Learning and Instruction 30 (2014) 25–31

Contents lists available at ScienceDirect

Learning and Instruction

journal homepage: www.elsevier.com/locate/learninstruc

Do preschool executive function skills explain the school readiness gap between advantaged and disadvantaged children?

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ARTICLE INFO

Article history:
Received 28 March 2013
Received in revised form
19 November 2013
Accepted 21 November 2013

Keywords:
Executive functions
Socioeconomic status
School readiness
Academic achievement
Cognitive development

ABSTRACT

We examine the extent to which executive functions (EFs), as opposed to other cognitive skills, account for socioeconomically based disparities in school readiness. Participants are 226 American children (aged 36–71 months) enrolled in either needs-based or private preschools. Children completed 6 tasks designed to measure EFs as well as assessments of general intelligence and speed of cognitive processing. Children were also assessed on math, reading, and vocabulary skills. EFs accounted for unique variance across all academic measures even when controlling for speed of processing and general intelligence and partially accounted for disparities in school readiness associated with type of preschool enrollment. When vocabulary was controlled in the model, EFs only mediated associations between type of preschool and math. Vocabulary skills accounted for associations between socioeconomic status and both math and reading achievement. General intelligence and speed of processing did not uniquely account for associations between disadvantage and school readiness.

1. Introduction

The educational achievement gap between advantaged and disadvantaged children is pervasive and likely plays a key role in the inter-generational transmission of poverty. The educational and cognitive inequalities associated with low socioeconomic status (SES) begin early in life (Bradley & Corwyn, 2002; Duncan, Yeung, Brooks-Gunn, & Smith, 1998). By later elementary school, these differences are robust and persist as children transition to high school (Alexander, Entwisle, & Dauber, 1993; Brooks-Gunn & Duncan, 1997; Entwisle, Alexander, & Olson, 2005). Consequently, it remains important to better understand how family poverty generates early academic risk in children.

One pathway through which low SES might influence scholastic achievement is through its effect on cognitive development. Economically disadvantaged children receive less cognitive stimulation. They are read to less often, watch more television, and attend lower quality daycare (Evans, 2004). They also have lower quality diets and are exposed to more pollutants in the air they breathe and the water they drink (Evans, 2004). The cumulative experience of these risk factors during a sensitive period of brain expansion and growth can compromise neurocognitive development (Shonkoff & Phillips, 2000).

Children who grow up in poverty arrive in kindergarten less well prepared to learn, placing them at long-term academic risk (Duncan & Brooks-Gunn, 1997; Duncan, Magnuson, Huston, Klebanov, & Brooks-Gunn, 2007). Disadvantaged children also underperform across multiple indicators of cognitive functioning. These include assessments of general intelligence, speed of cognitive processing, language ability and executive functioning (Hackman & Farah, 2009; Heckman, 2007; Mezzacappa, 2004; Noble, McCandliss, & Farah, 2007). What is less clear is how these differences account for socioeconomically based academic differences at the time of school entry.

It is possible that individual differences in executive functions partially account for economically based differences in child school readiness. Executive functions are believed to emerge as a function of the development of neural networks in prefrontal cortex. As children reach school age, executive function skills can help children hold information or instructions in mind during classroom activities, focus on task-relevant stimuli during problem solving tasks, and resist internal or external distractions. Furthermore, these skills are especially important for the exercise of willful control, delay of gratification, and cognitive and emotional self-regulation (Blair & Razza, 2007). From kindergarten to high school, executive functions have been shown to explain an

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http://dx.doi.org/10.1016/j.learninstruc.2013.11.003

important proportion of the variance in achievement, even after accounting for child IQ and SES (Blair & Razza, 2007; Duckworth & Seligman, 2005, 2006; Fitzpatrick & Pagani, 2012). A meta analysis involving samples of children from Canada, the United States, and the United Kingdom conducted by Duncan et al. (2007) showed that attention control, an important component of executive functions, predicted eventual academic performance in elementary school. These associations were not confounded by child characteristics (behavior problems, social skills) or family context (family configuration, parental education) and were replicated using a large sample of French-Canadian children (Pagani, Fitzpatrick, Archambault, & Janosz, 2010).

There is some experimental evidence that programs designed to boost preschool executive functions brought about improvements in early achievement (Bierman, Nix, Greenberg, Blair, & Domitrovich, 2008; Raver et al., 2011). Recent analyses of the effectiveness of the Perry Preschool program, which focused on the promotion of active learning, planning, and executing tasks were also consistent with this hypothesis (Almlund, Duckworth, Heckman, & Kautz, 2011). That is, though the Perry Preschool program did not produce lasting improvements in children's general intelligence, participants showed lasting improvements in educational achievement and adjustment well into adulthood. This suggests that improvements in executive function skills, which underlie self-control and self-regulation, may have been responsible for the observed outcomes.

Children who grow up in poverty also show delays in their verbal development (Fernald, Marchman, & Weisleder, 2013; Hart & Risley, 1995). Some research suggests that verbal competence either fully or partially mediated the association between executive functioning and later achievement outcomes (Noble, Norman, & Farah, 2005; Rhoades, Greenberg, Lanza, & Blair, 2011). In contrast, a recent study found that executive function skills accounted for part of the association between socioeconomic disadvantage and early math achievement, even after controlling for verbal ability (Dilworth-Bart, 2012).

1.1. Objective and hypotheses

The objective of the present study is to examine the importance of executive functioning relative to other cognitive functions such as IQ, speed of cognitive processing, and verbal skills in explaining socioeconomically-based disparities in achievement. We collected data on child executive functions using a battery of 6 tasks specifically developed to assess executive functions with preschool-aged children. Our first hypothesis is that child executive functions will be uniquely associated with academic achievement even once socioeconomic status, speed of cognitive processing, general intelligence, and child age are controlled (Hypothesis 1). We also hypothesize that executive functions will significantly account for part of the association between SES and academic achievement (Hypothesis 2).

2. Methods

2.1. Participants and procedures

Data are from 226 English-speaking American children between the ages of 36 and 66 months ($M = 56.88$, SD = 9.06) attending preschool in New York City. Recruitment flyers were sent home to families of children enrolled in six participating preschools. Three of the six participating preschools were needs-based and three were private with very high annual tuition requirements. Sample sizes, means, and ages for each socioeconomic group are presented in Table 1. Males represented 51.5% of the total sample, 40% of the disadvantaged sample, and 55% of the advantaged sample.

Our lower SES sample represented 41% of the total sample. In terms of ethnicity, 7% of children in the low SES group were White, 43% Black, 35% Hispanic, and 1% other. Children in the high SES group were 92% White, 2% Black, 4% Asian, 3% Hispanic, and 8% other. We collected information on demographic characteristics from one-third of the sample (selected pseudo randomly) in order to verify differences between the groups. In the low SES sample, the majority of parents had completed some college, with the remainder having completed a high school diploma or GED. In contrast, in the high SES sample, 75% had a graduate degree with the remainder completing a 4-year college degree. In terms of household income, 16% of the low SES group reported earning less than $10,000 annually, 44% earning between $10,000 and $25,000 annually, 20% earning between $25,000 and $40,000, and 20% earning more than $40,000 annually. In the high SES group, 96% of the sample reported earning more than $100,000 a year.

Children were assessed over two sessions with a trained research assistant at the preschool in which they were enrolled. On average, the sessions were 6 weeks, or 38.53 days, apart. In the first session, children completed a battery of executive function tasks. In the second session, children completed the Applied Problems and Letter-Word Identification subtests of the Woodcock–Johnson Tests of Achievement III and the Picture Vocabulary subtest of the Woodcock–Johnson Tests of Cognitive Abilities (Woodcock, McGrew, & Mather, 2001).

2.2. Measures

2.2.1. Socioeconomic status

We used enrollment in needs-based preschool education or private preschool education as an indicator of child SES. The eligibility requirements set by the New York City Administration for Children and Families for a family to receive subsidized child care is 225% of the State Income Standard (SIS) for a family of four. In 2010, the SIS was $22,050 and in 2011 it was $22,350. Most families enrolled in needs-based education had household incomes at or near the poverty line. In contrast, families of children enrolled in private preschool were paying upward of $25,000 per year for full day enrollment. SES was dichotomized and scored as either 0 for

Table 1
Descriptive statistics for study variables by socioeconomic status.

	Low socioeconomic status			High socioeconomic status		
	M (SD)	Min	Max	*M* (SD)	Min	Max
	N = 92			*N* = 134		
Child age (months)	55.22 (7.19)	37	71	56.53 (8.46)	38	71
Executive functions	68% (.18)	0	.90	79% (.13)	.41	.98
General intelligence	6.53 (1.71)	3	11	7.08 (1.66)	1	11
Speed of processing	97.76 (12.95)	67	139	104.19 (15.08)	65	133
Applied problems	11.50 (4.44)	0	27	17.69 (4.87)	5	31
Letter-word	10.66 (4.96)	2	31	14.79 (9.45)	2	51
Picture vocabulary	10.03 (1.52)	5	14	12.42 (2.72)	6	17

Notes. Socioeconomic status was scored as 0 (child enrolled in needs-based preschool) or 1 (child enrolled in private preschool). Executive function scores reflect composite scores of percent correct across the sound Stroop, item selection, spatial conflict, operation span, go-no go, and self-ordered pointing tasks.