

## The Role of Planning Skills in the Income–Achievement Gap

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The pervasive income–achievement gap has been attributed in part to deficiencies in executive functioning (EF). The development of EF is related to children’s planning ability, an aspect of development that has received little attention. Longitudinal data from the National Institute of Child Health and Human Development study of early child care show that early childhood poverty (1 and 24 months) is significantly related to fifth grade, math, and reading achievement ( $n = 1,009$ ). The ability to plan in Grade 3, indexed by the Tower of Hanoi task, mediates the income–achievement gap in math and to a lesser extent in reading. IQ was incorporated as a statistical control throughout.

The income–achievement gap is a major contributor to rising economic and social strains in our nation. Economic disparities are created in part because children from low-income households manifest reduced academic achievement leading to lower incomes when they become adults. Income-related gaps in achievement emerge as early as kindergarten and continue through high school (Bradley & Corwyn, 2002; Duncan, 2012; Duncan & Brooks-Gunn, 1997; Heckman, 2006; Sirin, 2005). Family income also influences the likelihood of staying in school (Duncan, 2012; Laird, Cataldi, Ramani, & Chapman, 2008). It is important to identify explanations of the pervasive income–achievement gap to better understand how these disparities arise and eventually to design effective interventions to break the linkages between childhood deprivation and poor academic outcomes. This study tests whether planning ability can help account for the income–achievement gap, utilizing a large, national data set.

Numerous potential mediators of the income–achievement gap have been studied. Two pathways that have received the most attention are parental investments and parental sensitivity. Parent to child speech in low-income households is of lower com-

plexity and quantity compared to wealthier households (Hart & Risley, 1995; Hoff, 2006) and partially accounts for delayed language acquisition in lower socioeconomic status (SES) toddlers (Hoff, 2003). Furthermore, the home environments of economically disadvantaged children have significantly fewer cognitively stimulating items compared to the homes of more affluent children (Bradley & Corwyn, 2002; Evans, 2004). In a nationally representative sample, for example, low-income homes did not have as many developmentally appropriate learning tools, including books and toys, compared to middle- and upper-income households from birth through adolescence (Bradley, Corwyn, McAdoo, & Garcia Coll, 2001). Low-income children are also not read to as often, watch TV more frequently, and typically have minimal access to computers and books (Evans, 2004). Similarly, numerous investigators have found that economic deprivation leads to elevated parental harshness and less parental responsiveness (Conger & Donnellan, 2007; Grant et al., 2003) with adverse consequences for early socioemotional and cognitive development.

### *Poverty and Planning Ability*

In addition to parental investment and sensitivity, another potential pathway linking early childhood deprivation to reduced achievement is deficits in executive functioning (EF). EF, which includes planning, working memory, inhibitory control, and attention regulation, is adversely influenced by

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early experiences of deprivation and chronic stress (Blair, 2010; Blair & Raver, 2012; Evans & Kim, 2013). Prospective memory, a critical component of time management and goal maintenance, is also affected by early experiences (Smith, Bayen, & Martin, 2010). We briefly review work on SES and EF among children and then discuss why childhood poverty could interfere with the developmental of planning skills.

In samples of 5- to 7-year-olds as well as 12-year-old children, Noble and Farah found that lower SES children performed significantly poorer than their middle-SES counterparts on various indices of inhibitory control (e.g., Go-No-Go task; Farah et al., 2006; Noble, McCandliss, & Farah, 2007; Noble, Norman, & Farah, 2005). Furthermore, in a sample of 8- to 12-year-olds, family SES was found to predict differences in working memory, flexibility, and inhibitory control (Sarsour et al., 2011). Finally, in two different samples of elementary and middle school children, respectively, the income-achievement gap was mediated by self-regulatory ability (Evans & Rosenbaum, 2008). Both analyses were prospective showing that the relation between early childhood poverty and subsequent deficits in academic achievement was mediated by intervening performance on the Mischel delay of gratification paradigm.

One key component of EF that has received little attention in the income-achievement gap literature is planning. Brody and colleagues, in a sample of low-income, rural African American families showed that income (Brody, Stoneman, & Flor, 1996) as well as perceived financial strain (Brody & Flor, 1997) were each negatively associated with both parental and teacher ratings of children's self-control abilities on a standard index that included some questions about planning (e.g., "plans ahead before acting"). Hughes, Ensor, Wilson, and Graham (2010) employed structural equation modeling to form a latent measurement model of EF at ages 4 and 6 that included an index of planning. This EF composite was significantly lower among young children from lower income families at both ages.

### Summary

We build upon prior studies of underlying mechanisms to explain the income-achievement gap by investigating the ability to plan. We examine the hypothesis that the well-documented income-achievement gap will be mediated, to some extent, by planning skills assessed by a standard behavioral protocol, the Tower of Hanoi (ToH) task. Planning

skills predict academic achievement among elementary school children (Dembo & Eaton, 2000; Montague & Bos, 1986; Pape & Wang, 2001). We expect early childhood poverty to interfere with the development of good planning skills for several reasons. Low-income households experience substantially greater chaos in their daily lives including more residential instability and school changes, greater family turmoil and turnover, more crowded and noisy households, and fewer structured routines and rituals (Evans, 2004; Evans, Eckenrode, & Marcynyszyn, 2010). Low-income parents themselves may also be less successful at planning because of their own higher burden of stress (Bradley & Corwyn, 2002; Conger & Donnellan, 2007; Grant et al., 2003; McLoyd, 1998). More chaotic households coupled with more overburdened parents could both interfere with the development of good planning skills among young children.

## Method

### Participants

Study participants were from four phases of the National Institute of Child Health and Human Development (NICHD) Study of Early Child Care and Youth Development that began in 1991 (Griffin & Friedman, 2007). Data were collected on families from 10 designated hospitals at different sites across the United States to enroll a diverse sample of families and their children. Phase I (1991–1994) of the study enrolled 1,364 families with healthy, full-term newborns. A conditionally random sampling plan was used to select a pool of participants that included mothers who planned to attend work or school full time (60%) or part time (20%) and mothers who were to stay at home with their children for the 1st year (20%). The recruited families were representative of the demographic diversity of the designated sites. Exclusionary criteria included mothers who were younger than 18 years when the child was born, families who planned to vacate the area in the next 3 years, children with clear disabilities at birth, and mothers who were not fluent in English (Friedman & Haywood, 1994). In Phase IV (2005–2007), 1,009 children remained in the study.

The mean income-to-needs ratio of 1,364 children at 1 and 24 months of age was calculated for each child. Income-to-needs is computed by dividing total household income by the poverty threshold determined by the U.S. federal government for the appropriate family size. An income-to-needs ratio of 1 is the U.S. poverty line. For those families

below the poverty line, the mean income-to-needs ratio was .36 and for those families above the threshold, the mean was 3.75.

### Procedure

*Tower of Hanoi.* Planning was measured with the ToH procedure (Scholnick & Freidman, 1993) in Phase III (Grade 3). The ToH is the most widely used task to study planning in children (McCormack & Atance, 2011; Scholnick & Freidman, 1993). It assesses the ability to organize a specific sequence of moves, requiring future-oriented planning, and is considered a subcomponent of EF (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). The ToH is sensitive to age differences in normal children (Welsh, 1991) and differentiates cognitively disabled children from normal controls (Welsh, Pennington, Ozonoff, Rouse, & McCabe, 1990). Furthermore, the ToH is novel to most children and not related to a particular knowledge base.

The task calls for the child to plan and develop a sequence of moves that will convert an original configuration of rings into a goal state. The ToH has three vertical pegs with three rings of different diameters around them. In the task, the rings are presented to the child in a certain configuration and the goal is to move the rings among the pegs to create a tower on a certain peg with the rings ordered by size with the smallest ring on top. There are three primary rules: (a) smaller rings cannot be placed under larger rings, (b) only move one ring at a time, and (c) a ring may only be in the person's hand or on a peg (Welsh, 1991). The tower must be constructed in the fewest number of moves. Figure 1 shows a completed ToH puzzle. A move is when the child takes a ring off of a peg and places on another peg or back on the same peg. Data on the number of moves made and the number of trials, which is the number of times the ring configuration is restarted, are added together to compute a planning score. A total planning score was calculated by summing across seven separate ToH trials.



Figure 1. The Tower of Hanoi puzzle.

*Wechsler Abbreviated Scale of Intelligence (WASI).* This study uses the WASI full-scale IQ at Grade 4 as a statistical control. The WASI is a widely used, short and reliable estimate of overall cognitive ability to operationalize IQ. The test consists of four subtests that each measures a particular aspect of cognitive functioning, including nonverbal and verbal reasoning, processing of visual information, and verbal understanding. The four subtests are used to determine the full-scale IQ, which is composed of the verbal IQ and performance IQ (Wechsler, 1999).

*Woodcock-Johnson Psycho-Educational Battery-Revised (WJ-R).* The WJ-R is a broad, comprehensive set of separately administered tests. This study operationalizes academic achievement using the WJ-R broad mathematics and broad reading scores at Grade 5. The reliability and validity of the WJ-R as a construct for academic achievement has been well established (Campbell & Ramey, 1994). The broad reading score is calculated by combining the scores on letter-word identification and passage comprehension. The letter-word identification task includes symbolic learning where one must match a pictographic symbol of a word to a picture of the actual object. The task also measures the participant's ability to identify isolated words and letters. Passage comprehension requires the participant to point to a picture represented by a passage in a multiple-choice format. The task also measures the participant's ability to state an appropriate word in the context of a passage (Woodcock & Johnson, 1989). The broad mathematics score is composed of the calculation and applied problems scores. The calculation task measures the participant's skill in performing mathematical calculations. The calculations include whole numbers, fractions, and decimals and the operations of addition, subtraction, division, and multiplication as well as geometric and logarithmic problems. The applied problems test determines the participant's skill in evaluating and solving word problems in mathematics. This task emphasizes the importance of recognizing appropriate procedures.

### Results

Correlation and structural equation modeling were used to analyze how early childhood poverty is associated with later academic achievement. Income-to-needs was calculated as the mean at ages 1 and 24 months. The child's planning skills were measured by the ToH task at Grade 3. IQ at Grade 4 was used as a statistical control. Descriptive statistics as

Table 1  
Descriptive Statistics and Zero-Order Correlation Coefficients

Variables	M (SD)	2	3	4	5
1. Income-to-needs	3.07 (2.68)	.19**	.33**	.31**	.31**
2. ToH: Total planning score	17.18 (7.69)		.30**	.33**	.25**
3. WASI full-scale IQ	106.86 (14.44)			.66**	.67**
4. WJ-R broad math score	69.07 (26.95)				.64**
5. WJ-R broad reading score	65.21 (25.45)				

ToH = Tower of Hanoi; WASI = Wechsler Abbreviated Scale of Intelligence; WJ-R = Woodcock-Johnson Psycho-Educational Battery-Revised.  
\*\* $p < .01$ .

well as the zero-order correlation matrix are displayed in Table 1. Table 1 demonstrates that the mean income-to-needs ratio at 1 and 24 months of age is positively associated with the WJ-R broad math and broad reading scores at Grade 5. Children from higher income households have higher scores on broad math and broad reading scores. Income-to-needs is also positively associated with the ToH planning score (Grade 3) and IQ as measured by the WASI.

We predicted that the child’s planning score on the ToH task would mediate, at least in part, the relation between early childhood poverty and the WJ-R, with IQ included as a statistical control. To test the mediational hypothesis, path analyses were conducted using the full information maximum likelihood estimation method in Stata 12 (Stata Corporation, 2011). This method enables us to obtain

estimates in the presence of missing data using the full sample of children.

The full path model for mathematic scores at Grade 5 is depicted in Figure 2. As indicated, higher income levels predicted better planning ability ( $\beta = .58, p < .001$ ), and this in turn was associated with lower levels of mathematical ability ( $\beta = .47, p < .001$ ). The overall indirect effect was highly significant, for mathematics  $\beta = .27, p < .001$ , indicating that the prospective effects of early childhood income on the development of mathematical skills in late elementary school are mediated by planning skills. Similar but weaker results were found for the development of reading skills at Grade 5 (see Figure 3) with higher income levels predicting better planning ability ( $\beta = .57, p < .001$ ), but this in turn was only marginally associated with reading ability ( $\beta = .15, p < .07$ ). The overall indirect effect was marginally significant for reading ability,  $\beta = .09, p < .08$ , suggesting that at least a portion of the influence of early childhood income on subsequent reading abilities is explained by planning skills.

Discussion

A vast array of research has documented an income-achievement gap (Bradley & Corwyn, 2002; Duncan, 2012; Duncan & Brooks-Gunn, 1997; Heckman, 2006; Sirin, 2005). Some studies also suggest that childhood poverty can lead to diminished EF causing deficits in skills such as working memory and inhibitory control (Blair, 2010; Blair & Raver, 2012; Evans & Kim, 2013; Raver, 2004). This study hypothesized

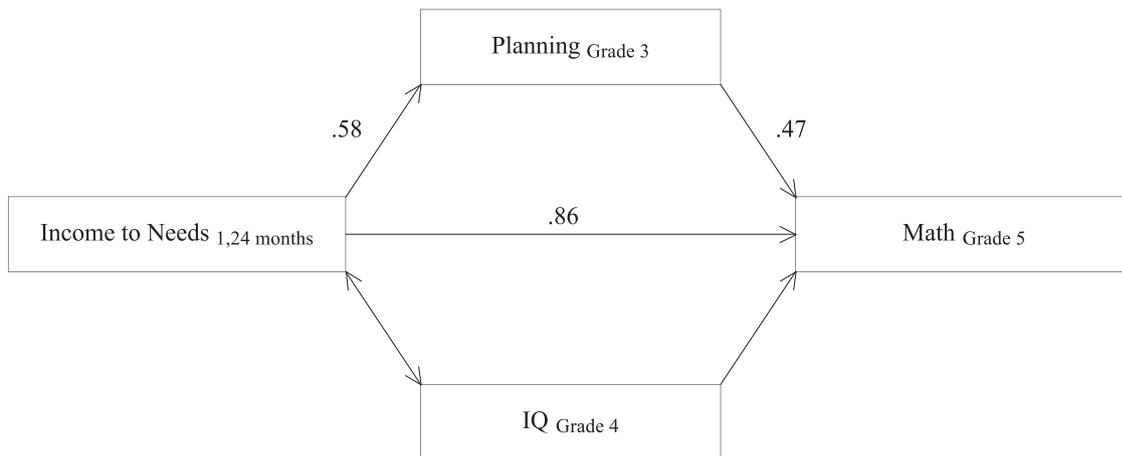


Figure 2. Path analysis of early childhood poverty (1 and 24 months), planning (Grade 3), and mathematical achievement (Grade 5). Grade 4 IQ included as a covariate.

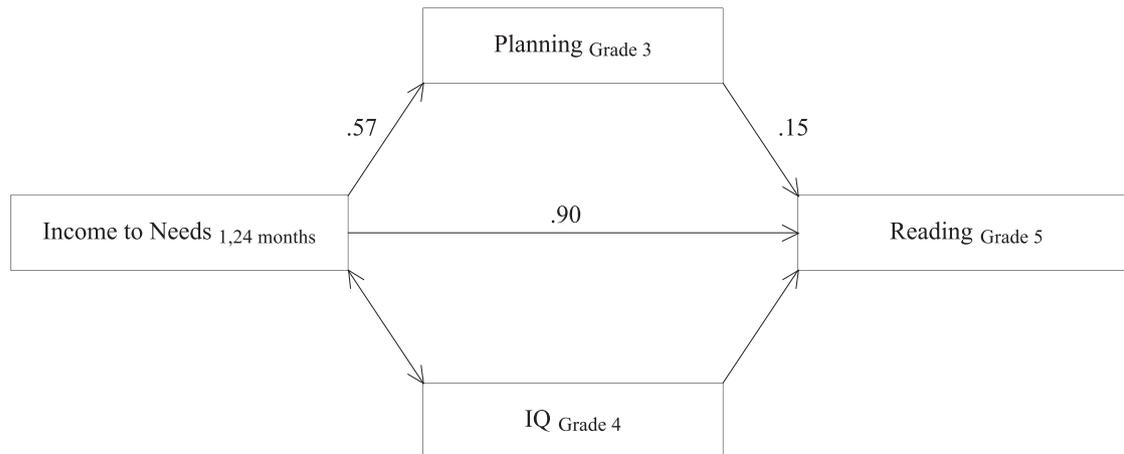


Figure 3. Path analysis of early childhood poverty (1 and 24 months), planning (Grade 3), and reading achievement (Grade 5). Grade 4 IQ included as a covariate.

that the income–achievement gap could be explained in part by the ability to plan, an aspect of EF that has received little attention in the childhood poverty literature. We found in an ethnically diverse sample drawn from across the United States that the income-to-needs ratio of households measured when children were infants predicted children’s reading and math outcomes at Grade 5 and that this relation was mediated by planning skills assessed in Grade 3. All analyses included a statistical control for IQ. The latter is important as many income–achievement gap analyses have not incorporated IQ.

There are many components involved in the ability to plan in a goal-oriented manner; a child must be able to form a representation of the problem, formulate a strategy and execute it, focus on a goal, and self-monitor progress toward the specific goal (McCormack & Atance, 2011; Scholnick & Freidman, 1993). All these abilities are involved in the ability to succeed academically. The tool set of being able to plan and execute is essential for continued academic success in many fields.

There are limitations of this study that warrant comment. The NICHD national data set supports the mediational pathway; however, it should be noted that this is a correlational study. Stronger causal conclusions could be made if goal setting and planning could be strengthened by an intervention. However, the longitudinal design of the NICHD national data set enabled use of a prospective, longitudinal research design that, when coupled with a statistical control for IQ, provides plausible evidence for the model posited herein. Recently, Spears (2011) showed in a true experiment that manipulations of resource availability in adults caused diminished

inhibitory control and motivation, additional elements of EF.

Another limitation of this study is that there are other measures of EF (e.g., working memory, cognitive control) that have previously been shown to relate to SES. Although the ToH is widely used to assess planning in children and adults, many have noted that this task likely incorporates multiple aspects of EF including attentional control and working memory as well as planning (McCormack & Atance, 2011; Miyake et al., 2000; Scholnick & Freidman, 1993). In a recent neural imaging study with adults, Crescentini, Seyed-Allaei, Vallesi, and Shallice (2012) demonstrated that the ToH selectively recruited the dorsal lateral prefrontal cortex, an area of the brain involved in planning. Nonetheless, the extent to which any one or a particular combination of subcomponents of EF operates as a critical and independent underlying mediator of the income–achievement gap remains an important question for future work.

Another valuable extension of this study would be to examine characteristics of children’s early environments such as chaos as well as the planning skills of low-income parents themselves that could lead to the apparent income–planning skills link uncovered herein. Poverty likely impacts children’s achievement through multiple paths (Duncan, 2012; Evans & Kim, 2013). In addition to fewer parental investments (e.g., language, cognitive stimulation) and harsher, less responsive parenting, early experiences of deprivation may damage EF, including the ability to plan. Low-income families are bombarded with numerous psychological and physical risk factors that are seemingly uncontrollable. These

stressors include chaotic living environments, relentless financial pressure, familial disorder and instability, and social isolation (Ackerman & Brown, 2010; Evans, 2004). These circumstances could lead to an inability to focus on everyday tasks necessary for the development of planning skills.

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