Persistence and fadeout in the impacts of child and adolescent interventions

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Abstract

When interventions target cognitive skills or behaviors, capacities or beliefs, promising impacts at the end of the programs often disappear quickly. Our paper seeks to identify the key features of interventions, as well as the characteristics and environments of the children and adolescents who participate in them, that can be expected to sustain persistently beneficial program impacts. We describe three such processes: skill-building, sustaining environments and foot-in-the-door. We argue that skill-building interventions should target "trifecta" skills – ones that are malleable, fundamental, and would not have developed eventually in the absence of the intervention. The sustaining environments perspective views the quality of environments subsequent to the completion of the intervention as crucial for sustaining early skill advantages. Successful foot-in-the-door interventions equip a child with the right skills or capacities at the right time to avoid imminent risks (e.g., grade failure or teen drinking) or seize emerging opportunities (e.g., entry into honors classes). These three perspectives generate both complementary and competing hypotheses regarding the nature, timing and targeting of interventions that generate enduring impacts.

Persistence and Fadeout in the Impacts of Child and Adolescent Interventions

I. INTRODUCTION

Far too often, impacts on outcomes targeted by intervention designers soon disappear. This is readily apparent in interventions begun in early childhood, with perhaps the most famous example being Perry Preschool, where the program's large end-of-treatment impact on IQ (.75 sd) at age 5 had dropped to a statistically insignificant .08 sd by age 8 (Schweinhart et al. 2005; Figure 1). More generalizable – and worrisome – is the finding by Puma et al. (2012), based on a random assignment of 4,442 children to a national sample of Head Start centers, that while noteworthy impacts were observed at the end of the Head Start year, virtually no statistically significant impacts on any cognitive or noncognitive measure persisted over the next several years. On the other hand, a second famous early childhood intervention begun a decade after Perry—the Abecedarian Project—generated IQ impacts that persisted well beyond age 8 (Campbell, Pungello, Miller-Johnson, Burchinal, & Ramey, 2001; also shown in Figure 1). Both Perry and Abecedarian produced substantial favorable impacts in adulthood, although not always on the same outcomes.

[Figure 1]

Examining this and other seemingly contradictory evidence on fadeout, we seek to identify the key features of child and adolescent interventions, as well as the characteristics and environments of their participants, that can be expected to generate persistent program impacts. We will speak of impacts on "skills" but use that term broadly to encompass any skill, behavior, capacity or psychological resource that helps individuals attain successful outcomes.[1] We consider skill-building interventions that are quite diverse in terms of their setting (both within and outside of classrooms) and timing (encompassing various stages of childhood and adolescence). We confine the bulk of our discussion to skills, capacities and contexts of typically developing children living in the broad range of environmental conditions found in the modern U.S.[2]

We begin in Section II with a selective review of evidence on fadeout, choosing our examples to illustrate the diverse patterns of fadeout across outcomes within and across interventions. We then formulate three distinct processes that might sustain benefits for children and adolescents: skill building, sustaining environments and foot-in-the-door skill or capacity boosts.

As detailed in Section III, the skill-building perspective is based on economists' human capital model of the skill accumulation process, which emphasizes that simpler skills support the learning of more sophisticated ones and that skills acquired prior to a given skill- or capacity-building intervention increase the productivity of that investment. Our main contribution here is to argue for the importance in this skill-building perspective of what we call "trifecta" skills – ones that are malleable, fundamental and would not have developed in the absence of the intervention. All three conditions are needed to generate long-run effects, which limits substantially the kinds of interventions that might be expected to produce long-run benefits. In the case of early childhood interventions, the third trifecta condition – eventual skill development in counterfactual conditions – is particularly problematic for interventions that build early literacy, math or executive function (EF) skills because most children are likely to eventually acquire these skills.

A second approach to understanding fadeout is what we call the "sustaining environments" perspective (Section IV). It recognizes the importance of interventions that build important skills and capacities, but views the quality of environments subsequent to the completion of the intervention as crucial for maintaining initial skill advantages. As explained in Section V, developmental timing is key to the third, foot-in-the-door, perspective. Successful foot-in-the-door interventions equip a child with the right skills or capacities at the right time to avoid imminent risks (e.g., grade failure, teen drinking or teen childbearing) or to seize emerging opportunities (e.g., entry into honors classes, SAT prep). The skill or capacity boosts need not be permanent, as with SAT prep that boosts chances of acceptance into a higher-resourced college. In this case, it is the enriched college resources, rather than any lingering test prep knowledge, that lead to a higher-paying job. Unlike sustaining environments, foot-in-the-door processes rely on the treatment group benefiting from a different series of subsequent environments than the control group. Section VI summarizes some of the implications of our analysis.

II. PATTERNS OF FADEOUT AND PERSISTENCE

Original calculations, using information from a meta-analytic database of the evaluations of 67 high-quality early childhood education (ECE) interventions published between 1960 and 2007, produce the pattern of geometrically declining effect sizes shown in Figure 2 for cognitive outcomes.[3] At the end of the programs, effect sizes averaged .23 standard deviations – considerably smaller than the end-of-treatment impacts shown for Perry and Abecedarian in Figure 1. Impacts measured no more than 12 months after the end of treatment had dropped by more than half, to .10 sd, and again by half one to two years later. Figure 1 shows that while Perry's IQ impacts approximate a geometric decline, Abecedarian's IQ impacts were much more persistent (although they did decline substantially during the treatment period), which suggests that fadeout patterns based on cross-study average impacts are likely to conceal study-to-study variation.

[Figure 2]

Most interventions targeting children's cognitive, social or emotional development fail to follow their subjects beyond the end of their programs (e.g., Durlak, Weissberg, Dymnicki, Taylor, & Schellinger, 2011; Smit, Verdurmen, Monshouwer, & Smit, 2008).[4] When they do, complete fadeout is common. As mentioned above, Puma et al. (2012) found virtually no statistically significant impacts of Head Start on either cognitive or noncognitive measures in kindergarten, first or second grades. That said, Deming's (2009) sibling-based analysis shows that while initial impacts of Head Start on achievement in the early grades had faded to statistical insignificance by early adolescence, a number of significant differences in attainment and behavioral domains were detected in early adulthood.

Some mathematics interventions for preschool or school-aged children generate impressive initial effects that have been found to fade over time (Clements, Sarama, Wolfe, & Spitler, 2013; Smith, Cobb, Farran, Cordray, & Munter, 2013). Bus & van IJzendoorn's (1999) meta-analysis of early phonological awareness training found substantial effects on children's initial reading skills (.44 sd) but much smaller effects on reading skills (.16 sd) in the subset of studies with a follow-up assessment 18 months, on average, after the completion of the programs.

In some long-run studies such as Perry and Abecedarian, initial fadeout is followed by the detection of impacts in adulthood, although not always on the same kinds of developmental outcomes. In the case of teacher effects, Jacob, Lefgren and Sims (2010) conclude that teacher-

induced (value-added) learning and other measures of teacher quality have low persistence, with three-quarters or more of teaching-year effects fading out within one year. However, Chetty, Friedman and Rockoff (2011, 2013) found longer-run impacts on both attainment and behavior in the same children when participants were followed through to adulthood via administrative records.

A similar pattern of fadeout and reemergence in young adulthood has been documented for early social skills training. For example, the Fast Track program provided a range of behavioral and academic services to a random subset of 1st grade boys exhibiting conduct problems. Impacts in elementary school were uniformly positive, producing improvements in the boys' prosocial behaviors and classroom social competence and reductions in their aggressive and oppositional behaviors (Conduct Problems Prevention Research Group, 1999a, 1999b). By middle or high school, most of these effects had disappeared for all but the highest-risk boys (CPPRG, 2011), although impacts on some of these outcomes reappeared when the participants were assessed in their mid-20s (Dodge et al., 2015).

All in all, it appears that some well-designed and implemented cognitive, social and emotional interventions produce immediate impacts on child and adolescent outcomes. Sharp reductions in subsequent intervention effects are typically observed among the regrettably small fraction of interventions where follow-up data are available. Interestingly, among some of the most rigorously implemented and evaluated early childhood interventions this pattern of rapid intervention-effect fadeout has been followed by the detection of impacts on attainment, behavior and sometimes health in adulthood.

III. SKILL-BUILDING MODELS

How can we account for these patterns of fadeout and persistence in child and adolescent interventions? The next three sections draw from the limited conceptual literature on fadeout to formulate three distinct processes that may explain persistence and fade-out of intervention effects over time – skill building, sustaining environments and foot-in-the-door capacity boosts needed to respond to windows of opportunity or risk that open and close across childhood and adolescence.

Skill-building economic models of human development formalize thinking about the human capital production function and emphasize how investments and child endowments interact to create a child's accumulating stock of human capital. Cunha and Heckman (2007) describe a cumulative model of the production of human capital that allows for differing childhood investment stages as well as roles for the past effects and future development of both cognitive and noncognitive skills. Their model highlights the interactive nature of children's skill building and investments from families, preschools and schools, and other agents.

Cunha and Heckman posit that human capital accumulation, as summarized in their phrase "skill begets skill," results from two distinct processes. First is "self-productivity" – the process by which more complicated skills develop from simpler ones. This insight is well developed in both the mathematics (e.g., Clements & Sarama, 2004, 2014) and literacy (e.g., LaBerge & Samuels, 1974) literatures, and supports the idea that intervention impacts may be particularly likely to persist when interventions are designed to build skills incrementally within any given developmental domain. An example would be a math intervention teaching the number line that facilitates the learning of higher-level math skills in later grades (Siegler, 2009).

Cunha and Heckman (2007; also see Ceci & Papierno, 2005) also introduce the concept of "dynamic complementarity," the idea that skills acquired prior to a given human capital investment increase the productivity of that investment. Thus, for example, children who enter school with the strongest cognitive and noncognitive skills will profit most from K-12 schooling by, say, learning the most from classroom instruction or being selected for gifted and talented programs in the early grades or for honors or AP classes in high school. Although this synergy between initial skills and later interventions may be observed for universal interventions such as K-12 schooling, it is less likely to hold for targeted programs such as Head Start, which have an explicit compensatory purpose (Purtell and Gershoff, 2013, but see also Aizer and Cunha, 2012).

The Cunha and Heckman model predicts greater impact persistence of early human capital interventions when the intervention: i) boosts skills that are important for the production of later skills, and/or ii) boosts skills that best increase the productivity of later investments. The key intervention implication in the Cunha and Heckman model is the need to identify fundamental cognitive and noncognitive skills, capacities, behaviors or beliefs and develop them as early and efficiently as possible. Under this model, the quality of subsequent learning environments (e.g., K-12 schooling) may affect a child's eventual level of skills, but the skill *gap* between treatment and control-group children resulting from an effective early childhood intervention ought to be maintained or even widen with time under a range of subsequent environmental conditions.

Trifecta Skills in the Context of the Skill Building Model

Cunha and Heckman (2007) speak generally of cognitive and noncognitive skills, but do not identify which skills matter the most. We propose that to provide persistent intervention-generated benefits for children, the skills, behaviors, capacities or beliefs targeted by interventions must share three key features: they are *malleable* through intervention, they are *fundamental* for success, and they *would not develop eventually* in most counterfactual conditions. Our characterization of these skills as "trifecta" connotes the importance of meeting all three criteria, which we argue limits substantially the kinds of skills that interventions can target productively. Trifecta skills may be influenced directly, as by an intervention (e.g., direct classroom instruction) designed to influence children's skill development, or indirectly, as through an intervention that changes children's environments (e.g., positive parent-child relationships, neighborhood and school safety) in ways that promote their fundamental skills.

Malleability and fundamentality. Setting aside for the moment a consideration of counterfactual conditions, we note that to provide lasting benefits for children, human capital interventions must target skills, behaviors or beliefs that can be changed (malleability) and are crucial for achieving the desired outcomes (fundamentality). We see malleability and fundamentality as continua; each varies within and across individuals, depending on age, other personal characteristics, and circumstances. Figure 3 categorizes a variety of child and adolescent skills, capacities, beliefs and characteristics according to their malleability and fundamentality. We begin our discussion in the lower left-hand quadrant, which contains fundamental but not readily malleable skills.[5]

[Figure 3]

Fundamental but not readily malleable. Since it supports performance across a wide variety of important tasks, general intelligence, or *g*, is the best example of a "fundamental" capacity. General intelligence is the single strongest predictor of many measured traits and abilities, including previous occupational experience, occupational level and performance (Schmidt &

Hunter, 2004), and strongly predicts other life outcomes as well (Herrnstein & Murray, 1994; Gottfredson, 1997; Heckman, 1995; Cawley, Conneely, Heckman, & Vytlacil, 1997).

Unfortunately, despite the apparent long-run malleability of intelligence test performance at the population level (Flynn, 2012), attempts to influence general intelligence experimentally in individuals within the commonly observed range of intervention intensity and child characteristics have rarely proved successful (Jensen, 1998; but see Nisbett et al 2012 for a more optimistic review). Although performance on any particular intelligence test can be improved through training, these gains rarely transfer broadly to performance on very different cognitive tests (Haier, 2014; te Nijenhuis, van Vianen, & van der Flier, 2007, but see Au et al., 2015, and response by Melby-Lervag & Hulme, 2015).

This has problematic implications for interventions seeking to improve this fundamental skill, since it means that training designed to enhance performance on cognitive tests is unlikely to enhance children's general learning. However, as shown in Figure 1, at least one early childhood education intervention – Abecedarian – generated persistent effects on children's general intelligence, perhaps because of the intense nature of the Abecedarian program, combined with the conditions of relative deprivation facing control group children and their families.

Conscientiousness – one of the "Big Five" personality traits identified by personality psychologists – is also likely to be fundamental.[6] Conscientiousness is the most powerful correlate in the personality domain of later job performance (Judge, Higgins, Thoresen, & Barrick, 1999; Almlund, Duckworth, Heckman, & Kautz, 2011), and is also associated with other important outcomes, such as children's grades in school, health behaviors and longevity (Bogg & Roberts, 2004; Friedman et al., 1993; Poropat, 2014). Historically, individual differences in traits such as conscientiousness have been viewed as largely stable across time (McCrae et al., 2000; for a review see McAdams & Pals, 2006), with substantial continuity documented between childhood behavioral styles and personality in early adulthood (Caspi, 2003).There is evidence suggesting that personality traits may be amenable to change, particularly during adolescence and young adulthood (Magidson et al., 2012; Roberts et al., 2006). Unfortunately, there is little direct evidence from interventions illustrating that personality characteristics such as conscientiousness are malleable.[7]

Malleable but peripheral. A second set of skills are malleable but peripheral (the upper right corner in Figure 3). A classic example is test-specific knowledge. Being able to identify a picture as a "blue house" might improve a young child's score on an early intelligence assessment, but this piece of knowledge alone is unlikely to benefit a child's later schooling or labor market success. Impacts from interventions that focus on improving children's knowledge of a limited number of peripheral facts or test-specific test-taking skills will likely fade out quickly. Indeed, peripheral skill targeting of this kind has been proposed as an explanation for fadeout of IQ score effects produced by ECE interventions (Jensen, 1998).

That said, interventions targeting peripheral skills may still deserve intervention attention if those skills provide "foot-in-the-door" advantages linked to longer-run benefits. An example might be test prep that increases chances of admission to a four-year or higher-status college, which in turn leads to a higher-paying job. But this is a very different process from Cunha-Heckman skill building. We discuss foot-in-the-door avenues for sustaining intervention impacts in Section V.

Fundamental and malleable. The fourth and most promising quadrant of Figure 3 contains skills, behaviors or beliefs that have been – or may eventually be – shown to be both fundamental for later success and malleable through intervention. Examples listed in Figure 3 include academic skills, child-based social-cognitive behaviors and beliefs, and relation-based social and relationship skills.

Reflecting the Cunha and Heckman (2007) idea of "self-productivity," the combination of fundamentality and malleability is most apparent in children's early basic literacy and mathematics skills. Children's literacy is built in part on knowledge of the letters of the alphabet, just as children's mathematical knowledge is built on understanding of the number line. Both of these early skills are fundamental for subsequent learning within and across achievement domains, and both are easily taught. Ample correlational evidence supports this skill-progression view of eventual learning; early academic skills are robust statistical predictors of children's achievement much later in school, as well as of labor market outcomes (Duncan et al., 2007; Ritchie & Bates, 2013).

However, as can be seen in previously discussed ECE interventions targeting early mathematics or literacy skills, malleability and fundamentality alone do not guarantee impact persistence. Below we suggest that simple academic skills fail to meet a third condition for impact persistence – the absence of eventual development without the intervention.

Personality psychologists often make a distinction between hard-to-change *dispositional traits* (e.g., conscientiousness and other dimensions of the Big Five) and more malleable *characteristic adaptations* (McAdams and Pals, 2006). Characteristic adaptations include many motivational and socio-cognitive features of personality, such as beliefs, values, goals, plans, strategies, and developmental tasks, some of which are viewed as both fundamental and malleable (Kenthirarajah and Walton, 2015; Yeager & Walton, 2011) as well as more closely linked than dispositional traits to an intervention's targeted outcome (Littlefield, Stevens, & Sher, 2014). For example, children's understanding of their ability to learn is hypothesized to be both malleable and fundamental for academic achievement (Wilson & Linville, 1982, 1985), since students who encounter difficulties in school but attribute these difficulties to transitory factors may be more likely to persist in their efforts to succeed, compared with students who encounter difficulties in school and attribute them to their own persistent shortcomings. Such characteristic adaptations are also viewed as more context-specific than traits, and may express themselves differently in school versus family contexts, for example.

Another set of capacities in the "malleable and fundamental" quadrant involve cognitive and emotional self-regulation, which has been defined as the "processes by which the human psyche exercises control over its functions, states, and inner processes" (Baumeister and Vohs 2004; Raver 2004). Emotional regulation includes the ability to control anger, sadness, joy and other emotional reactions, and early measures of it predict such behaviors as aggression and internalizing problems (Bridges, Denham, & Ganiban, 2004; Eisenberg et al., 2005). Positive preschool intervention impacts on emotional regulation are reported in Morris et al. (2014), while positive impacts for later socioemotional interventions are summarized in Durlak et al. (2011).

Cognitive self-regulation is a key component of executive functions, which cognitive and developmental psychologists have viewed as fundamental skills for children's school readiness (Blair & Razza, 2007). The components of executive function – impulse control, working

memory and the ability to shift between tasks – are basic cognitive processes required in the performance of many everyday activities (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). Moreover, some evidence suggests that performance on tasks measuring executive functions can be altered in early childhood and later through curricula such as Tools of the Mind, which teaches children strategies for becoming deliberate, self-regulated learners who are capable of relating well to fellow students and engaging in teacher-directed activities (Diamond & Lee, 2011; but see null effects for Tools reported in Morris et al., 2014).

Targeting self-regulation skills in parents and/or children is believed to play an important role in generating positive long-term outcomes for children. However, because many of these programs contain multiple components (e.g., skills training for parents and children, after care support, school-level engagement), it is difficult to isolate the specific contribution of changes in parents' and/or children's self-regulation to intervention effects and persistence. Nonetheless, because the development of self-regulation skills among both children and parents, and especially those living in adverse contexts, is a core component of most evidence-based interventions, future research on the role of self-regulation in sustaining intervention impacts is needed.

Finally, there is a long, and relatively successful, history of targeting relation-based social and parenting skills to improve children's social, emotional and behavioral skills. For example, a recent review of 46 randomized experimental trials of preventive parenting interventions reported positive effects on wide range of outcomes from one to twenty years following the intervention (Sandler et al., 2011). Interventions that demonstrated long-run impacts from infancy and early childhood targeted parenting skills, warmth and responsiveness, often in high-risk mothers (e.g., Nurse-Home Partnership; Olds et al., 2007). Long-term impacts have also been documented reliably in multi-component family-level interventions with older children (e.g., Brotman et al., 2008). Unfortunately, despite the long-run impacts of preventive parenting interventions, there is still little evidence to explain the processes that account for these effects over time (Sandler et al, 2015).

Development in Counterfactual Conditions

Merely targeting malleable and fundamental skills is insufficient for generating persistent impacts because many of these skills are soon mastered by children in the comparison groups. For example, although knowing the sounds corresponding to the letters of the alphabet is essential for learning how to read words, it is a skill that almost all children will eventually learn, whether or not they receive special targeted intervention in early childhood (Paris, 2005). Counting is an analogous skill from early mathematics.

Early academic skills develop quickly in counterfactual conditions. For example, on nationally normed reading and mathematics tests, children learn over a full standard deviation of material between kindergarten and first grade but considerably less in later grades (Hill, Bloom, Black, & Lipsey, 2008). Thus, while these kinds of early cognitive skills may be among the most fundamental and malleable, they may also be subject to intervention effects that fade out most quickly.[8]

An example of fadeout caused by rapid growth among children in counterfactual conditions comes from Clements et al.'s (2013) evaluation of the Building Blocks pre-K math intervention. Figure 4 shows that math achievement for children in the control group grew by nearly a full standard deviation between the fall and spring assessment points during the pre-K

year, and then by about a full standard deviation in the annual intervals between spring of the pre-K year and spring of kindergarten as well as between the springs of kindergarten and first grade. Math achievement for children receiving the Building Blocks curriculum grew even faster – about .50 sd faster – than controls during the pre-K year, but not as quickly after that. The shrinking gap between the two groups after program completion reflects the fading of the program's impacts after it ended, as well as the "catch up" among those in the control condition.

[Figure 4]

Similarly, most measures of children's executive function improve very quickly in early and middle childhood, reaching adult levels in adolescence (Rothbart, Posner, & Kieras, 2006). Figure 5 plots raw scores from two common measures of executive function: the Flanker Inhibitory Control and Attention Test of impulse control and the Dimensional Change Card Sort test of cognitive flexibility.[9] Scores on the Flanker test grow very rapidly – by one-and-a-half standard deviations per year during the preschool period – as do scores on the Card Sort test (about a standard deviation per year). This type of rapid growth in the absence of an intervention sets a high threshold for early interventions seeking to generate permanent boosts in executive function. Diamond and Lee's (2011) evaluation of the Tools of the Mind curriculum improved Flanker-type scores by .3-.4 standard deviations at the end of treatment (no longer-run follow-ups were conducted). While this effect may seem substantial, it amounts to less than half of the annual growth occurring for most four-year-olds even in the absence of interventions.

[Figure 5]

While educators may have an intuitive understanding of this problem, they sometimes point out that during the time when the children in the counterfactual condition are mastering a constrained or closed skill, the children in the treatment group will be able to learn additional skills that keep them ahead of the control-group children. We will address this possibility in Section V, in our discussion of "foot-in-the door" effects.

Trifecta Skills, Behaviors and Beliefs

So which skills meet all three criteria – malleable, fundamental and unlikely to develop in the absence of the intervention? Our list, which should be viewed as tentative given the limited evidence that is currently available, includes advanced academic and concrete vocational skills as well as achievement-related beliefs and behaviors (Table 1). Owing to difficulties in meeting all three of our criteria, this list is not nearly as long as might be hoped and, in the top panel, includes almost nothing of relevance to early childhood education.

[Table 1]

Although swift development in counterfactual conditions means that lower-level academic skills such as counting or letter recognition do not make the cut, more advanced levels of literacy and numeracy might. Using data collected by the OECD, Hanushek, Schwerdt, Wiederhold, and Woessmann (2015) show that these skills are powerful correlates of labor market success, even after adjusting for worker differences in completed schooling, measurement error and the possibility of reciprocal causation between worker skills and the nature of their jobs.

More focused studies have shown that although American children generally acquire rudimentary early mathematics and reading skills, many of them never master fractions and algebra, both of which are used in advanced classes in secondary school and higher education

(NMAP, 2008; Siegler, Fazio, Bailey, & Zhou, 2013). Moreover, these skills are malleable: intensive interventions have successfully improved children's fraction knowledge (Fuchs et al., 2013a, 2013b), and additional algebra instruction for children who are at risk for failure in this subject increases children's subsequent math achievement as well as their likelihood of graduating from high school (Cortes & Goodman, 2014; see Section V for elaboration). Still, questions remain about the degree to which the factors targeted by these math interventions are fundamental, in and of themselves, for most children's later academic and labor market success (Bailey, Watts, Littlefield, & Geary, 2014).

As for vocational skills, the community college literature shows payoffs to completing the career-oriented courses such institutions offer, even if this does not lead to a vocational certificate (Belfield and Bailey, 2011). Moreover, rigorous evaluations of some models of vocationally oriented secondary education programs show long-term impacts on earnings; perhaps the most successful is Career Academies, which boosted earnings, post-secondary education and, for men, marriage rates (Kemple and Wilner, 2008).

We see considerable merit in arguments for the importance – and malleability – of children's academic motivation and implicit theories about intelligence and self-concept (Yeager & Walton, 2011). In the case of motivation, the expectancy-value theory of academic motivation holds that children's cognitive representations of their own academic abilities shape their expectations for success, course choice and, ultimately, the careers they pursue (Wigfield & Eccles, 2000). But positive self-appraisals are not enough; children also need to attach intrinsic or instrumental value to their academic pursuits. Interventions targeting some combination of expectations and values are potentially promising ways to boost motivation and promote academic performance.

Gaspard et al. (2015) asked students to list arguments for the personal relevance of mathematics to their current and future lives and to write an essay explaining these arguments. Six months after the interventions, students who were randomly assigned this task had higher levels of mathematics motivation (more specifically, they valued mathematics more highly). A similar science-oriented intervention showed positive impacts on high school students' science grades (Hulleman & Harackiewicz, 2009). Although we lack longer-run evidence on attainment impacts, if motivation can be affected by low-cost writing-based interventions, perhaps such interventions might be used persistently to boost children's academic motivation throughout their school years.

Implicit theories about intelligence and self-concept concentrate on the importance – and malleability – of a person's core beliefs and/or construal of the social world (Yeager & Walton, 2011). Students in a New York City public school learned study skills, and a random subset of them also learned about research showing that the brain grows connections and "gets smarter" when a person works on challenging tasks (Blackwell, Trzesniewski, and Dweck, 2007). Students learning only the study skills continued the downward decline in math grades commonly found in middle school, while students learning the incremental theory earned better math grades over the course of the year.

Cohen, Garcia, Purdie-Vaughns, Apfel, and Brzustoski (2009) found a substantial effect on low-performing African American students' grade point averages two years after an intervention in which the students (as 7th graders) wrote a series of essays in which they affirmed values important to them. The selective effectiveness of the intervention was attributed to the

fact that the affected students faced environments that generated stereotype threat (Sherman & Cohen, 2006; Steele, 1988). However, it is notable that some attempts to replicate this intervention have shown no consistent impacts (e.g., Dee, 2015).

Trifecta Skills in Very Adverse Counterfactual Conditions

We began by noting that, to maximize the generalizability of our analysis, we would confine most of our discussion to children living in the normative range of environmental conditions found in the modern U.S. Relaxing that constraint broadens the potential set of trifecta skills. For example, significant numbers of children have experienced extreme forms of trauma and neglect before they reach adulthood (Dube, Felitti, Dong, Giles, & Anda, 2003). High risk of exposure to these forms of adversity, or "toxic stressors," is likely to influence the types of interventions that meet the "trifecta" criteria for interventions within our framework.

Shonkoff et al. (2012) describe toxic stress as "strong, frequent, or prolonged activation of the body's stress response systems in the absence of the buffering protection of a supportive, adult relationship" (p. e236). Exposure to toxic stress is thought to occur among children in abusive or neglectful early environments and is related to a host of adverse changes in the brain that can affect cognitive functioning and mental health. In the context of our framework, abusive or neglectful environments establish counterfactual conditions that do not lead children to develop normative functioning. Effective interventions targeting these children and/or their environments have the potential to restore normative functioning or buffer the negative effects of the environment, which certainly constitutes building fundamental capacities.

A substantial body of literature suggests that the malleability of some fundamental cognitive skills varies as a function of the environments to which children are exposed. Specifically, environmental conditions explain more of the cognitive differences among children of lower socioeconomic status than among children of higher socioeconomic status (e.g., Tucker-Drob, Rhemtulla, Harden, Turkheimer, & Fask, 2011; Turkheimer, Harden, D'Onofrio, & Gottesman, 2009; Turkheimer, Haley, Waldron, D'Onofrio, & Gottesman, 2003), perhaps indicating a larger role for adverse environmental conditions for influencing the cognitive skill levels of poor children.[10] Nisbett et al. (2012) argue that one interpretation of these findings is that poor children do not get the chance to develop their full genetic potential, and thus there may be substantial room for interventions with this group targeting IQ.

These findings are also consistent with the pattern of difficult counterfactual conditions experienced by children in the limited set of experimental studies that have shown long-term effects on children's intelligence. One reason why participants in the Abecedarian Project may have enjoyed long-term increases in IQ is that Abecedarian combined a treatment that lasted 5 years with year-round full-day preschool and focused on children growing up in very low-SES families. Similarly sized long-term treatment effects on intelligence have been reported in randomized controlled trials in Jamaica and Guatemala, where children received nutritional supplementation (or nutritional supplementation and psychosocial stimulation in the Jamaican study; Maluccio et al., 2009; Walker, Chang, Powell, & Grantham-McGregor, 2005).

A recent example of an intervention that targeted a potential trifecta skill in the context of very dangerous neighborhoods is the Chicago Crime Lab's *Becoming a Man* (BAM) curriculum. Throughout the school year, youth living in high-poverty neighborhoods on Chicago's South Side were given the chance to participate in up to 27 one-hour group sessions held during the school day. A key focus is on the tendency of some teens to respond automatically to negative

events by making hasty decisions, which in their dangerous neighborhoods often results in violence. In the BAM group sessions, participants learn that emotional reactions to events are influenced by automatic thoughts, and they are taught relaxation techniques to help avoid overly automatic reactions ("out of control" behavior). Based on RCT evidence, Heller, Pollack, Ander, and Ludwig (2013) find that the intervention reduced rates of violence involvement by 44% and increased schooling engagement. These types of Cognitive Behavioral Therapies (CBTs) have been shown to effectively reduce anger and aggression among children and adolescents (see Sukhodolsky et al, 2004 for a meta-analysis).

It remains to be seen exactly how the extension of CBT strategies into BAM-type interventions will work in reducing long-term involvement in violence and crime, and whether this type of intervention would be as effective for youth living in much less violent neighborhoods. We hypothesize that their targeting of adolescents in dangerous neighborhoods is key to BAM's success, since emotional regulation skills are likely to be most fundamental and possibly more malleable within these contexts.

The moderation of malleability by counterfactual conditions has important implications for predicting which early intervention studies will show persistent effects on fundamental skills. Interventions that target children who face the most significant external environmental obstacles to fulfilling their potential are likely to have the most persistent effects. However, more work is needed to isolate the specific mechanisms underlying the malleability of these skills. As counterfactual conditions improve for all children in the U.S. (Duncan and Magnuson, 2013), interventions targeting malleable skills may show diminishing returns. Still, our findings suggest that research on early identification of children in the U.S. with the greatest environmental obstacles to developing fundamental skills, as well as early intensive interventions in developing countries with poor counterfactual conditions, may be the most promising ways to produce persistent effects on fundamental skills that would not develop in the absence of interventions.

Notable Omissions From the Trifecta List

The three criteria that constitute trifecta skills – fundamentality, malleability and lack of development under normal counterfactual conditions – leave us with a surprisingly short list of skills in this category (Table 1). One reason lies in some of the tradeoffs inherent in trifecta conditions. Skills that are clearly fundamental and malleable (e.g., basic language and literacy) are likely either to develop based on natural experiences under most counterfactual conditions or to be specifically targeted in universally available early formal or informal learning environments. Executive function and rudimentary mathematics skills, both of which develop rapidly in early childhood, do not make our trifecta list for similar reasons.

Another limiting tradeoff for trifecta skills is that some clearly fundamental skills that do not develop under most counterfactual conditions are not likely to be malleable by scalable interventions. This is why we do not include general intelligence or conscientiousness as trifecta skills. And while we do not dispute the malleability of performance on specific EF tasks, evidence from twin studies of children and adults suggests that individual differences in higher-level factors influencing performance across EF components may be almost entirely genetically influenced (Engelhardt, Briley, Mann, Harden, & Tucker-Drob, 2015; Friedman et al., 2008). This does not mean we will never find a way to change these factors, particularly for children living in particularly adverse counterfactual conditions or through interventions that begin very early in life, but it should give intervention designers pause.

Although our list of trifecta skills is brief, it and the skill-building model that supports it represent only one possible avenue for sustaining intervention impacts. Below, we describe two alternative pathways to achieving sustained impacts on important life outcomes.

IV. SUSTAINING ENVIRONMENTS

What we are calling the "sustaining environments" perspective recognizes the importance of building skills and capacities early in life, but views subsequent environments as crucial for the persistence of these early skill advantages wrought by prior interventions. Ramey and Ramey (2006) draw from their experience with the Abecedarian Project as well as a broader review of the early intervention literature to develop five principles of effective early interventions for at-risk children. Most relevant for impact persistence is their principle that sustaining intervention effects requires ongoing post-program educational supports to "maintain children's positive attitudes and behavior and to encourage continued learning relevant to the children's lives" (p. 455). They point out that if birth-to-age-five programs are to be deemed successful over the long term, treatment but not control-group children must exhibit rates of development after they enter school that parallel those of more advantaged children. In short, early intervention impacts can be sustained only if they are followed by environments of sufficient quality to sustain normative growth.

Enriched post-intervention environments can be consciously planned and implemented, for example by providing high-quality elementary school instruction that complements what has been taught before, or they may arise spontaneously. As detailed below, this may occur when interventions are conducted at sufficient scale to generate positive peer processes that sustain treatment impacts.

Generating enriched subsequent environments can also be a conscious goal of the design of an early intervention. For example, prevention research often targets child-parent dyads in hopes of ensuring that the higher-quality parent-child relationships will persist long after the interventions end (Webster-Stratton and Taylor, 2001). In this case, the program's joint child-parent skill building is intended to generate immediate improvements in the quality of parent-child interactions, but also to provide exposure to better environments across the course of the child's development as parents work to monitor the behaviors of their children more closely and play a role in shaping the children's exposure to more positive home, school and neighborhood environments.[11]

Most of these ideas differ from the human capital skill-building model, which posits that the right kinds of skills and capacities equip children to take better advantage of any environmental opportunity for further skill development. The sustaining environments perspective views early investments as unproductive *unless* they are accompanied by subsequent investments in sufficiently high-quality schools and other environmental contexts in which development takes place. Proponents of this perspective would not find it surprising that Abecedarian children, who entered desegregated and relatively high-quality Chapel Hill public schools in the 1970s, showed persistently higher IQs than control-group children, while Perry's children, who entered low-quality and overwhelmingly African-American public schools in Ypsilanti, Michigan did not.[12]

Sustaining Environments Following Early Childhood Education Programs

Some proponents of early childhood interventions for children from low-income households argue that such programs can launch children on more positive "trajectories." A pre-K program might succeed in boosting targeted outcomes at the end of pre-K, but what subsequent processes are needed to sustain or even amplify those initial impacts? As illustrated in Figure 4, the issue is designing subsequent environments that preserve the math gains seen at the end of the pre-K year.[13]

One possible but unlikely process is akin to inoculation, with the pre-K program providing some sort of permanent increase in a key skill or capacity that provides a lifetime of benefits. In the case of vaccines, the antibodies generated in response to the vaccine provide continuous protection against infection for years to come. But it is hard to imagine counterparts for the vaccination analogy among the kinds of skills and capacities that we have been discussing. Indeed, it seems unlikely that the often mediocre classrooms and other environments surrounding low-income preschoolers as they move through middle childhood and adolescence will make it possible for gains in the rudimentary skills fostered in pre-K to be translated into sustained gains in more sophisticated skills without some kind of extraordinary environmental enrichment.

Indirect evidence supporting the sustaining environments hypothesis for the Head Start program comes from Currie and Thomas (2000), who find that black Head Start children go on to attend schools of lower quality than other black children, which may have prevented longer-run impacts. More direct but unsupportive evidence on the sustaining environments hypothesis comes from data from the National Head Start Evaluation Study. Jenkins et al. (2015) find no treatment effect interactions for a host of measures of kindergarten and 1st-grade classroom quality. In the case of data from the Building Blocks preschool mathematics intervention, they also fail to find treatment interactions between assignment to Building Blocks and a host of measures of the quality of kindergarten and 1st-grade math instruction. All of this evidence suffers from the methodological problem that the post-treatment environments were not randomly assigned.

A stronger design for understanding the effects of sustaining environments on impact persistence is to build sustaining environments into a third treatment condition. Building Blocks randomly assigned kindergarten and 1st-grade teachers in schools that housed the pre-K Building Blocks intervention to receive additional professional development (PD) designed to help bridge the gaps between preschool, kindergarten and first grade. These additional PD sessions brought teachers from all three grades together to discuss what students learn in each grade and to minimize the amount of repeated content. Although this intervention generated somewhat higher math achievement at the end of 1st grade ($p<.10$), it is not clear that the follow-up moderated the treatment persistence effect, since the design did not assign the K-1 intervention to children who did not participate in Building Blocks during their pre-K year.

Other attempts to build treatment arms involving sustaining environments have not been successful. Half of Abecedarian's treatment group was randomly assigned at school entry to a 3-year home and school resource program that provided individualized schoolwork assistance to children and help for parents in making home-school connections, plus a learning-oriented camp in each of the three summers. No IQ impacts were observed for the follow-on supplement to Abecedarian's birth to age-5 intervention, and modest impacts on math achievement at age 8 quickly disappeared. Reading achievement impacts may have been more persistent, but the study

was underpowered to detect them.

There are too few experimental studies assessing the impacts of providing subsequent enriching environments to graduates of human capital intervention to warrant firm conclusions. The limited evidence that does exist suggests that (as with the Building Blocks teacher follow-through) it may be important for supplemental enrichment to be geared closely to the activities and goals of the original intervention.

When the Intervention Scale is Large Enough to Generate Peer Processes that Sustain Treatment Impacts

A high concentration of higher-achieving and/or better-behaved peers may comprise a "sustaining" environment that increases the persistence of impacts from human-capital interventions. An interesting special case is when the intervention itself is conducted at sufficient scale to generate a beneficial set of peer processes that can act to sustain program impacts for "treated" children and may spill over to benefit "untreated" children as well.

In medicine, some vaccinations reduce but do not eliminate a risk of infection. In this case, the vaccination is the treatment and, everything else the same, vaccinated children enjoy a lower, but not zero, chance of infection. Mass vaccination lowers the degree of exposure and thus infection risk for untreated children (so-called "herd immunity"; Fox, Elveback, Scott, Gatewood, & Ackerman, 1971). But mass vaccination may also generate a sustaining environment that lowers the lingering risk of infection for vaccinated children.

In the context of early childhood education interventions, the larger the scale at which ECE is offered, the larger the fraction of higher-achieving and better-behaved classmates in K-12 classrooms. This in turn could generate more positive peer effects and allow teachers to push their students through more advanced material, thereby increasing the likelihood of sustaining ECE gains. Some intriguing evidence suggesting that this might be the case comes from a series of papers on elementary school outcomes associated with expenditures on two North Carolina early childhood programs – Smart Start and More at Four (Ladd, Muschkin, & Dodge, 2014; Muschkin, Ladd, & Dodge, 2015; Dodge, Bai, Ladd, & Muschkin, 2015). Both programs rolled out across North Carolina's counties in the 1990s and early 2000s and produced large variation in county expenditures across time. Dodge et al. (2015) found that spending on both programs boosted test scores and reduced grade retention and special education placements. Most important for our focus on impact persistence, Dodge et al. (2015) found that test score impacts appearing in 3rd grade were sustained through at least 5th grade.

Given the nature of the North Carolina data, it is impossible to distinguish among the direct impact of participating in these preschool programs, the boost to this direct impact from being surrounded by higher achieving and better behaved elementary school peers, and the benefits accruing to "untreated" children. However, taken together, these results suggest that some kinds of peer processes are at work, which argues against the current practice of concentrating almost exclusively on small-scale evaluation studies.

V. FOOT-IN-THE-DOOR INTERVENTIONS

Developmental timing is crucial for the foot-in-the-door perspective, which holds that building capacities or beliefs at the right time will reduce risk long enough to sustain individuals through periods of high vulnerability (Dodge, Greenberg, Malone, & CPPRG, 2008). Early adolescence is viewed as a particularly productive time for foot-in-the-door interventions, owing

to the rapid biological, social and emotional changes that are occurring in a young person's life, coupled with new opportunities for educational, vocational and social skill development.

Pregnancy prevention is a classic foot-in-the-door intervention example, since it seeks to delay the onset of sexual activity and pregnancy beyond the teen years rather than eliminating these outcomes altogether. Delaying early initiation into substance use is another example, as there is evidence that a delay beyond early adolescence can reduce the long-term risk of substance use and dependence (Spoth et al., 2011; Chen et al., 2004).[14] Appropriately timed interventions might equip a child with the right skills or capacities at the right time to seize emerging opportunities (e.g., entry into honors classes). Foot-in-the-door processes are key to the intervention approaches taken in prevention science (Coie et al., 1993).

Foot-in-the-door interventionists thus leverage sensitive periods of development to alter children's trajectories. These periods are viewed as windows of opportunity and/or vulnerability, often marked by intense change in individuals and their contexts, as well as in the interactions between individuals and their contexts (Dahl & Spear, 2004; Masten et al., 2004). Our discussion of early brain development under conditions of toxic stress provides one example in which a period of rapid growth and development may present a window of risk for the child or an opportunity for interventions to have a large, lasting and positive impact on development.

The foot-in-the door perspective differs fundamentally from the other two. Unlike the skill-based perspective of Cunha and Heckman (2007), which views the intervention task as one of identifying and improving key skills (e.g., grit, executive function, gratification delay) that will persist and generate lifelong benefits, foot-in-the-door views the intervention task as one of producing a potentially transitory augmentation of skills or beliefs that will sustain a child or adolescent through a period of risky environments or transitory opportunities to provide a solid foundation for entering the next developmental stage (e.g., adulthood). And in contrast to Ramey and Ramey's (2006) emphasis on environments that sustain the positive skills or attitudes developed by the intervention, the foot-in-the-door perspective would seek potentially transitory augmentations of skills, behaviors or beliefs that provide individuals with transitory advantages that insulate them from dangerous environments or steer them toward positive ones. In the prevention science perspective, the most active intervention ingredients involve the often transitory match between skills and environments. In these cases, persistence in treatment effects results not from sustaining the skill targeted by the intervention, but from the cascade of positive intervention effects that follow the intervention period.

Foot-in-the-Door Processes Involving Early Childhood Education Programs

Although early education programs such as Perry and Abecedarian are typically conceived as building a broad and durable set of early skills, it is difficult to distinguish between the mediating roles of subsequent skill-based versus foot-in-the-door processes. The first column of Table 2 shows impacts on special education placement and grade retention based on calculations from the meta-analytic database described earlier. Average effect sizes, as measured by Hedges' *g*, are in the .30-.40 range, more than enough to lead to subsequent advantages associated with staying on track in mainstream instruction.

[Table 2]

If being held back in school or placed in special education leads to negative cascades for some children, perhaps some of the long-term positive outcomes associated with Abecedarian

stem from foot-in-the-door processes, rather than being the direct result of skill-based factors such as higher IQ. In the Abecedarian Project, nearly half of the children in the control group were placed in special education; this was true of only 30% of the children who received the Abecedarian preschool treatment – a difference that translated into an effect size (-.45 sd) that was only slightly more negative than that of the meta-analytic average. The effect size on special education in the Perry Preschool Project was smaller (-.31 sd) and statistically insignificant, but not far from the meta-analytic average.

In the case of grade retention, Abecedarian treatment and control rates were 34% and 58%, which generated an effect size (-.54 sd) that was almost twice as large as the meta-analytic average (-.29 sd). Perry's impact on grade retention was statistically insignificant (-.17 sd), but not much lower than the meta-analytic average. Thus, Abecedarian's, but perhaps not Perry's, long-run impacts may have been sustained in part because of foot-in-the-door advantages in school structures and processes.

Foot-in-the-Door Advantages from Algebra Mastery?

Although algebra mastery may constitute a fundamental skill for the successful performance of some adult jobs, timely mastery of algebra in the early high school years may also provide crucial "foot-in-the-door" advantages for keeping a student on track for a chance at a four-year college education. Most colleges require successful completion of three years of math courses in high school, and the more competitive colleges require four. Algebra and geometry skills are also important for college entrance exams. Efforts to provide "just in time" boosts to algebra skills may yield the right skills at the right time for future success, even if the math skills themselves no longer matter.

Evidence suggesting that appropriately timed and targeted algebra instruction may convey foot-in-the door advantages comes from the Chicago Public Schools' implementation of a policy that assigned children who performed below a certain level on an 8th-grade mathematics exam to take a "double dose" of algebra classes in 9th grade. Using a regression discontinuity design, Cortes and Goodman (2014) estimated that children just below the cutoff who received the extra algebra instruction earned higher grades in 9th grade algebra, outperformed controls on a grade-11 mathematics exam, were 12 percentage points more likely to graduate from high school within 5 years, and were 11 percentage points more likely to enroll in college than children just above the cutoff.

It is difficult to evaluate the extent to which foot-in-the-door processes are responsible for Double Dose's persistent intervention effects. Did the program affect children's high school graduation rates because children who received the treatment learned a malleable and potentially fundamental skill (algebra), or because a higher likelihood of success in a key class at the beginning of high school set off a positive cascade, leading to more school engagement and, eventually, a higher likelihood of graduation?[15] Of course, these are not mutually exclusive hypotheses. However, the treatment effect of the double-dose algebra intervention was larger on students' 11th grade ACT verbal scores than on their 11th grade ACT math scores, suggesting that algebra knowledge alone was not responsible for the positive effects of the intervention (Cortes & Goodman, 2014).

Light-Touch Interventions Relying on Foot-in-the-Door Processes

Foot-in-the-door effects have several attractive qualities, including their often low implementation cost. For example, an intervention that sent college freshmen information via text messages on how and when to re-file FAFSA applications boosted community college students' continued enrollment into the spring of their sophomore years by 14 percentage points relative to control-group students who did not receive such messages (Castleman & Page, 2014; similar results have been reported by Bettinger, Long, Oreopoulos, & Sanbonmatsu, 2012, and Owen, 2012). The cost of the intervention averaged about $5 per student served. Information about when and how to fill out FAFSA applications is clearly a peripheral rather than fundamental skill, since it is not useful in other contexts. However, assisting students with their FAFSA applications generated persistent effects on college attendance because it opened the door to college enrollment.

Foot-in-the-door effects might justify efforts to teach children achievement skills that they would probably acquire soon in any event, provided that those gains trigger positive developmental cascades that propel children ahead of their peers in the years that follow. Thus, while teaching children how to count a few months early will not produce a permanent advantage in counting skills, it might allow children to learn simple addition strategies before their peers, which in turn could provide the opportunity for early learning of complex addition strategies and other higher-level math skills. However, as shown in Figure 4, evidence from the Building Blocks experiment does not support the idea that foot-in-the-door processes sustained its pre-K math impacts.

It is important to note that some foot-in-the-door treatment effect gains produced by peripheral skills or fleeting gains in more fundamental skills might reflect only positional (rather than absolute) gains for the treatment group. An example would be entry into a limited number of slots in a gifted or talented program. When interventions enable treated children to benefit from these slots, this means that other children are crowded out of their slots. In these cases, the collective effects of an intervention conducted at scale would add up to less than the sum of its individual effects (Penner, Domina, Penner, & Conley, 2015).

Relying on foot-in-the-door positive cascades is not without risks. Learning a skill makes a child only probabilistically more likely to learn subsequent, more complex, skills in the sequence. And peripheral skills leading to placement in an initially more positive environment do not guarantee that environmental advantages will persist over time. As the probabilities multiply, the estimated effects of an early intervention on later positive outcomes decrease geometrically. This is particularly likely in the case of early interventions. Nonetheless, foot-in-the-door processes may sustain treatment effects if multiple processes are triggered by the intervention. Alternatively, if the probability is close to 100% that the child will learn more advanced skills or enjoy more positive environments if he or she has learned a precursor skill or been placed in a positive environment, foot-in-the-door processes may fully sustain initial impacts.

VI. SOME IMPLICATIONS FOR INTERVENTIONS AND RESEARCH

Bearing in mind limitations arising from the dearth of evidence on longer-run impacts of promising interventions, we outline some of the most promising intervention approaches, given the three routes to impact persistence that we have described above. An obvious one is to ensure that human-capital interventions successfully target what we refer to as "trifecta" skills, behaviors and beliefs – which can be changed, are fundamental for later success, and would not have developed in the absence of the intervention.

The last of these conditions is the trickiest, particularly in the case of interventions conducted prior to school entry; indeed, failure to focus on skills that would not otherwise have developed may account for the fadeout patterns observed in preschool literacy, math and executive function interventions. A key question for ECE intervention design is this: What preschool literacy, numeracy, executive function, or emotional self-regulation skills do not develop reasonably well over the course of kindergarten and first grade for most children, independent of any intervention?

From a skill-building perspective, the list of early trifecta skills and behaviors may be small indeed, which suggests that later interventions successfully targeting higher-level but far from universally acquired skills may be more promising than early interventions. Examples include an understanding of fractions or algebra, vocabulary or background knowledge that substantially exceeds typical levels, or self-regulation skills among the subset of children who may otherwise never master them. The strategy of focusing on such skills, behaviors or beliefs for disadvantaged children and adolescents is implicit in interventions such as Fast Track, Becoming a Man, double-dose algebra and intensive tutoring programs aimed at struggling readers. It is also behind interventions that target children's implicit theories of learning and self-concepts. While some of these interventions appear promising, all are in need of much more development, testing (including replication of previous work) and longer-run follow-up.

Disentangling skill-building vs. foot-in-the-door processes requires measuring both in intervention follow-ups. Skill and capacity measurement is commonly done in skill-based intervention follow-ups, although not always for as broad a set of skills and capacities as one might like. Foot-in-the-door measurement of processes such as grade failure or school suspensions is most common in prevention science but needs to be a routine part of follow-ups to all interventions that might operate through foot-in-the-door processes.

A second promising intervention strategy might rely on beneficial peer, classroom and other sustaining environmental effects generated by interventions conducted at scale. It is worrisome that we may be underestimating longer-run impacts from scaled-up ECE intervention because their evaluations are based on small numbers of children scattered across dozens of elementary schools, who are never present in sufficient numbers in any given post-intervention classroom to enable teachers to use more advanced curricula or to generate other kinds of peer benefits to the children themselves and their remaining "untreated" classmates. Understanding peer and classroom dynamics generated by large-scale interventions is clearly an important objective for future research. On the policy side, subsequent peer and classroom dynamics might justify universal preschool interventions targeting non-trifecta academic and socioemotional skills because they would support higher-level instructional content in subsequent grades.

A third intervention approach is to target important but difficult-to-change skills or behaviors with very intensive interventions for subgroups of children most in need of help and least likely to develop those skills in the absence of the intervention. Abecedarian appears to have successfully boosted the IQ levels of children with low initial IQ scores who are living in families with multiple disadvantages. But pulling it off took five years' worth of year-round full-day center-based services, a highly structured and individualized curriculum focusing specifically on language and literacy, and ongoing monitoring of implementation by university researchers. To our knowledge, however, few interventions within the commonly observed range of intervention intensity that have targeted conscientiousness or its key components (e.g., grit) among children or adolescents have been successfully implemented, although there is some

evidence of intervention-driven change among adults. That said, there are some promising strategies for targeting conscientiousness and associated personality traits within intervention contexts (Magidson et al, 2012).

We began by documenting that, on balance, cognitive impacts of early childhood education programs drop quickly after the end of the programs (Figure 2) and suggesting that, more generally, fadeout is a common feature of many early interventions. It is surprising, then, that growing evidence points to beneficial impacts in adulthood of an assortment of interventions ranging from model ECE (Schweinhart et al., 2005; Campbell et al., 2014) and behavior management programs (Dodge et al., 2015) to Head Start (Deming, 2009), a good kindergarten or middle-school teacher (Chetty et al., 2013; Chetty et al., 2010) and the MTO residential mobility program (Chetty, Hendren, & Katz, 2015). How might these long-run impacts have emerged, despite the fadeout of intervention effects on targeted skills?

The answer to this question is unclear, and probably varies across studies. Even model ECE studies show heterogeneous effects. Some studies, such as the Perry Preschool Project and Chetty's analyses of classroom quality impacts in the Project STAR study, show persistent effects on children's noncognitive skills (Chetty et al., 2010; Heckman, Pinto, & Savelyev, 2012). Noncognitive data are much less detailed in Abecedarian than Perry, but impacts on the study's teacher-reported index of child hostility in the early grades were perversely positive (Haskins, 1985). No Abecedarian impacts were found for an assortment of child self-ratings in early adolescence.

Unlike Perry, Abecedarian showed persistent effects on intelligence test scores (Figure 1), but both Perry and Abecedarian had a persistent impact on children's academic achievement (Campbell et al., 2001; Schweinhart et al., 1993). On the other hand, classroom quality impacts on children's achievement faded out completely in Chetty and colleagues' (2010) analysis of Project STAR. Finally, Abecedarian generated substantial effects on grade retention and special education placement; Perry's impacts were smaller, but statistically indistinguishable from our estimated meta-analytic average for ECE studies (Table 2).

In all of these cases, it is difficult to rule out either the set of all trifecta skills or the set of all foot-in-the-door pathways that occur independent of persistence effects on skills. Distinguishing among these explanations can be challenging, particularly in the absence of measures of all of the possible skill and structural pathways. Further, it is difficult to imagine that the same set of channels governed the process by which these various interventions generated their adult impacts. Solving these puzzles is the single most important task for future intervention research.

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Table 1: Possible "trifecta" skills

Possible trifecta skills, beliefs or capacities by domain

Academic skills

- Advanced mathematics (e.g., fractions, algebra) and analytic skills
- Advanced literacy and communication skills
- Concrete vocational skills

Beliefs, behaviors and capacities

- Implicit theories of intelligence
- Academic motivation
- Self-concept for adolescents facing stereotype threat

Additional trifecta skills for children in very adverse environments

- Normative cognitive, stress and immune function for children in fetal or early life conditions characterized by "toxic stress"
- General intelligence for young children in very unstimulating, nutritionally poor or toxin-laden early environments
- Emotional self-regulation for adolescents in violent neighborhoods
- Parenting and communication skills for parents experiencing multiple stressors

Table 2: Impacts of early childhood education programs on two cascade channels – special education and grade retention

	Meta-analysis			Abecedarian			Perry		
	Impact	Odds Ratio	Notes	Impact	Odds Ratio	Notes	Impact	Odds Ratio	Notes
Special Education	-0.397** (0.149)	0.609	Averaged over 7 studies and 15 effect sizes; 31.4% for control group, 21.8% for treatment group	-0.451** (0.226)	0.406 (0.412)	Ever received any special education services between grades K-9; 49% for control group, 30% for treatment group	-0.308 (0.202)	0.587 (0.368)	Ever received any special education services between grades K-12; 50% for control group, 37% for treatment group
Retained in Grade	-0.288** (0.074)	0.625	Averaged over 16 studies and 34 effect sizes; 34.9% for control group, 25.1% for treatment group	-0.540** (0.223)	0.373 (0.408)	Ever been retained between grades K-9; 58% for control group, 34% for treatment group	-0.169 (0.261)	0.706 (0.481)	Ever been retained between grades K-12; 20% for control group, 15% for treatment group

Notes: **p<.05, *p<.10 in two-tailed tests
Meta-analysis and Abecedarian impacts are calculated by the authors using Hedge's g. Perry impacts are calculated using Hedge's g from Table 2 in Barnett, W. S. (1995). Meta-analysis impacts come from McCoy et al. (2015).

ENDNOTES

[1] With apologies to psychologists, we follow the practice in other social and behavioral sciences in sometimes calling the collection of behaviors, beliefs and capacities "noncognitive," realizing that all involve cognitive processes. We do not concentrate on adult health outcomes since the physiological processes linking experiences in childhood, particularly early childhood, to adult health are only just beginning to be understood (Center on the Developing Child, 2010).

[2] This decision was a practical one, and was not made because we think the generalizability of these findings is unimportant. We acknowledge that malleability, fundamentality, and development in counterfactual conditions may vary substantially across contexts, and that this variation has important implications for our understanding of human development and for practice.

[3] The meta-analytic database is the product of the National Forum on Early Childhood Policy and Programs (http://developingchild.harvard.edu/initiatives/forum/) based on a comprehensive search of the literature from 1960 to 2007, when the coding project began. Studies had to have a treatment and control/comparison group, rather than simply assessing the growth of one group of children over time. Early childhood education programs were defined as structured, center-based early childhood education classes, day care with some educational component, or center-based child care. These include full pre-school programs such as Head Start and other interventions conducted by researchers. Programs included were required to have provided services to children, their families, or staff at the program sites, and assessed program impacts on children's cognitive and achievement outcomes. About one-third of the ECE studies used random assignment with the remainder following quasi-experimental designs such as change models, individual or family fixed effects models, regression discontinuity, difference in difference, propensity score matching, interrupted time series, instrumental variables and some other types of matching. Studies that used quasi-experimental designs must have had pre- and post-test information on the outcome or established baseline equivalence of groups on demographic characteristics determined by a joint test.

[4] In the meta-analytic data base used in Figure 2, only about one-third of the studies followed subjects beyond the end of treatment. In a meta-analysis of adolescent alcohol using RCT designs, only 3 of 18 studies reported on long-term effects (>48 months; Smit et al (2008). In the case of prevention of depressive symptoms, only 12 of 30 studies collected data past 6 months depression (Horowitz & Garber, 2006).

[5] We ignore the lower-right quadrant containing skills that are neither fundamental nor malleable. Examples might include height and natural eye color, both of which are under strong genetic control and virtually impossible to change across the normal range of environments encountered by U.S. children. Lacking both malleability and fundamentality, they are the least promising kinds of characteristics to target with interventions.

[6] Conscientiousness is highly correlated with the lower-level construct, "grit", which has been found in some studies (bot not others) to predict achievement outcomes above and beyond conscientiousness (Duckworth, Peterson, Matthews, & Kelly, 2007; Duckworth & Quinn, 2009; Ivcevic & Brackett, 2014). Other "Big Five" personality traits are Openness to experience, Extraversion, Agreeableness and Neuroticism.

[7] Heckman, Pinto, and Savelyev (2012) show that Perry is a possible exception; see also Krasner et al. (2009) for recent evidence of intervention-driven change in conscientiousness among adults. Heckman and Kautz (2013) argue that behavioral outcomes, such as substance abuse and crime, are better operationalizations of "character" than self-reported measures. Although we agree with their concerns about measuring changes in conscientiousness using self-reported measures, using positive behavioral outcomes as effects of personality changes evidenced by these very outcomes is worrisome, especially given the possible changes in other skills and environments that might plausibly affect such outcomes (Benda, 2005).

[8] The distinction between skills that do and do not develop quickly in most counterfactual conditions is akin to Paris's (2005) distinction between "constrained" and "unconstrained" reading skills and Ackerman's (2007) distinction between "closed" and "open" tasks. Constrained and closed skills require only a limited amount of knowledge and are simple enough for virtually all individuals who practice them to master. Intervention-induced impacts on these kinds of skills fade out because children would have acquired them in any case. Accordingly, the strong predictive power of early academic skills, many of which fall into the "closed" category, for later academic achievement likely reflects individual differences in more fundamental skills or environments that influence learning across time, rather than a causal impact on later achievement of the rudimentary literacy or numeracy skills themselves. In contrast, mastery of open tasks, such as general mathematics achievement or vocabulary is always incomplete, so that even extensive practice still leaves room for improvement. More complex closed tasks, such as fraction arithmetic or knowledge of basic scientific principles may also never reach expert levels without intervention for many children.

[9] As explained in its NIH Toolbox documentation, the Flanker test requires the participant to focus on a given mid-screen stimulus while inhibiting attention to stimuli flanking it. Sometimes the middle stimulus points in the same direction as the "flankers" and sometimes in the opposite direction (NIH, 2015). The Card Sort tests cognitive flexibility by presenting two target pictures that vary along two dimensions (e.g., shape and color). Participants are asked to match a series of bivalent test pictures (e.g., yellow balls and blue trucks) to the target pictures, first according to one dimension (e.g., color) and then, after a number of trials, according to the other dimension (e.g., shape) (NIH, 2015).

[10] Consistent with this possibility, the variance in academic achievement that can be explained by environmental factors varying between families is smaller for low- and high-income children exposed to a positive early environmental context (Tucker-Drob, 2013). Research has also found that environmental conditions explain more of the differences in intellectual interest among children of lower socioeconomic status than among children of higher socioeconomic status (Tucker-Drob & Harden, 2012).

[11] The idea that children's skills built during the intervention can lead to more positive subsequent environments experienced by the child overlaps with the Cunha-Heckman (2007) hypothesis that early skills increase the productivity of subsequent investments. If the definition of "investments" includes, say, school- or community-based opportunities for establishing positive peer relations, then the right kind of early parent-child interventions may increase the chance that these opportunities are taken up.

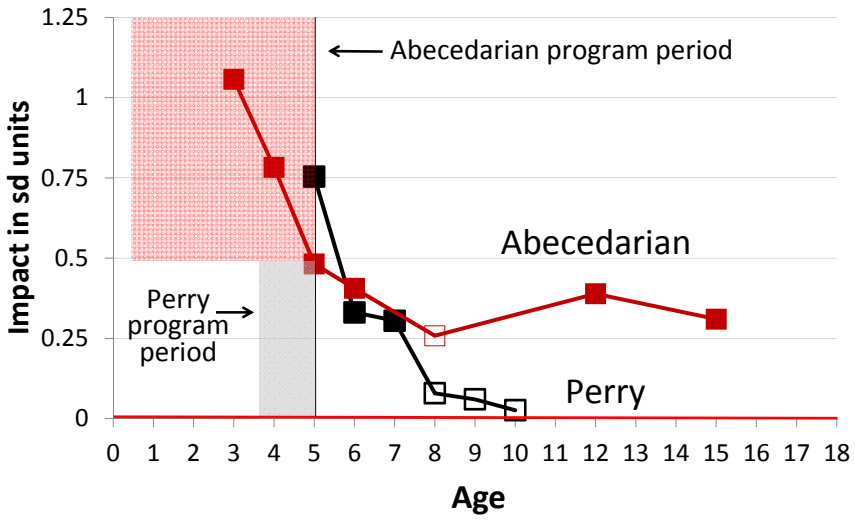
[12] Although residential mobility enabled some Perry children to eventually attend higher-resourced and more integrated middle and high schools, almost all spent at least their first few school years in Ypsilanti schools (personal communication from Larry Schweinhart, August 15, 2015).

[13] Of course, it is also possible that enriched environments might boost the achievement of control-group children even more than treatment-group children. That pattern best fits the data on preschool impacts observed in Magnuson, Ruhm, & Waldfogel (2007).

[14] Spoth et al. (2011) summarizes this view as follows: "The extant literature on universal interventions emphasizes the importance of timing program implementation to occur during the developmental window when adolescents are just beginning to initiate substance use. Epidemiological research suggests that well-timed interventions could accrue substantial public health and economic benefits, should they delay onset of substance use or delay transition to more serious use."

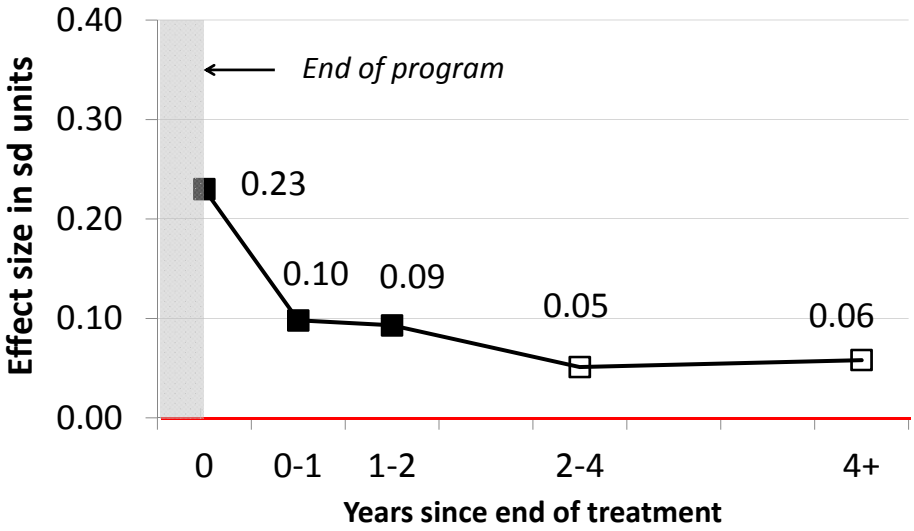
[15] Another possible source of impacts is that the extended instructional time in the Double Dose bcondition enabled teachers to use instructional activities such as working in small groups and on boards and engaging in more probing and open-ended questions

Figure 1: IQ impacts in Perry and Abecedarian



Solid marker denotes p<.05. IQ impacts are based on national norms

Figure 2: Cognitive impacts in 67 ECE studies

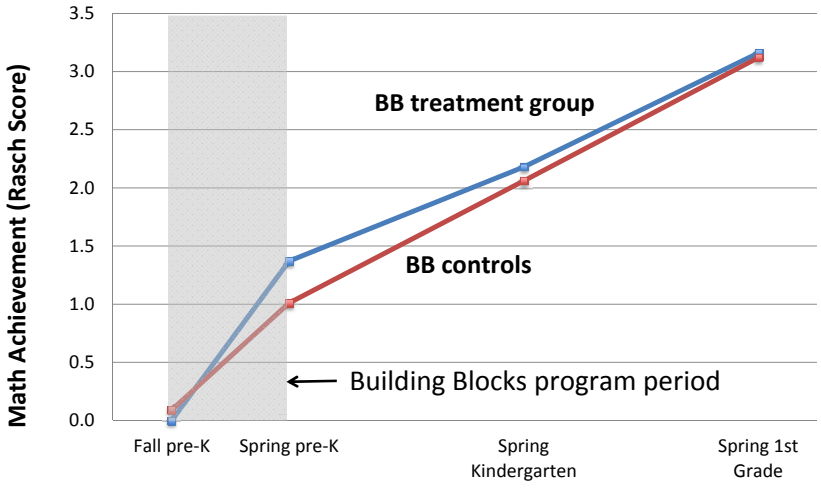


Solid marker denotes p<.05.

Figure 3: Fundamentality and malleability in skills, behaviors and beliefs

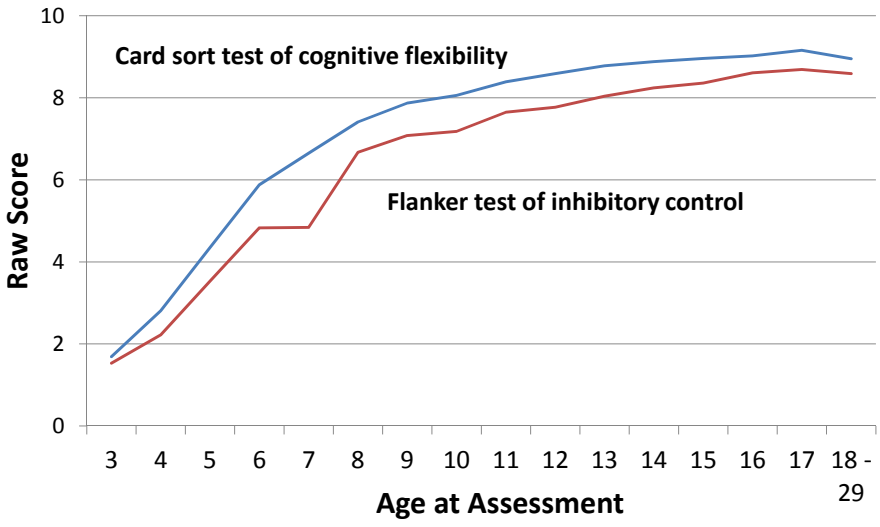
	Fundamental ⟷ Peripheral	
More malleable ↕	• Math & literacy • Self-concept, academic motivation & implicit theories of intelligence • Emotional self-regulation & executive function • Social and relationship skills	• Test-specific knowledge • SAT test prep • FAFSA information
Less malleable	• Conscientiousness (including grit) • General intelligence	• Height • Natural eye color

Figure 4: Math Achievement During and After the Pre-K Building Blocks Program



Note: Rasch score standard deviation = 1

Figure 5: Average Raw Scores on Two Assessments of Executive Function, by Age



Age 3-7 standard deviations range from 0.9-1.3 for Card Sort and 0.6-1.2 for Flanker