, WA), to test the hypothesis that improving child competencies in high-risk children would, over time, contribute to the prevention of adverse outcomes in adolescence and young adulthood. Competencies were conceptualized in four domains, and interventions were directed toward these four domains. One domain is parenting competency, which is not considered further

here due to our focus on child skill development. The three child competencies were academic (cognitive) skills, intrapersonal self-regulatory skills, and interpersonal social skills. Interventions were created to address each domain, for example: tutoring for the academic domain; social-cognitive skills training groups for the intrapersonal domain; and peer-pairing/coaching for the interpersonal domain (CPPRG, 1992).

The most intensive phase of the intervention took place in elementary school. This phase included six components: a *teacher-led curriculum*, adapted from a program called Promoting Alternative Thinking Strategies (PATHS), aimed at helping children develop emotional concepts, social understanding, and self-control; *parent training groups*, intended to promote positive family-school relationships and to teach parents behavior-management skills; *home visits*, to help foster parents' problem-solving skills and life management; *child social-skill training groups*; *tutoring* for children in reading; and *peer-pairing* to enhance children's friendships in the classroom (CPPRG, 2010c). The adolescent phase (grades 6–10) included both standard and individualized activities for youth and families.

Previously published findings of the impact of random assignment to the Fast Track intervention indicate consistent positive impact on skills and adjustment during elementary school (CPPRG, 1999, 2002a, 2004), mixed and sometimes null effects on antisocial behavior during middle school (CPPRG, 2010b), and significant impact on preventing delinquency, arrests, and physical and mental health service utilization in later adolescence and young adulthood (CPPRG, 2007, 2010a, 2013; Jones et al., 2010).

In contrast to manuscripts that have examined the effects of the Fast Track program on child, adolescent, and young adult outcomes, less work has sought to identify the mechanisms through which the intervention brought about results. CPPRG (2002b) assesses mediation of program effects on teacher and parent ratings of conduct problems, peer social preference scores, and association with deviant peers after four years. Significant but modest mediation is found through children's social cognitive skills and interpersonal competence. Dodge, Godwin, and CPPRG (2013) use SEM to support the hypothesis that child social information processing patterns during elementary school would mediate the intervention's impact on antisocial behavior in ninth grade. The authors find that 27% of the intervention's effect on antisocial behavior is mediated via three social information processing patterns: hostile-attribution biases, competent response generation to social problems, and devaluing aggression. The current study goes well beyond Dodge, Godwin, and CPPRG in its inclusion of a broader set of academic, social, and self-regulatory capabilities; its empirical approaches for determining the nature of mediation; and its inclusion of arrest, health, and mental health outcome measures through young adulthood.

Impact of childhood skill development on adult outcomes

Some research supports the hypothesis that personality attributes are stable across the life course, whereas other research emphasizes how children develop different skills and behaviors over time (Caspi & Roberts, 2001). Additionally, certain studies treat cognitive and social-emotional (or "non-cognitive") traits as distinct, yet others purport that similar cognitive processes in the brain underlie both academic and social-emotional behaviors and

therefore one should not distinguish between the two (Almlund et al. 2011). And finally, even when researchers agree on the underlying theories of ability development, terminology and measurement can vary widely. Diamond (2013) describes the importance of executive functions (such as inhibitory control and cognitive flexibility) to outcomes as diverse as mental health, physical health, quality of life, school success, job success, marital harmony, and public safety, whereas Crick and Dodge (1994) assert an essential role for social information processing skills (in particular, hostile attribution biases, intention cue detection accuracy, response access patterns, and evaluation of response outcomes) in promoting positive social adjustment. We consolidate and classify these types of measured child competencies into three main categories: academic, intrapersonal self-regulation, and interpersonal.

According to Bronfenbrenner (1977), individuals change and grow through reciprocal interactions with layers of ecological systems surrounding them: family, peers, institutions, and society. This interaction makes the task of isolating a linear relation between child competencies and young-adult indicators problematic. Thelen and Smith (1996) also observe that even within an individual, biological and neurological systems interact continuously over time, with the rate of change in one system affecting qualitative and quantitative changes in other systems. This notion of an integrated individual – integrated both within oneself and with one's environment – makes the business of predicting young adult outcomes a challenge. With these caveats in mind, we briefly summarize major longitudinal studies investigating the relation between child capabilities and young adult indicators of well-being in three domains: health, mental health, and crime.

Health

Physical health in adulthood is predictable from behaviors and skills built up over the entire life course. Although this field of inquiry is somewhat new, several studies relate children's academic, intrapersonal, and interpersonal skills to adult health status. Odgers et al. (2007) use longitudinal data from the Dunedin study to find that early interpersonal deficits predicted poor health in adulthood. Lochner (2011) summarizes quasi-experimental research on the relation between educational attainment and health indicators and concludes that an extra year of schooling produces health benefits in terms of longevity, increased self-rated general health, and reduced health limitations. Hampson, Goldberg, Vogt, and Dubanoski (2007) demonstrate that measures of agreeableness, conscientiousness, and intellect-imagination in grades 1, 2, 5, and 6 predict a composite measure of general health, functional status, and body mass index at ages 41–50.

A meta-analysis by Almlund et al. (2011) indicates that conscientiousness, extraversion, and IQ all predict lower mortality risk, and a longitudinal study by Copeland, Angold, Shanahan, and Costello (2014) finds that individuals with a history of separation anxiety or generalized anxiety had poorer health outcomes from ages 19 – 26. Although it is unclear whether these results reflect a causal relationship, they still provide suggestive evidence that academic, intrapersonal, and interpersonal skills are important predictors of adult physical health.

Mental Health

Research on childhood skill predictors of young adult mental health disorders is scarce, apart from evidence showing, for example, the continuity of mental health symptoms from childhood to adulthood (Lara et al., 2009). We know little about the relation between early academic and social skills and internalizing problems in young adulthood. A large part of this research instead examines associations between internalizing and externalizing behavior problems in childhood and substance abuse or mental health problems in adolescence and adulthood. Dodge et al. (2009) show that teacher-rated child behavior problems, low social preference, and peer rejection in kindergarten through third grade all increase the prevalence of substance use in adolescence. Erath et al. (2009) show that kindergarten internalizing behavior problems also predicted mental health service utilization at age 16.

In terms of intrapersonal capabilities, child sensation seeking, impulse control, harm avoidance, temperament, and ADHD all contribute to greater substance use in adolescence (Farmer, Compton, Burns, & Robertson, 2002; Hawkins, Catalano, & Miller, 1992). When considering positive aspects of mental health, Ollson et al. (2013) find that child and adolescent language development, academic achievement, and social connectedness all contribute to adult well-being, defined as sense of coherence, positive coping styles, social participation, and prosocial behavior at age 32.

Crime and Delinquent Behavior

The final domain of young adult well-being included in our study is crime and delinquent behavior. It appears that academic, self-regulation, and interpersonal factors in childhood all significantly contribute to the probability of criminal behavior later in life. Heckman, Stixrud, and Urzua (2006) compare cognitive and non-cognitive factors for predicting a given outcome and find that a cognitive measure of Armed Services Vocational Aptitude Battery (ASVAB) test scores affect probability of incarceration by age 30, but that measures of self-esteem and locus of control induce more sizeable changes in the probability of incarceration. Lochner (2011) present consistent results that additional years of schooling reduce arrest rates and self-reported crimes.

In the self-regulation capabilities category, prior research indicates that children possessing high social response evaluation, decision-making skills, and early self-control are less likely to engage in antisocial behavior and delinquency in late adolescence (Fite et al., 2008; Fontaine, Yang, Dodge, Bates, & Pettit, 2008; Henry, Caspi, Moffitt, & Silva, 1996). Henry et al. (1996) posit that while social environments such as family and peer relationships may change over time, early self-control captured in a child temperament measure may remain fairly constant over time and thus reliably predict probability of violent crime. Fite et al. (2008) demonstrate how the intergenerational transmission of aggression in romantic relationships may in fact reflect changes in how offspring generate and evaluate potential responses to social conflict based on their personal experiences with inter-parental relationship conflict. In the interpersonal domain, peer rejection and low levels of popularity in elementary school lead to increased violence toward peers and involvement with antisocial or deviant peers in later adolescence (Laird, Pettit, Dodge, & Bates, 2005; Pettit, Lansford, Malone, Dodge, & Bates, 2010).

The quality of inference possible from these different study findings varies, however. For longitudinal studies, the main threat to validity is omitted variable bias. If any childhood skill measure is correlated with some other important individual or environmental characteristic such as family background, the predictive power of the childhood skill measure for young adult outcomes could be greatly overstated. Studies that make use of natural experiments or that control for important confounding variables generally provide stronger evidence, but these studies are still imperfect.

The current study provides experimental evidence in which we test the hypothesis that random assignment to the Fast Track intervention will have an impact on developmental mechanisms which mediate long-term outcomes. Fast Track's reported prevention effects on health (Jones et al., 2010), mental health (CPPRG, 2007), and criminal outcomes (CPPRG, 2010) in young adulthood beg the question: which competencies in children were most responsible for bringing about these positive outcomes in participants? Without a more complex randomization scheme, it is impossible to tease apart completely the efficacy of each component separately. However, given the richness of the longitudinal interview and administrative record data collected by the Fast Track project, it is possible to test the mechanisms in a different way – by analyzing capabilities within individuals that plausibly mediated positive outcomes.

For example, if children's improved school grades were found to explain a sizeable portion of a treatment effect, one could infer that academic competencies are crucial in the process of antisocial behavioral development, and that the tutoring component of the intervention held value for that particular outcome. If, on the other hand, improved social relationships with peers better explained the treatment effect, this finding would highlight the value of interpersonal competence and the social skills training component. These sorts of findings hold implications for replicating or modifying interventions in a cost-effective manner, if indeed the components of an intervention correspond to growth in targeted child capabilities.

Attempting to encompass the breadth of Fast Track's goals, this study includes a large set of capability measures from ages 6–11. Empirical analyses support the grouping of these measures into three latent capabilities: academic, intrapersonal, and interpersonal. Figure 1 illustrates a framework of potential pathways for treatment effects via the early enhancement of these three individual capabilities. An "alternative mechanisms" pathway could include, for example, unmeasured child capabilities, lasting changes in the home environment, or lasting changes in the school environment. This graphic does not capture the extent to which capabilities may be complementary in producing outcomes. For example, some combination of improved problem solving and prosocial behavior among Fast Track participants could reduce young adult criminal behavior or health problems more than increases in either capability would accomplish alone. We test an alternative "general skills" model that captures common variance among the three components[KMH1].

Method

Participants

We identified and recruited a sample of high-risk kindergarteners through multistage screening of 9,594 children in four communities (Durham, NC; Nashville, TN; rural PA; and Seattle, WA), which began with teacher reports of child behavior problems, followed up by parent reports of child behavior problems for the 40% highest-scoring children within each site and cohort. Scores were standardized and averaged, and then the highest-scoring children were selected and recruited until all slots were filled. The process was designed to identify early-starting conduct problem children who were at high risk for adolescent antisocial behavior.

Research directors matched sets of 55 schools according to site, size, ethnic composition, and poverty, and randomly assigned schools to intervention or control conditions. The program recruited three successive cohorts, in 1991, 1992, and 1993, to yield a total sample of 891 high-risk children (445 in the intervention group and 446 in the control group). Of this final sample, 51% of participants were African American and 69% were male. Control and treatment groups were balanced on pre-treatment characteristics (CPPRG, 1999). Attrition throughout the study has been low, with participation rates for year 19 and 20 at 80 percent. The attrited group does not significantly differ from the retained group on a set of 22 pre-treatment demographic and skill characteristics, and the intervention group attrition rate likewise does not differ from control group attrition (CPPRG, 2007; Dodge, Godwin & CPPRG, 2013).

Measures

The current analysis uses 15 years of longitudinal data from the Fast Track project to track each individual's progression from baseline characteristics, to recorded growth in psychological capabilities during the intervention, and to ultimate adolescent and young adult outcomes. The first phase of data collection in kindergarten took place before the random assignment of treatment and control groups. Baseline controls include demographic variables such as race and gender, cohort identifiers, site identifiers, and 20 other baseline covariates consistent with earlier Fast Track studies. The chosen demarcation between the "mediating capabilities" and "outcome variables" time periods is somewhat arbitrary but was chosen to correspond to 6th grade, the end of the most intensive phase of the intervention and typically the transition to middle school. Our outcome measures therefore provide cumulative counts of any arrest and delinquency offenses, general health visits, and mental health visits reported up through age 20.

In identifying capability measures for the present study, we balanced thoroughness with practical considerations. The study conceptually focuses on three general categories: 1) cognitive and academic skills; 2) intrapersonal self-regulation; and 3) interpersonal capabilities and interactions. These capability measures correspond neatly to key elements of the Fast Track program, including, respectively: 1) child tutoring in reading, 2) child self-control aspects of children's Friendship Groups, the PATHS classroom curriculum,

individual interventions, and parental behavior-management training, and 3) peer pairing to enhance friendships.

Table 1 lists the capability and outcome measures included in this study. We included capability measures meeting the following criteria: 1) significantly affected by intervention (CPPRG, 1999, 2002, 2004); 2) directly measuring an academic, intrapersonal, or interpersonal capability; and 3) available in any year between grades 1 and 5.

We then performed confirmatory factor analysis on the set of potential mediating capabilities in order to reduce measurement error, avoid issues of inter-rater reliability, and facilitate clearer interpretation of results. These variables represent a variety of child-reported, teacher-reported, parent-reported, and test-based and administrative measures between ages 6 and 11 (years 2 to 6 of the study). This plan allowed for collection of all crime, delinquency, and health outcomes after this age, from ages 12 to 20. Previous work confirmed the reliability and validity of psychological constructs, and Table S1 and the project website (*http://fasttrackproject.org*) provide full descriptions of all data instruments and scoring procedures.

The cumulative crime and delinquency measures at age 20 (year 15 of the study) include: the probability of never having been arrested as an adult; the probability of never having been arrested as a juvenile; and an index of self-reported acts of delinquency, summed across all available years. Fast Track significantly influenced all three of these outcomes (CPPRG, 2010a, 2013), and Table 1 lists the exact variables and data instruments used. This study codes the severity of offenses as in CPPRG (2010a), with severity 1 including status and traffic offenses; severity 2: breaking and entering, disorderly conduct, possession of a controlled substance, shoplifting, vandalism, and public intoxication; severity 3: simple assault, felonious breaking and entering, possession of controlled substances with intent to sell, and fire setting; severity 4: assault with weapons and first-degree burglary; and severity 5: violent crime such as murder, rape, kidnapping, and first-degree arson.

The remaining two young adult outcomes in Table 1 reflect general health and mental health well-being. After each of grades 9–12, parents or primary caregivers provided information on the use of health and mental health services in the past year through the Service Assessment for Children and Adolescents (SACA), which is shown to have high reliability and validity (Hoagwood et al., 2000; Horwitz et al., 2001). The two SACA outcome measures included in this study are taken from Jones et al. (2010): parent-reported number of youth general health service visits (including general hospital, emergency department, or pediatric health); and parent-reported number of youth mental health service visits for emotional or behavioral problems.

Latent Factor Model

Before disentangling the different pathways through which Fast Track improved child skills and ultimately prevented health and mental problems and criminal behavior, we must further consider the question of measurement. We define a simple factor model and use this framework to measure latent capability factors C_k in each category k ($k = a$, academic; r, regulatory or intrapersonal; and s, social or interpersonal). Each latent capability C_k

therefore underlies all measurements, m_{jk}, associated with that category k for the total number of measures in the category, J_k, as follows:

Academic: $m_{ja} = \alpha_0 + \alpha_1 C_a + \eta_{ja}$ for all $j = 1,\ldots,J_a$

Intrapersonal: $m_{jr} = \alpha_0 + \alpha_1 C_r + \eta_{jr}$ for all $j = 1,\ldots,J_r$

Interpersonal: $m_{js} = \alpha_0 + \alpha_1 C_s + \eta_{js}$ for all $j = 1,\ldots,J_s$

Maximum likelihood estimation of these simultaneous equations, allowing error terms for measures from the same data instrument to covary, leads to prediction of the three latent capabilities: an academic factor, a self-regulation factor, and an interpersonal factor. Figure 2 presents the graphic form of the factor model, described in more detail in the results section. While the remainder of this paper focuses on the capabilities in their combined factor form, a sensitivity analysis indicates that many raw capability measures individually mediate Fast Track's effects on outcomes. Because of potential collinearity among the three factors, we constrain the covariance matrix of the three latent factors to be a diagonal matrix so that each factor reflects unique rather than shared qualities. To test whether we lose explanatory power by focusing on orthogonalized factors, we also run an alternative analysis using a single general skills factor to capture the shared covariance.

Decomposition of Treatment Effects

Strong evidence that a given personal capability mediated Fast Track's effect on outcomes later in life requires a demonstration of several relations. First, the Fast Track program must have a significant impact on the particular capability. Second, Fast Track must have a significant impact on the ultimate outcome. And third, even when controlling for treatment and other possible mediating variables, the capability must predict the outcome of interest. Heckman et al. (2013) developed a method for analyzing the channels through which an early education program, Perry Preschool, boosted participant outcomes. The authors isolated experimentally induced changes in personality traits and demonstrated the unique impacts of these changes on adult outcomes. The current study subjects Fast Track's treatment effects to a similar decomposition strategy so as to minimize the problems of endogeneity plaguing mediation analysis.

Fast Track's total treatment effect on crime outcomes, as estimated in CPPRG (2010a, 2013) and Jones et al. (2010), can be separated into two main components shown below: the effect attributable to improvements in measured latent skills, and the effect due to other mechanisms.

$$\underbrace{E(Y_1 - Y_0 \big| X)}_{\text{Total Treatment Effect}} = \underbrace{(\tau_1 - \tau_0)}_{\text{Due to Other Mechanishm}} + \underbrace{\sum_{k \in \{a,r,s\}} \xi_{k2} E(C_{k1} - C_{k0} \big| X)}_{\text{Due to Measured Skills}}$$

In this equation, Y_1 and Y_0 represent the potential outcomes of an individual under the treatment and control conditions. The intercept, $(\tau_1 - \tau_0)$, describes average differences in young adult outcomes between the treatment and control groups that are *not* attributable to measured increases in academic, intrapersonal, or interpersonal capabilities. The final term

from this equation, $k \in \{a,r,s\} \gamma_k E(C_{k1}) - C_{k0}|X)$, represents the sum of all of an individual's capability increases due to Fast Track, multiplied by their respective prediction of the outcome Y.

We estimate the parameters in this decomposition through a series of regression steps. In the first step, each outcome variable Y_i for individual i is regressed on a treatment indicator T_i and baseline characteristics X_i:

$$Y_i = \beta_0 + \beta_1 T_i + \beta_2 X_i + \varepsilon_i \quad (1)$$

The vector X_i includes a set of gender, race, site, and cohort indicators, as well as 20 additional baseline covariates. The parameter of interest β_1 therefore captures the average Fast Track treatment effect, conditional on X. Step 1 primarily replicates the findings of prior work demonstrating the effect of Fast Track on adolescent and young adult arrests, delinquency, and general and mental health service utilization.

For step 2, we also regress individual latent capability C_{ki} for each category k (a, academic; r, regulatory or intrapersonal; and s, social or interpersonal) on the treatment indicator and the vector of baseline characteristics.

$$C_{ki} = \delta_{k0} + \delta_{k1} T_i + \delta_{k2} X_i + \mu_i \text{ for all } k \in \{a, r, s\} \quad (2)$$

In this estimation step, the parameter δ_{k1} represents the expected change in latent capability k from the treatment, again conditional on X.

In the third step, we regress each outcome on the treatment indicator, vector of baseline characteristics, and academic, intrapersonal, and interpersonal capability factors:

$$Y_i = \xi_0 + \xi_1 T_i + \sum_{k \in \{a,r,s\}} \xi_{k2} C_{ki} + \xi_3 X_i + \varepsilon_i \quad (3)$$

In this formulation, ξ_{k2} measures the relation between ability k and the outcome of interest, controlling for both the overall treatment effect and other potential mediating capabilities. Step 3 essentially serves as a mediation equation, testing which if any of the childhood skills mediated Fast Track's effects on crime and delinquency in adolescence and young adulthood.

Finally, in step four, the previous estimation results are combined to calculate $(\tau_1 - \tau_0)$ the portion of the treatment effect due to mechanisms other than increases in the measured capabilities. The formula is derived from the original treatment decomposition equation, and is estimated as follows:

$$(\tau_1 - \tau_0) = E(Y_1 - Y_0 \big| X) - \sum_K \xi_{k2} E(C_{k1} - C_{k0} \big| X) = \beta_1 - \sum_k \xi_{k2} \delta_{k1} \quad (4)$$

This last stage allows calculation of the exact proportions of a Fast Track effect on young adult outcomes attributable to each type of capability growth or to alternative mechanisms.

The objective of this decomposition is to provide evidence regarding the relative importance of different measured capabilities for mediating the Fast Track effect of reducing crime. This study also demonstrates the joint importance of these capabilities when compared with the set of all other plausible mechanisms. Unbiasedness of the treatment decomposition parameter estimates relies on a number of key assumptions. Looking in particular at equation 3, the estimates of ξ_{k2} will only be unbiased under a strict exogeneity assumption that $E(\in|T,C,X) = 0$ where C is the vector of capabilities C_k. Any omitted variable – such as an unmeasured individual capability, family factors, or school environment – that drives the outcome of interest and correlates with an included capability C_k, conditional on baseline characteristics, could bias the parameter estimates of ξ_{k2}. This study seeks to identify a lower bound of mediation effects by using only experimentally induced changes in capabilities, combined with their predicted effects on young adult indicators when controlling for treatment, baseline characteristics, and other potential mediators.

Structural Equation Model

We compare estimates from the treatment effect decomposition approach detailed above with a more traditional generalized SEM approach. For this approach, we simultaneously estimate equation (1) – equation (4) using maximum likelihood, and use the path coefficients to determine the level of mediation by childhood skills. For count outcomes we use negative binomial regression, and for indicator outcomes we use logistic regression. The three latent capability factors (academic, intrapersonal, and interpersonal) are identical across the reduced form and SEM analyses.

There are certain necessary assumptions under which multiple regression is an appropriate tool for estimating a structural mediation model. First, there can be no reverse causation: the dependent variable outcomes cannot directly or indirectly affect one of the causal variables. Second, the causal variables should not have significant measurement error; and third, there should be no omitted variable that is correlated both with the dependent outcome variable and with one of its causal variables (Judd & Kenny, 1981). The temporal order of our mediation model is such that reverse causality is unlikely. The Fast Track treatment indicator is unlikely to introduce omitted variable bias or contain measurement error, but these problems are possible with the mediating latent capability factors. Under these assumptions, both multiple regression and SEM should generate meaningful estimates of direct and indirect Fast Track effects.

In general, we find that the point estimates from SEM match those from Step 2 of the treatment effect decomposition, because estimates from recursive SEM with endogenous and exogenous variables only are equivalent to equation-by-equation OLS regression. For step 1 (the effect of Fast Track on young adult outcomes), there are differences between the two methods due to the fact that the total effect does not equal the combination of indirect and direct effects when logistic and negative binomial models are used in place of linear regression. The most important difference between the methods is that standard errors differ because maximum likelihood computes standard errors from the information matrix of the whole system and makes assumptions (such as normality of the covariates and marginal normality of the outcome variables) that are not made by linear regression.

Results

We first predict latent capability factors for each child using maximum likelihood estimation of a structural equation model. Table 2 describes the relations of each raw child capability measure with the three latent factors, corresponding to the factor model path diagram from Figure 2. The academic factor loads heavily onto a word skills measure; the interpersonal factor loads primarily onto prosocial behavior and authority acceptance measures; and the intrapersonal factor loads primarily onto emotion recognition and hostile/aggressive attribution bias. Goodness-of-fit statistics suggest that the three constructed capability factors successfully reflect this array of childhood skills measured during Fast Track, although model fit is reduced when covariance among latent factors is deliberately restricted to zero. Figure S1 displays, by Fast Track assignment, the densities of the three orthogonal skill factors, which are standardized to have mean of zero and standard deviation of one.

We next attempted to parse potential pathways of treatment effectiveness. The first step of the treatment effect decomposition regresses each young adult well-being measure on the treatment indicator and baseline covariates. Table 3 presents these results, corresponding approximately to those found in CPPRG (2010a, 2013) and Jones et al. (2010). As demonstrated in previous research (CPPRG, 2010a, 2013; Jones et al., 2010), participants of the Fast Track program were less likely to have been arrested in juvenile court and adult court by age 20, had committed fewer severe acts of delinquency, and had fewer instances of general health and mental health visits. Adjusting standard coefficients from Table 3 to incidence rate ratios, we find that the incidence rate of cumulative self-reported delinquent offenses is 27% lower for participants in the Fast Track program than for the comparison group (the standard coefficient is –0.31). Fast Track participants are also 34% more likely to have never been arrested as an adult and 39% more likely to have never been arrested as a juvenile by age 19–20 (standard coefficients –0.29 and –0.33, respectively). Fast Track reduced, on average, the number of general health visits by 0.17 and the number of visits for mental health purposes by 0.41. SEM estimates mirror these findings. Together, these results confirm previous findings that the intervention curtailed individuals' propensities for criminal and delinquent behavior and for general and mental health services later in life.

The second step of the decomposition estimates the impact of Fast Track on academic, intrapersonal, and interpersonal capabilities as formerly identified and described. Table 4 summarizes the results from these three regressions. Overall, the Fast Track program increased academic capabilities by 0.23 standard deviations, interpersonal capabilities by 0.14 standard deviations, and intrapersonal capabilities by 0.31 standard deviations. Once again, SEM generates identical results to the reduced form strategy. The program's effectiveness in enhancing a wide variety of child capabilities confirms that the intervention achieved a number of its primary objectives.

For the third estimation step, we regress each young adult outcome on a treatment indicator, the three capability factors, and baseline covariates, as shown in Table 5. The coefficients on each capability represent the power of each skill set to predict crime outcomes when controlling for the treatment itself and other potential mediators. Significant coefficients indicate these capabilities as likely mediators of the Fast Track crime impacts.

A few trends emerge from these results. First, coefficients on 'treatment' decreased from all step 1 to step 3 equations, indicating that academic, intrapersonal, and interpersonal capability measures may account for some portion of Fast Track effects on arrests and delinquency. A one standard deviation increase in intrapersonal skills predicts a decrease in the incidence rate of severity-weighted delinquency by 22% (standard coefficient of -0.25) and an increase in the probability of no juvenile arrest by 26% (standard coefficient of 0.23), controlling for assignment to treatment and other potential mediating skills. Furthermore, a one standard deviation increase in interpersonal skills predicts a 21% rise in both the probability of no adult arrest and the probability of no juvenile arrest (standard coefficients of 0.19). Academic capabilities predict crime and delinquency poorly but appear more important for the mental health outcome. A one standard deviation increase in academic skills reduces mental health service visits by 0.37. None of the childhood skill factors significantly predict the number of general health visits later in life.

Equation 4 above describes statistically how to divide the average Fast Track effects into additive components corresponding to growth in different types of individual skills, using parameters estimated in steps 1 through 3. The residual of this equation then reflects the unexplained portion of the effect – any alternative pathways through which Fast Track reduced arrest or delinquency, $(\tau_1 - \tau_0)$. Figure 3 presents this final decomposition of the Fast Track program's average effects on adolescent and young adult outcomes for the SEM estimates.

Unexplained pathways $(\tau_1 - \tau_0)$ represent about 75% of the total Fast Track effect on self-reported offenses, 86% of the effect on adult arrest, 67% of the effect on juvenile arrest, 100% of the effect on general health visits, and 79% of the effect on mental health visits, according to the reduced form estimates. The discrepancies between the reduced form and structural estimates are small except for the self-reported delinquency outcome. According to SEM results, as much as 68% of Fast Track's effect on delinquency derives from increases in self-regulation capabilities during childhood. These differences may reflect that zero-inflated Poisson was used for the reduced form estimation and regular Poisson was used for the SEM estimation due to computational constraints.

Although much of Fast Track's effectiveness remains unexplained, the accumulation of skills in childhood still accounts for a substantial fraction of prevention of youth arrest, delinquency, and mental health service utilization. Sobel-Goodman mediation tests generally confirm the development of these same childhood skills as important pathways of prevention.

The role of cognitive-academic capabilities is modest and insignificant for Fast Track's effects on crime and delinquency, but explains 21% of the cumulative effects on mental health service utilization in adolescence and young adulthood ($p<0.05$). Intrapersonal capabilities explain 25% of the reduction in self-reported delinquency ($p<0.05$) and 22% of the decreased probability of juvenile arrest ($p<0.05$). And increases in interpersonal capabilities constituted 9 and 8% of decreased probabilities of juvenile and adult arrests, respectively ($p<0.1$).

Heterogeneity

Do pathways of intervention effectiveness look similar across the entire Fast Track sample? We explore potential heterogeneity in results across the targeted population. Previous work suggests that differential impact on crime prevention may occur for boys and girls in this intervention setting (CPPRG, 2013). The small sample size of females with arrest records makes comparison for arrest outcomes difficult, however. Wald tests (of equality of coefficients) indicate that interpersonal skills reduce self-reported delinquency marginally more effectively for females than for males ($p<0.1$). The non-differences in effects for intrapersonal skills suggest that these skills are important parts of developmental pathways for both girls and boys. Males experienced a larger reduction in mental health visits from Fast Track than did female participants ($p<0.05$), but the level of mediation did not appear different by gender.

The next analyses split the sample in half by level of risk from initial screening in kindergarten. We observe from the mediation equations that intrapersonal capabilities benefit participants above the median risk level more than those with lower risk ($p<0.05$). However, the Fast Track program improved development of social capabilities relatively more for participants below the sample median risk level ($p<0.01$) in step 1 regressions. And for this lower-risk group, measured interpersonal and academic capabilities also prevented delinquent offenses and juvenile arrests more effectively ($p<0.05$). These findings are consistent with hypotheses that pathways to criminal outcomes differ for various groups of children, with initially high-risk children developing criminality from self-regulation deficits whereas initially more moderate-risk children developed criminality from social and academic failure.

General and domain-specific skills

The approach used in this study relies on an assumption that skills are primarily domain-specific, e.g., a child's skills in social interactions develop largely independently from his or her skills in academics. An alternative model, consistent with research on "executive function," purports that a single set of mental processes predicts success in a broad array of different behavioral domains (Gilbert & Burgess, 2008). This debate between domain-general and domain-specific cognition and skills has generated a large body of research (Hirschfeld & Gelman, 1994).

Because we orthogonalize the three childhood skill factors – academic, interpersonal, and intrapersonal, we risk underestimating mediation when we exclude the shared covariance among these three factors. Therefore in this section we test an alternative explanation – that one "general skill" factor explains a significant portion of Fast Track's effect on arrests and delinquency in young adulthood, rather than several unique domain-specific skills. To this end, we estimate a new latent factor model, similar to that in Figure 2, but containing only one latent skill that predicts all capability measures. All measures from grades 2 to 6 load significantly onto the general skills factor. However, teacher-rated academic competence, word skills, emotion recognition, and hostile attribution have the largest loading coefficients suggesting these measures reflect a large portion of the general capability factors.

As before, we implement steps 1 through 3 of the treatment effects decomposition to discern the role of childhood skills in explaining Fast Track's effects on arrest, delinquency, and general and mental health. The results for step 2 show that the Fast Track intervention had a significant, positive impact on the standardized general skills factor with a magnitude of 0.10 standard deviations (p<0.01). Regression results from step 3 also indicated that childhood general skills reduce the probability of being arrested as a juvenile or adult. In fact, a one standard deviation increase in the general skills factor in elementary school approximately increases the likelihood of no adult arrest by 100% and the likelihood of no juvenile arrest by 300% even when controlling for Fast Track placement and 27 baseline covariates. The general skills factor did not predict general or mental health visits.

Combining findings from each of these regression analyses, we determine that the general skills factor accounts for 18.4% of Fast Track's effect on self-reported delinquency, 23.1% on adult arrest, and 42.6% on juvenile arrest. Although it is unclear why the general skills factor does not predict each adolescent and young adult outcome to the same degree, it is clear that domain-general skills during childhood are important mediators. Figure 4 combines the domain-general and domain-specific measures such that the potential mediators are classified into four groups: a domain-general cognitive capability, academic skills, intrapersonal skills, and interpersonal skills. This analysis suggests that different child capabilities measured in our data are likely complementary in the sense that they predict young adult arrest and delinquency better when taken together than when taken separately.

Discussion

This study contributes to the existing literature by exploring potential mechanisms through which the Fast Track intervention targeted at high-risk children prevents adverse outcomes. The statistical decomposition split treatment effects on arrests, delinquent offenses, and general and mental health service utilization, into segments explained by increases in three separate capability domains (academic, intrapersonal, and interpersonal) during the childhood intervention and a segment explained by other unspecified pathways. The Fast Track project uniquely contained many components aimed at improving child competencies in a number of domains, including academic, intrapersonal self-regulation, and interpersonal. Given the direct links between intervention components and childhood skills, we were able to tease out the components that successfully improved child capabilities and, through these channels, subsequently enhanced behavior in adolescence and young adulthood.

The findings generally indicate that improvements in intrapersonal and interpersonal skills account for a significant portion of the treatment impact on delinquency and crime outcomes, in contrast with improvements in academic skills which have little effect on later delinquency and crime. These findings are consistent with those of Heckman, Pinto, and Savelyev (2013), who analyzed the mediation of the Perry Preschool program's impact on adult outcomes, and with those who are advocating for an increased emphasis on teaching so-called "non-cognitive skills" in educational settings. However, we also find that academic skills improvement mediates the impact of Fast Track on mental health outcomes, an unexpected finding.

Although the design of the study linked interventions in all three domains and did not allow an experimental test of different components, we are inclined to speculate that different components of the Fast Track intervention had different effects on children's capabilities. Our results are consistent with the parent behavior-management training and social-emotional training components increasing children's intrapersonal skills in emotional regulation, making them less prone to destructive outbursts in adolescence. The friendship groups and peer pairing programs may likewise have enhanced children's positive interpersonal peer relationships, thus preventing violent crime and delinquency in late adolescence. A different study with several intervention experimental branches containing different components would be necessary, however, to make more conclusive inferences about the relative values of different intervention activities.

This evidence demonstrates that Fast Track's emphasis on teaching non-cognitive capabilities, such as learning how to regulate emotions, or how to help and respect others, or at least children's acquisition of intrapersonal and interpersonal skills through any component of the Fast Track intervention, played a vital role in the prevention of criminal behaviors and arrests. The academic training in the intervention appears to have supplemented this main criminal behavior effect with the prevention of mental health problems.

The methods of this study feature some limitations. In particular, one should exercise caution when applying causal arguments to step three of the regression results. Even when controlling for baseline characteristics, program assignment, and other capability scores, it is possible that the capability measures of interest are correlated with unobserved variables. Nonetheless, this study provides an important framework for opening the "black box" of successful childhood interventions, and for more fully exploring the ways in which these interventions affect individual developmental trajectories.

A large portion of Fast Track's reductions in criminal behavior and mental health and health problems remains unexplained by child skill development – ranging from 32 percent to 100 percent across our set of outcomes. There are four possible explanations. First, there may be other important child capabilities that we miss out on due to our focus on academic, interpersonal, and intrapersonal competencies. Second, our methodological choices to constrain the covariance and number of latent factors could lead to inadequate measurement of these competencies. Third, the intervention could make lasting changes in parents or the child's environment that are not explained by growth in specific skills. And finally, our analysis cannot observe the extent to which the less-intensive middle school component of the intervention drove long-term results. Future research could investigate these additional potential pathways linking interventions with outcomes. Doing so presumably would reduce the intervention effects on adverse outcomes in young adulthood that remain unaccounted for by measured growth in child capabilities.

With the U.S. facing both the world's highest incarceration rate and highest per-capita healthcare expenditures, it is nonetheless worth considering evidence that early skills such as self-control, emotion awareness, problem solving, and prosocial behavior, constitute important developmental mechanisms for prevention of such costly adverse outcomes.

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Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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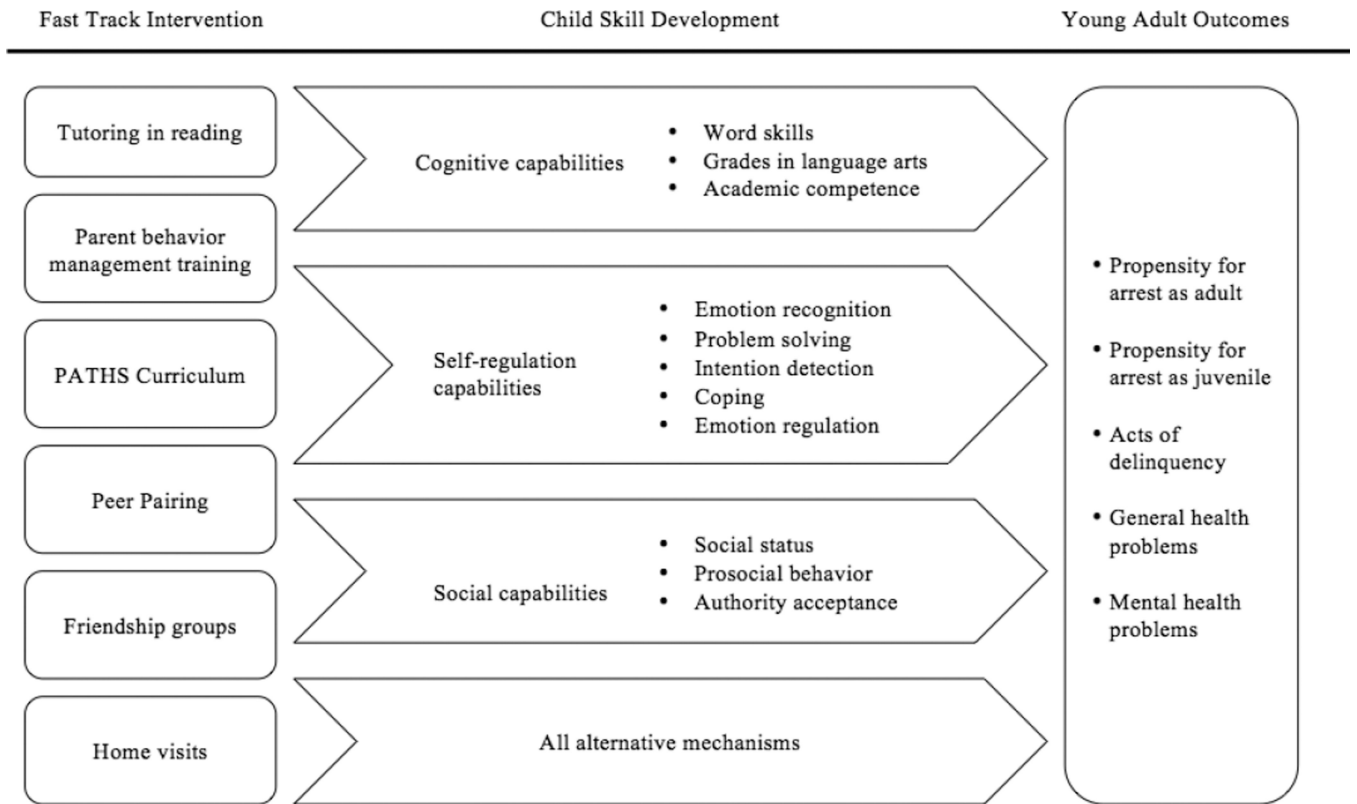
Figure 1.
Pathways of intervention impact on mediators and outcomes.
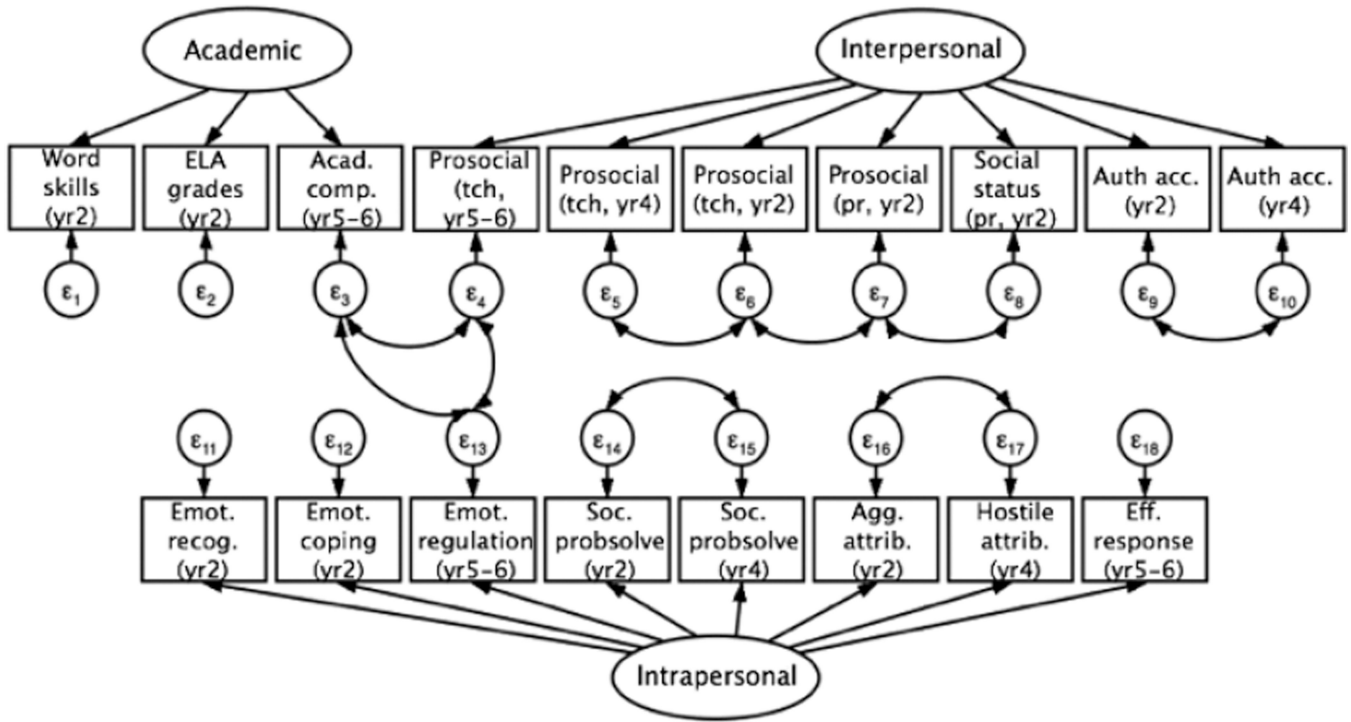
Figure 2.
Latent factor model of child capabilities.

Note. See Table 1 for variable definitions. In parentheses below each measure name, "yr" represents the year of data collection. For measures rated both by teachers and peers, "tch" represents the teacher report, and "pr" represents the peer report. The factor model is identified by setting latent factor variance equal to one. Error terms are allowed to covary for constructs measured across multiple years, or for constructs measured within the same data instrument in the same year.
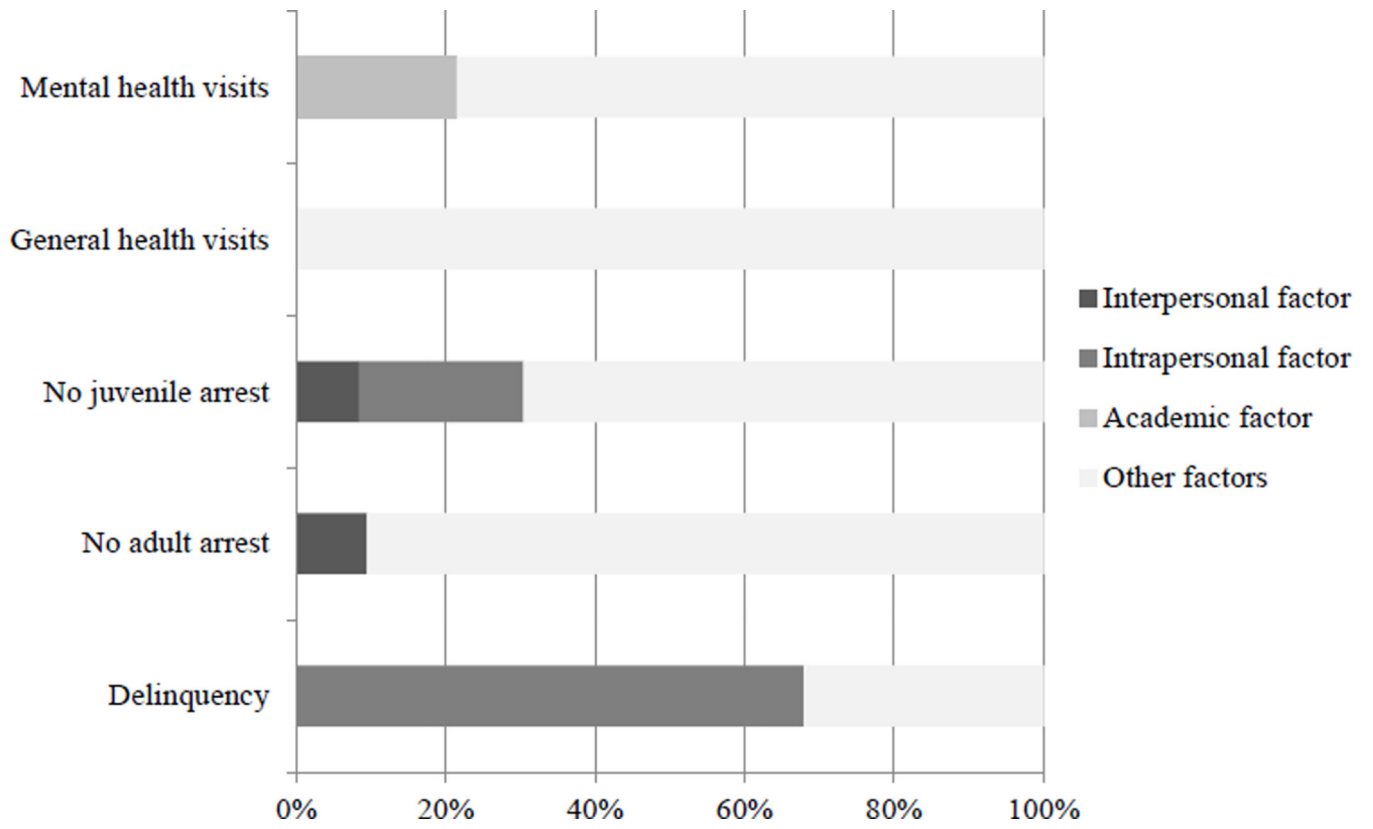
Figure 3.
Percent of Fast Track program effects explained by capability factors: SEM estimates.
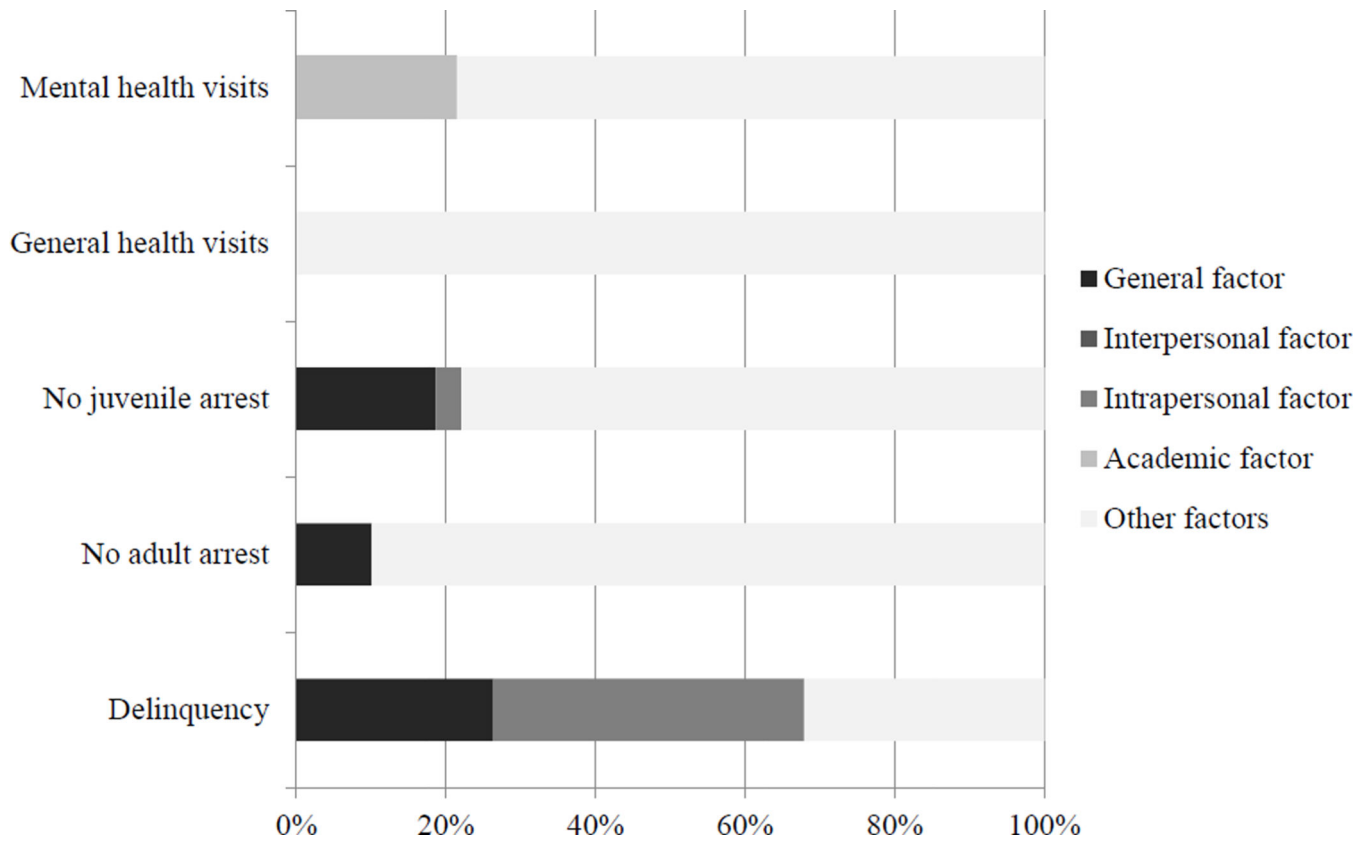
Figure 4.
Fast Track program effects explained by general and specific capability factors.
Note. This figure was constructed by displaying the percent explained by domain-general skills; then, the difference between each specific skill and general skill percent explained was added to the graph only if the specific skill explained more uniquely than the general skill factor.

Table 1

Measures.

| Variable	Variable Label	Age	Data Instrument
Cognitive Competence			
Word skills (yr2)	Spache Word-Attack Score	6–7	Spache
ELA grades (yr2)	Language Arts Grades	6–7	School Record Form
Acad. comp. (yr5–6)	Academic competence	9–11	Teacher Social Competence
Interpersonal Competence			
Social status	Social Preference Z–Score	6–7	Sociometrics
Prosocial (pr, yr2)	Prosocial Sum Z-Score	6–7	Sociometrics
Prosocial (tch, yr2)	Prosocial Behavior Mean	6–7	Teacher Post Report
Auth. acc. (yr2)	Authority Acceptance	6–7	Social Health Profile
Prosocial (tch, yr4)	Prosocial Behavior Mean	8–9	Teacher Post Report
Auth. acc. (yr4)	Authority Acceptance	8–9	Social Health Profile
Prosocial (tch, yrs5–6)	Prosocial Teacher Rating	9–11	Teacher Social Competence
Intrapersonal Competence			
Emot. rec. (yr2)	Total # Correct Emotion Recognition Questionnaire	6–7	Emotion Recognition Questionnaire
Emot. coping (yr2)	Positive Response Scale	6–7	Interview on Emotional Experience
Soc. probsolve (yr2)	Mean % of Competent Responses All Pictures	6–7	Social Problem Solving
Agg attrib. (yr2)	% Aggressive/Threatening Behavior	6–7	Home Interview with Child
Soc. probsolve (yr4)	Mean % of Competent Responses All Pictures	8–9	Social Problem Solving
Hostile attrib. (yr4)	% Hostile Attributions	8–9	Home Interview with Child
Emot. reg. (yr5–6)	Emotion Regulation Rating	9–11	Teacher Social Competence
Eff. response (yr5–6)	Total of Subscales	9–11	What Do You Think
Young Adult Outcomes			
SRD index (yr20)	Lifetime Severity-Weighted Self-Report Index	12–20	Self-Reported Delinquency
No ad arrest (yr 20)	Indicator of no Adult Arrest	12–20	Juvenile and Adult Court Data
No juv arrest (yr 20)	Indicator of no Juvenile Arrest	12–20	Juvenile and Adult Court Data
Gen health (yr 18)	Number of General Health Service Visits	14–18	Service Assessment for Children and Adolescents
Mental health (yr 18)	Number of Mental Health Service Visits	14–18	Service Assessment for Children and Adolescents

Note. See Table S1 for full descriptions. In parentheses next to each measure name, "yr" represents the year of data collection. For measures rated both by teachers and peers, "tch" represents the teacher report, and "pr" represents the peer report. Baseline covariates include: site indicators,

cohort indicators, screening score, gender, race, maternal depression, hostile attribution, aggressive behavior, appropriateness, family satisfaction, friendship satisfaction, physical punishment, stress, verbal punishment, socioeconomic status, oppositional behavior, discipline, social competence, educational battery score, emotion recognition, maternal warmth, social problem solving, neighborhood satisfaction, and intelligence score. For more information on these measures, see Conduct Problems Prevention Research Group (1999).

Table 2

Latent Factor Model Estimation.

Measure	Loading Coefficient	Standard Error	P>|z|
Cognitive Factor			
Word skills (yr2)	0.755	0.072	0.000
ELA grades (yr2)	0.345	0.044	0.000
Acad. comp. (yr5–6)	0.537	0.056	0.000
Social Factor			
Prosocial (tch, yr5–6)	0.472	0.062	0.000
Social status (yr2)	0.255	0.039	0.000
Prosocial (pr, yr2)	0.165	0.038	0.000
Auth. accept (yr. 2)	0.211	0.060	0.000
Auth. accept (yr. 4)	0.658	0.079	0.000
Prosocial (tch, yr2)	0.144	0.049	0.004
Prosocial (tch, yr4)	0.095	0.050	0.056
Self-Regulation Factor			
Emot. rec. (yr2)	0.413	0.050	0.000
Host. attrib. (yr4)	0.386	0.051	0.000
Agg. attrib. (yr2)	0.470	0.051	0.000
Emot. reg. (yr5–6)	0.092	0.036	0.011
Eff. resp. (yr5–6)	0.255	0.050	0.000
Emot. coping (yr2)	0.377	0.049	0.000
Soc. probsolve (yr2)	0.215	0.057	0.000
Soc. probsolve (yr4)	0.307	0.050	0.000

Note. See Table 1 for variable descriptions; in parentheses next to each measure name, "yr" represents the year of data collection; for measures rated both by teachers and peers, "tch" represents the teacher report, and "pr" represents the peer report; the model allows covariance of error terms across measures taken from the same data instrument; GOF stats with restriction on covariance of factors: RMSEA = 0.065; CFI = 0.811; p > Chi^2 = 0.000; GOF stats without restriction: RMSEA = 0.040; CFI = 0.929; p > Chi^2 = 0.000.

Table 3

Fast Track effects on young adult outcomes (Step 1).

	Severity-weighted delinquency index		Probability of no arrest as an adult		Probability of no arrest as a juvenile		Number of general health visits		Number of mental health visits	
	(SEM)	(RF)	(SEM)	(RF)	(SEM)	(RF)	(SEM)	(RF)	(SEM)	(RF)
Intervention	−0.217	−0.309*	0.286	0.289*	0.328*	0.330*	−0.171**	−0.168*	−0.396*	−0.405*
	(0.190)	(0.155)	(0.176)	(0.174)	(0.191)	(0.186)	(0.087)	(0.088)	(0.235)	(0.238)
Baseline	3.870	3.870	0.637	0.637	0.563	0.563	6.332	6.332	0.554	0.554
N	836	636	836	836	836	739	836	836	836	836

*
p<0.05,

**
p<0.01

Note. Standard coefficients reported for each model; robust standard errors in parentheses, clustered by school; the baseline is the mean of the outcome variable for the control group; Poisson regression used for self-report offense index (controlling for zero-inflation in column 2); logistic regression used for probability of no arrest outcomes; negative binomial regression used for health visit outcomes; control variables include sex, race, cohort, site, and twenty other pre-intervention covariates.

Table 4

Fast Track effects on child capabilities from ages 6–11 (Step 2).

	Academic Skills		Interpersonal Skills		Intrapersonal Skills	
	(SEM)	(RF)	(SEM)	(RF)	(SEM)	(RF)
Intervention	0.233***	0.233***	0.144*	0.144*	0.309***	0.309***
	(0.068)	(0.069)	(0.078)	(0.079)	(0.061)	(0.062)
Baseline	−0.141	−0.141	−0.049	−0.049	−0.158	−0.158
N	836	836	836	836	836	836

*
p<0.1,

***
p<0.01.

Note. Robust standard errors in parentheses, clustered by school; the baseline is the mean factor score for the control group; OLS regression used for each factor; control variables include sex, race, cohort, site, and twenty other pre-intervention covariates.

Table 5

Mediation equation of young adult outcomes (Step 3)

	Severity-weighted delinquency index		Probability of no arrest as an adult		Probability of no arrest as a juvenile		Number of general health visits		Number of mental health visits	
	(SEM)	(RF)	(SEM)	(RF)	(SEM)	(RF)	(SEM)	(RF)	(SEM)	(RF)
Intervention	−0.113	−0.296[*]	0.246	0.246	0.217	0.217	−0.139	−0.139	−0.334	−0.334
	(0.194)	(0.159)	(0.179)	(0.179)	(0.195)	(0.195)	(0.086)	(0.086)	(0.242)	(0.242)
Academic	0.143	0.012	0.053	0.053	0.043	0.043	−0.010	−0.010	−0.365[**]	−0.365[**]
	(0.127)	(0.080)	(0.089)	(0.089)	(0.103)	(0.103)	(0.047)	(0.047)	(0.165)	(0.165)
Interpersonal	0.067	0.108	0.187[**]	0.187[**]	0.191[**]	0.191[**]	−0.042	−0.042	−0.133	−0.133
	(0.092)	(0.068)	(0.084)	(0.084)	(0.079)	(0.079)	(0.044)	(0.044)	(0.113)	(0.113)
Intrapersonal	−0.475[***]	−0.251[**]	0.002	0.002	0.234[**]	0.234[**]	−0.077	−0.077	0.136	0.136
	(0.130)	(0.119)	(0.101)	(0.101)	(0.114)	(0.114)	(0.058)	(0.058)	(0.134)	(0.134)
N	836	636	836	836	836	739	836	836	836	836

[*]
p<0.1,

[**]
p<0.05,

[***]
p<0.01

Note. Standard coefficients reported; robust standard errors in parentheses, clustered by school; Poisson regression used for self-report offense index (controlling for zero-inflation in column 2); logistic regression used for probability of no arrest outcomes; negative binomial regression used for general and mental health visit outcomes; control variables include sex, race, cohort, site, and twenty other pre-intervention covariates.