Submitted to *Developmental Psychology*, August 8, 2019
Revision 1 submitted March 17, 2020
Revision 2 submitted July 31, 2020
Accepted August 7, 2020

PERSISTENCE AND CONVERGENCE: THE END OF KINDERGARTEN OUTCOMES OF PRE-K GRADUATES AND THEIR NON-ATTENDING PEERS

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Running Head: Persistence and convergence
Word Count: 182 (Abstract), 7,942 (Focal Text),
2 Tables, 2 Figures, 1 Supplemental Table

* Correspondence concerning this article should be addressed to the first author at The Ohio State University 1787 Neil Avenue, Columbus, OH, 43210 (email: ansari.81@osu.edu). We gratefully acknowledge the support of our many partners: school district leaders, community programs, teachers, parents and children. Their enthusiastic cooperation and participation made much of this work possible. We also extend appreciation and recognition to Marcia Kraft-Sayre, Marianna Lyulchenko, Laura Helferstay, Brittany Kerr, Tara Hofkens, and Peg Burchinal who each made valuable contributions to the project. The research reported here was supported by the Institute of Education Sciences, U.S. Department of Education, through Grant #R305N160021 to the University of Virginia. The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education.

Abstract

The present investigation examined the benefits of pre-K through the end of kindergarten for children from low-income homes who lived in a large and diverse county (n = 2,581) as well as factors associated with a reduction in benefits during the kindergarten year. Results revealed that pre-K graduates outperformed non-attenders in the areas of achievement and executive functioning skills at the end of kindergarten, and also that the benefits of pre-K at the start of the year diminished by a little over half. This convergence between groups' performance was largest for more constrained skills, such as letter-word identification, and was attributed to the fact that non-attenders made greater gains in kindergarten as compared with graduates of pre-K. Importantly, convergence in the groups' performance in kindergarten was not attributed to pre-K children's classroom experiences in kindergarten. Convergence was, however, attributable to pre-existing individual differences and there was support for the notion that even though children's skills are susceptible to improvement as a result of pre-K, their longer-term outcomes are likely to be impacted by factors that are outside the scope of early schooling.

Keywords: low-income children; public pre-kindergarten; convergence; persistence

Persistence and Convergence: The End of Kindergarten Outcomes of Pre-K Graduates and Their Non-Attending Peers

Across the United States, more and more young children enroll in a formal preschool program in the year or two before kindergarten (Child Trends Databank, 2019). National estimates reveal that, today, roughly 4.69 million children attend preschool as compared with 2.88 million children in 1989 (Chaudry & Rupa Datta, 2017). This growth in preschool enrollment reflects decades of empirical evidence that make a strong case for program participation: Children who attend preschool, on average, enter kindergarten more ready to learn than their classmates and peers who have no prior school experience (for reviews of the literature see: Phillips et al., 2017; Yoshikawa et al., 2013). Although the depth of knowledge on the short-term benefits of preschool has grown tremendously over the past several decades, many questions remain. Two questions in particular that have been the focus of much discussion are both *whether* and *why* the benefits of preschool persist over time as children progress throughout the elementary grades.

It is with these questions that this study is primarily concerned. More specifically, the present investigation considers the differences in school readiness skills across the kindergarten year between a group of pre-K attenders and non-attenders who came from low-income and ethnically and linguistically diverse homes. As part of this effort, we also consider the degree to which the benefits of pre-K diminish by the end of kindergarten (i.e., convergence) and the extent to which this convergence is a result of children without prior pre-K experience making ground (i.e., catch-up) or children with prior pre-K experience losing ground (i.e., fadeout). This study also adds to the extant literature by focusing on the underlying reasons for convergence, with a focus on differences in children's skills and their kindergarten classroom experiences.

The Near-term Benefits of Pre-K

These past several decades of research have produced important insights into the effectiveness of pre-K. Notwithstanding the diversity in program delivery and various investigations' analytic designs, there is now strong evidence from the developmental and educational sciences to suggest that children who attend pre-K, as compared to those without pre-K experience, are more ready for kindergarten in the areas of language, literacy, and math, particularly at the start of the year, when compared with children who do not have such experience (Barnett et al., 2018; Camilli et al., 2010; Duncan & Magnuson, 2013; Phillips et al., 2017; Yoshikawa et al., 2013). These results have been shown through evaluations of small-scale demonstration programs in the 1960s and 1970s (Campbell & Ramey, 1994; Schweinhart et al., 2005), and verified over the years with evaluations of a variety of scaled-up state and federal programs (Barnett et al., 2018; Montrosse-Moorhead et al., 2019; Gormley, Gayer, Phillips, & Dawson, 2005; Puma et al., 2012; Weiland & Yoshikawa, 2013). And even though the magnitude of program impacts varies considerably and scaled-up evaluations see smaller end-of-treatment impacts than earlier small-scale demonstration programs, a meta-analysis by Li and colleagues (2020) of over 65 programs reports that the cognitive impacts of program participation are approximately a quarter of a standard deviation upon program exit.

Additionally, although much of the extant literature has focused on children's academic achievement as the benchmark for program success, a few studies have also examined children's socioemotional and executive function skills as outcomes. These studies of non-academic outcomes of pre-K have generally reported mixed evidence. Some document negative associations between program participation (relative to non-program participation) and children's socioemotional and executive function performance (Ansari, 2018; Bassok et al.,

2018; Magnuson et al., 2007; National Institute of Child Health & Human Development [NICHD] Early Child Care Research Network, 2003), whereas others present positive or null effects (Forry et al., 2013; Puma et al., 2012; Weiland & Yoshikawa, 2013; Zachrisson et al., 2013). Even with the variability in findings, the average effect sizes for these associations are generally less than a sixth of a standard deviation and, therefore, are small in magnitude.

Of note is that a prior correlational study of pre-K benefits, drawing from the dataset used in the present investigation, confirms the general findings discussed above. In spite of the heterogeneity in the at-scale pre-K educational opportunities in the large urban county that is the context for the investigation, Ansari and colleagues (2020) found that graduates of pre-K, on average, entered kindergarten the following year demonstrating stronger academic and executive function skills than non-attenders, net of a wide range of demographic controls. The effect sizes of pre-K participation was roughly 40% of a standard deviation for academic achievement and 25% of a standard deviation for executive functioning (Ansari et al., 2020). Moreover, even with the accelerated learning of children enrolled in pre-K, Ansari and colleagues (2020) documented no consistent differences in teachers' reports of the children's socioemotional adjustment upon kindergarten entry. That is, graduates of pre-K entered kindergarten exhibiting stronger academic and executive function skills than there non-attending peers, but did not display any advantages (or disadvantages) in the areas of socioemotional adjustment.

Sustaining the Benefits of Pre-K

Despite the promising evidence about the short-term benefits of pre-K, a number of recent studies that have followed program graduates over time report that the benefits of pre-K, relative to earlier patterns of skill growth and relative to the skills of non-attenders, diminish soon after program completion (e.g., Ansari, 2018; Clements et al., 2013 Li, et al., 2016; Lipsey

et al., 2018; Puma et al., 2012). For example, although the meta-analysis by Li and colleagues (2020) revealed that the cognitive impacts of early childhood education are roughly a quarter of a standard deviation at program exit, these benefits diminish to only a tenth of a standard deviation a year later. As illustrated in Figure 1, this convergence in performance between attenders and non-attenders is presumed to stem from: (a) *catch-up*, whereby non-attenders make ground on program graduates; (b) *fadeout*, whereby program graduates demonstrate slowed progress over time; or (c) both (e.g., Bailey et al., 2016; Barnett et al., 2011; Magnuson et al., 2007; Protzko, 2015, 2016). Accordingly, understanding how gains from pre-K can be sustained and increased over time (especially in the year or two after program completion) has been a focal point of research and of increasing policy interest, not only for accountability, but also because of public investments in programs across the country (Friedman-Krauss et al., 2018).

Understanding the persisting benefits of pre-K (or lack thereof) calls for special attention to the intersection of developmental change and experiences in educational settings across the pre-K and elementary school years. As part of the present investigation, we focus on key elements of kindergarten experiences emphasized as factors that may play a pivotal role in whether pre-K benefits are sustained over time (e.g., Bailey, 2019; Bailey et al., 2016, 2017; Phillips et al., 2018; Reynolds & Temple, 2019; Yoshikawa et al., 2013). More specifically, we consider the role of: (1) the different types of kindergarten classrooms attended by children; (2) the differences in children's kindergarten entry academic, executive function, and socioemotional skills; and (3) the role of children's individual experiences in classrooms.

Sustaining Environments. In the context of considering the intersection of developmental change and experiences in educational settings across the pre-K and elementary school years, longer-term program effects have been hypothesized as a function of alignment

between the instructional programs of the pre-K and elementary systems, or as a matter of individualization of instruction within a given classroom. For example, kindergarten teachers may respond to the higher skill levels of incoming students with pre-K experience by raising the level of instruction (Bassok et al., 2016) and reinforcing learning gains (Claessens et al., 2014). In contrast, kindergarten teachers may fail to adapt instruction to pre-K graduates and teach skills that these children have already mastered (Engel et al., 2013), resulting in children losing early gains (Lipsey et al., 2018). Likewise, a number of studies have shown that children require continued high quality opportunities for learning gains to be sustained (Ansari & Pianta, 2018; Cash et al., 2019; Zhai et al., 2012) and that the types of classrooms/schools children subsequently experience may explain the convergence of early program benefits (Currie & Thomas, 2000). This alignment of educational systems (or lack thereof) is of interest because the benefits of pre-K for closing skills gaps can only be realized if program graduates continue to learn new skills at the same or a faster rate than their peers who did not attend pre-K. Accordingly, in the present study, we consider the extent to which the different kindergarten classrooms attended by pre-K attenders and non-attenders may help sustain (or inhibit) the persistence of pre-K effects.

Constraining Content versus Preexisting Differences. The benefits of pre-K may also diminish because of constraints on children's growth over the course of the school year, which imposes a ceiling on higher achieving children (Ansari & Purtell, 2018; Phillips et al., 2017; Reynolds & Temple, 2019); however, this remains a largely unexplained hypothesis. With that said, if this hypothesis were true, then this constraint or ceiling would be present *both* for children whose skills were boosted by pre-K as well as non-attenders with similar higher-level skills at kindergarten entry (see top hand panel of Figure 2). Put another way, under this

hypothesis, both highly skilled non-attenders and pre-K graduates would display smaller gains in kindergarten. However, in one of the only tests of this hypothesis, Bailey and colleagues (2016) found that persistent individual differences in children's long-term functioning contribute to the converging benefits of a pre-K intervention more so than school- or classroom-wide factors. More specifically, Bailey and colleagues (2016) found that control group children with similar scores at kindergarten entry as children who had experienced a pre-K intervention had preexisting differences (e.g., cognitive abilities, academic skills, and motivation) compared with pre-K non-attenders. These high-achieving children in the control group experienced greater learning gains during the kindergarten year than similarly achieving pre-K attenders (see bottom panel of Figure 2), suggesting that individual differences beyond pre-K attendance may have influenced their rates of growth. Put another way, children's skills are malleable to pre-K education and intervention; however, longer-term school success may be largely influenced by factors beyond the scope of these programs. In considering the degree to which the short-term effects of pre-K persist or diminish, we test the hypothesis that convergence occurs because of pre-existing differences as compared with constraints on student learning in kindergarten.

Individual Differences in Classroom Experiences. Finally, as can be seen by the literature outlined above, progress has been made in understanding the ways in which the long-term benefits of pre-K may (or may not) vary as a function of children's subsequent experiences at the classroom-level; however, less attention has been paid to variability in children's experiences within classrooms. That is, no two children are alike and no two children experience the classroom in the same way. As such, we focus on two aspects of children's individual experiences in kindergarten classrooms – the quality of their relationship with the teacher, and their perceptions of the classroom as an enjoyable and engaging setting. For young children,

these indicators of the quality of the classroom as a social setting have been identified as factors accounting for student success (Hamre & Pianta, 2001; Mantzicopoulos et al., 2008; Pianta, 1997; Valeski & Stipek, 2001). Teachers' perceptions and feelings regarding their relationship with a specific child, which consist of the closeness (i.e., levels of warmth, positive affect, and approachability) and conflict (i.e., negativity and lack of rapport), have been implicated in numerous studies as a predictor of outcomes as diverse as academic achievement and referral for special education. Teacher-child relationships are an important marker of individual experience given evidence that teachers provide more support to children with whom they have a close and conflict-free relationship than children with whom they may have a more conflictual relationship (Cadima et al., 2016; Hamre & Pianta, 2001; Pianta, 1997; Silva et al., 2011). Additionally, children's academic orientations, which captures children's school enjoyment (i.e., positive feelings toward and experiences of school (Mantzicopoulos et al., 2008) and feelings about their peers (Valeski & Stipek, 2001) reflect the extent to which young children experience the classroom as a supportive resource for learning. These markers of academic orientation are critical in understanding the ways in which children experience the classroom because children who enjoy school more and who report better relationships with their teachers and peers demonstrate greater classroom engagement (Papadopulou & Gregoriadis, 2017; Ruzek et al., 2020). These two indicators of individual children's experiences of the classroom setting (assessed from teacher and child perspectives) enable further exploration of the possible individual differences in classroom experience that account for convergence.

The Current Study

In the context of a large and diverse county pre-K program, the present investigation addresses three research questions. First, we consider the extent to which the benefits of

participation in publicly funded pre-K in the year before kindergarten persist through the end of the kindergarten year, and whether there is empirical evidence for convergence between pre-K attenders and non-attenders. If there is empirical evidence of convergence, then we examine the extent to which convergence is attributed to catch-up among children who did not participate in pre-K at age 4 as compared with fadeout among those who did. Finally, we decompose convergence to estimate the degree to which it is attributed to: (a) the different kindergarten classrooms attended by children; (b) children's kindergarten entry skills; and (c) individual children's experiences in kindergarten. Given the conflicting evidence regarding the persistence of program benefits and plausibility of the various explanations for convergence (e.g., Bailey et al., 2017; Phillips et al., 2017; Yoshikawa et al., 2013), we left our study objectives as largely exploratory.

Method

Participants were drawn from a large, culturally and linguistically diverse county in a mid-Atlantic state that serves over 186,000 students from pre-K through 12th grade. The study school district serves a growing number of vulnerable families and children, including a large immigrant population, with 18% of families in which neither parent is a U.S. citizen. County students are ethnically (39% White, 26% Hispanic, 19% Asian, 10% African American, and 6% other or mixed race/ethnicity) and linguistically (53% of children have a home language other than English) diverse. Moreover, 10% of households have no full-time wage earner, one third of children qualify as low-income, and 25% receive public assistance.

The sample for the present study draws from the full population of children who were income eligible for pre-K (described in more detail below) and who were enrolled in kindergarten in the county. This sample included 2,581 children (1,247 non-attenders; 1,334

attenders), which represents two-thirds of kindergartners from low-income families in the county. Overall, sample of children were ethnically (62% Hispanic, 12% Black, 15% Asian/other, and 11% White) and linguistically (59% spoke Spanish, 24% spoke another language, and 17% spoke English) diverse. Additionally, children came from households with an income-to-needs ratio of approximately 1.10 (*SD* = 0.72) and their mothers averaged less than a high school education (*M* = 11.76, *SD* = 3.71). For other sample descriptives stratified by pre-K enrollment, see Table 1. Note that this study received approval by the Institutional Review Board at the University of Virginia.

Recruitment of pre-K teachers and attenders. In the study county, children attend one of two full-day programs. The largest, which serves over 1,500 children, consists of publicly funded pre-K classrooms within schools. The second consists of Head Start classrooms and subsidized slots in private pre-K programs that together serve more than 400 children. Pre-K teachers were recruited from the population of school and community-based pre-K programs in the county. All teachers in public schools and Head Start centers were eligible; however, in community programs, teachers were eligible if they taught at a center in which more than five publicly-funded pre-K children were enrolled. At the start of the 2016-2017 school year, 156 pre-K teachers were initially recruited (100 from public schools, 56 from community programs, including Head Start). If center directors indicated that they were interested in participating, researchers and program staff contacted teachers in their program to describe the project in more detail and obtain teachers' consent. Of the 156 recruited teachers, 126 met eligibility requirements and enrolled in the study. Lead pre-K teachers averaged 16.86 years of education and had 15.68 years of teaching experience (Pianta et al., 2018).

Then, at the start of the pre-K year, teachers who consented to participate in the study

sent families a consent form and short demographic survey. Children were eligible to participate if they were enrolled in the program, turned 4 by the start of the study, and were not receiving special education services (except for speech). Roughly 80% of parents had children who were eligible to participate and consented, and roughly 90% were successfully followed through kindergarten.

Recruitment of non-pre-K attenders. As children entered kindergarten, pre-K non-attenders were recruited. Non-attenders were considered eligible if they: (1) did not attend center-based pre-K at age 4; (2) had a total household income less than 250% of the federal poverty line; and (3) attended the same kindergarten classroom *or* elementary school as the pre-K attendee sample. Using parent-reported data that was collected by the district at the time of kindergarten enrollment, the research team determined each kindergarten enrollee's pre-K enrollment status. In elementary schools in which there were pre-K attendees enrolled in the study, if a parent or guardian indicated that a child attended family child care or had no other prior preschool experience, they were deemed eligible for recruitment. Then, similar to our recruitment of pre-K attenders, we asked kindergarten teachers to send consent forms and family demographic surveys to eligible non-pre-K attenders' parents or guardians. A total of roughly 2,600 packets were sent to families and this process consented approximately 1,600 non-attenders. Using the income data that parents reported on the family demographic survey, we confirmed that roughly 80% of the consented children met eligibility criteria.

It is important to note that all kindergarten teachers with at least one study-enrolled child were eligible to participate in the study. Recruitment meetings with district leaders took place in June 2017 to maximize principal support and teacher recruitment efforts. Beginning in August 2017, district leadership sent memos to principals and teachers with information about the study.

A primary point of contact at each school assisted in the distribution of flyers and consent forms. Of the 478 eligible teachers, more than 75% agreed to participate in all study components; an additional 20% agreed only to allow the research team to assess participating students and did not consent to having their classroom observed or completing surveys; and the remaining 5% of teachers refused participation or worked in a school (9) that declined participation.

Measures

Kindergarten outcomes. Children's kindergarten outcomes were assessed both in the fall (September–November) and spring (April-June) of the school year by trained data collectors. Data collectors completed a one-day training prior to assessing children. At both time points, children were assessed in a quiet space, outside of the classroom when possible. All children were assessed in English unless they failed the language screener (PreLAS; Duncan & De Avila, 1998); if this was the case, and if they spoke Spanish, then they were also assessed with parallel Spanish measures in the fall (when available). In the spring, however, all children were assessed in English. The present study utilizes only the English-language assessment data.

Academic achievement. Children's academic skills were assessed with five subtests of the Woodcock Johnson III (WJ-III; Woodcock et al., 2001). To begin, children's literacy skills were assessed with the *Letter-Word Identification* subtest of the WJ-III, which required children to identify individual letters and words ($\alpha = 0.94$). Language skills were assessed with the *Picture Vocabulary* subtest ($\alpha = 0.81$), which asked that children classify objects that were depicted in a series of pictures. Next, two subscales of the WJ-III were used to measure children's math skills: 1) *Applied Problems* ($\alpha = 0.93$), which required that children perform basic math calculations and 2) *Quantitative Concepts* ($\alpha = 0.91$), which required children to identify number patterns. Finally, children's general knowledge was assessed with the

*Academics Knowledg*e (α = 0.90) subscale, which assesses children's skills in the areas of science, social studies, and humanities. We used the standard scores for each assessment, which were nationally normed to have a mean of 100 and a standard deviation of 15 and describe children's academic performance relative to the average performance of their same-age peers.

Executive functioning. Children's executive functioning was assessed using three separate assessments. Working memory was measured using the Backwards Digit Span subtest (Carlson, 2005), which asked children to repeat sequences of numbers in reverse that increase in length. It has a median reliability coefficient of .88. This task has been widely used as a test of working memory. Next, the Head-Toes-Knees-Shoulders assessment (McClelland et al., 2007) was used to examine children's inhibitory control, attention, and working memory. Children's inhibitory control was also assessed using an adapted version of a standard peg-tapping task with pencils rather than pegs (Diamond & Taylor, 1996; see Smith-Donald et al., 2007). This assessment required children to tap once when the assessor tapped twice and vice versa. Percent of correct responses on this assessment has demonstrated good concurrent and construct validity with other measures of inhibitory control as well as predictive validity for school readiness outcomes such as phonemic awareness (Blair & Razza, 2007; Smith-Donald et al., 2007).

Socioemotional skills. Teachers rated each child on four general competencies using the Teacher-Child Rating Scale (Hightower, 1986). On a 5-point Likert scale (1 = *not at all*, 3 = *moderately well*, 5 = *very well*), teachers were directed to indicate how well a given characteristic described the child. The task orientation subscale comprised five items (e.g., completes work, well organized, functions well even with distractions, and works well without adult support; fall α = 0.92; spring α = 0.93). The peer social skills scale (e.g., has many friends, is friendly toward peers, and makes friends easily; fall α = 0.93; spring α = 0.94) and frustration

tolerance scale (e.g., accepts things not going his/her way, ignores teasing, copes with failure fall $\alpha = 0.90$; spring $\alpha = 0.92$) were both also comprised of five items each. Finally, the conduct problems subscale included six items (e.g., disruptive in class, defiant, overly aggressive with their peers; fall $\alpha = 0.89$; spring $\alpha = 0.89$).

Children's individual kindergarten classroom experiences. Two different protocols were used to capture children's individual classroom experiences. First, children's relationships with their kindergarten teacher was measured by the Student-Teacher Relationship Scale (STRS; Pianta, 2001). Although the STRS is based on 15 items, asking teachers to report on their perspectives of their relationships with individual children in the classroom, the current study used a subset of nine items to minimize teacher burden. Five items are included in the *conflict* score ($\alpha = .88$), where teachers are asked about the extent to which they perceive negative interactions and emotions with the child. Four items are included in the *closeness* score ($\alpha = .83$), where teachers report on the degree of warmth and open communication they share with the child. For the current analyses, items were drawn from the fall of the kindergarten year.

Second, three dimensions of children's feelings about school were assessed with child surveys that were created from a combination of existing surveys and newly developed scales. These surveys were conducted like an interview with children where they were asked to indicate their level of agreement by pointing to one of three increasingly larger circles, corresponding to less or more agreement (for more details see: Ruzek et al., 2020). As part of these surveys, *children's feelings about their teacher* ($\alpha = .58$) was assessed using four items (e.g., "Is your teacher nice to you?" and "Does your teacher help you?"). *Children's feelings about their classmates* ($\alpha = .58$) was assessed using four items (e.g., "Do you have good friends in your class?" and "Do the kids in your class play with you?). *Children's school enjoyment* ($\alpha = .70$)

was assessed with four questions (e.g., “Is school fun?” and “Do you enjoy school?”). Although these internal consistency values are just at or below typical cutoffs, these particular measures have shown factorial and convergent validity and invariance across child groups in the present sample (Ruzek et al., 2020) and these types of measures have been used in other research on young children (e.g., Nurmi & Anoula, 2006; Valeski & Stipek, 2001).

Analytic Strategy

To address our focal research objectives, we estimated a series of ordinary least-squares linear regression models in Stata (StataCorp, 2009) that accounted for the nesting of children in classrooms with clustered standard errors and used the chained equations method to impute 50 datasets in order to retain the full sample of children (missing data rates by pre-K type are provided in Table 1). Within this general analytic framework, our first set of models considered the links between children’s participation in pre-K at age 4 (vs. children who did not attend pre-K) and their academic, socioemotional, and executive function skills at kindergarten entry. These models served as a replication of Ansari and colleagues (2020) and were necessary because they also served as a baseline comparison for our subsequent analyses. These same models were then re-estimated with the spring of kindergarten outcomes. Statistically significant coefficients for pre-K (at fall or spring) would indicate that program graduates performed better (or worse, depending on the outcome) on the assessment of interest as compared with non-participants. We estimated the aforementioned (and below) models for all 12 child outcomes, but to facilitate interpretability, we also created composite measures of academic, socioemotional, and executive function skills and estimated outcome scores for these three composite scores as well.

The above analyses capture whether pre-K graduates perform better in the fall and spring of kindergarten. Our next set of analyses consider whether there was convergence in the benefits

of pre-K across the kindergarten year. Put another way, to what extent do the slopes in student learning differ between pre-K attenders and non-attenders in the kindergarten year. To test this possibility, we created a difference score (spring of kindergarten outcomes – fall of kindergarten outcomes), which captures the regression slopes of children's enrollment in pre-K for their kindergarten outcomes (for a similar approach see: Ansari, 2018; Magnuson et al., 2007). To illustrate the meaning of this variable, consider the following example. If we found a positive and statistically significant association between pre-K enrollment and academic achievement in the fall of kindergarten and a negative and statistically significant association for the fall to spring of kindergarten difference score, this would suggest that enrollment in pre-K is associated with more optimal academic performance at the start of kindergarten, but these associations diminish by the end of the year. In contrast, if we found a positive and statistically significant association between pre-K enrollment and academic achievement in the fall of kindergarten and a positive and statistically significant association for the difference score, this would suggest that enrollment in pre-K is associated with more optimal academic performance at the start of kindergarten, and these benefits increase by the end of the year. It is important to note that our academic measures were externally benchmarked, and thus, this also allowed us to consider the extent to which convergence was attributed to fadeout (i.e., pre-K graduates lost ground) as compared with catch-up (i.e., non-pre-K participants made ground). To partition the convergence estimate in this way, we estimated the predicted gains for pre-K graduates and non-attenders from the regression model above where the difference score was the outcome while holding all covariates constant at their mean.

Finally, we took several approaches to explore the underlying reasons for convergence. First, to determine the extent to which convergence was attributed to classroom-level processes

in kindergarten, we added classroom fixed effects (i.e., 0/1 indicators for each classroom in the study). Doing so allowed us to hold constant all classroom-wide characteristics (e.g., process quality, structural quality, classroom composition) that were the same for pre-K attenders and non-attenders in the same kindergarten classroom. We considered this to be our first block and explanation for convergence. We would conclude that convergence was attributed (at least partially) to the different types of classrooms attended by pre-K attenders and non-attenders if the magnitude of convergence diminished after incorporating classroom fixed effects. The next block of models built on the first block by incorporating children's kindergarten entry skills. This block of models allowed us to consider the extent to which convergence was attributed to the constraints hypothesis or pre-existing differences hypothesis. If the degree of convergence between pre-K graduates and non-attenders in the same classroom was completely (or largely) accounted for *after* including children's kindergarten entry skills, we would conclude that there was support for the constraint on student learning hypothesis because the constraints hypothesis implies that higher achieving children—regardless of pre-K experience—will have fewer opportunities to learn, which explains convergence. If, however, the inclusion of kindergarten entry skills does *not* account for convergence, then this would lend support for the pre-existing differences hypothesis because if pre-K attenders demonstrate fewer gains in kindergarten than non-attenders with the same-level of kindergarten entry scores, that would imply that pre-K graduates are doing less well on other unobserved factors. Finally, our third block built on the second block of models by including several indicators of children's individual experiences in kindergarten to isolate the proportion of convergence attributed to the different ways in which pre-K attenders and non-attenders experienced the same classroom, net of classroom-wide factors and their school entry skills. As before, the degree to which our convergence estimate

was accounted for with the inclusion of this block of variables would either lend support (or refute) this possibility.

It is important to acknowledge that children were *not* randomly assigned to attend pre-K and, consequently, there are likely to be issues of selection. To address these concerns, our models control for a large set of theoretically informed child and family factors (see: Coley et al., 2014; Crosnoe et al., 2016). Models include controls for: child age, child gender, child race/ethnicity (White, Black, Hispanic, Asian/other), home language (English, Spanish, other), parent years of education, parent work hours, parent marital status (married, living with partner, separated or widowed, never married), income-to-needs-ratio, household size, number of children under 18 in the household, and parent age. Given that children were tested between the months of September and November and again between April and June, all models also control for the time between September 1st and the administration of the fall and spring child assessments.

Results

The Benefits of Pre-K at the Start and End of Kindergarten

As can be seen in column 1 of Table 2, and similar to Ansari and colleagues (2020), we found that pre-K graduates entered kindergarten demonstrating stronger academic skills upon kindergarten entry as compared with non-attenders, with an effect size difference of 0.52 ($p < .001$; for the specific outcome subscales, see Table 2). In addition, pre-K graduates demonstrated stronger executive function skills at the start of the kindergarten year (effect size = 0.34, $p < .001$), however, there were no aggregate differences documented between pre-K attenders and non-attenders in teacher reports of children's socioemotional skills (effect size = .02, *ns*). When assessing these same groups of students at the end of kindergarten, pre-K graduates continued to

demonstrate stronger academic skills (average effect size = 0.22, $p < .001$) and executive function skills (average effect size = 0.20, $p < .001$) than their non-attender peers. And even though no consistent differences emerged in children's socio-emotional skills upon kindergarten entry, pre-K graduates demonstrated less optimal socio-emotional skills by the end of the year (effect size = .10, $p < .05$). This difference was largely attributed to the elevated levels of conduct problems among pre-K graduates (see column 2 of Table 2).

The Converging Benefits of Pre-K

We followed up the above end-of-kindergarten models with a series of analyses examining convergence. These models confirmed that for each of the academic outcomes and for two of the three executive function outcomes, there was empirical evidence of convergence ($ps < .001$; see column 3 of Table 2). That is, the associations between pre-K enrollment and the child outcomes of interest were significantly smaller by the end of the kindergarten year as compared with the start of the school year. On average, the associations between pre-K enrollment and children's academic achievement and executive functioning shrunk by approximately 55-60%. Convergence was largest for children's letter word identification skills (roughly 80%) and smallest for children's language and general knowledge skills (roughly 45%). When decomposing these estimates, we find that convergence in the benefits of pre-K, at least with regard to differences in performance between attenders and non-attenders, was largely attributable to "catch-up". All children (regardless of pre-K participation) demonstrated improvements in their academic and executive function skills in kindergarten; however, pre-K graduates made smaller improvements than their peers who did not attend pre-K.

There was also evidence to suggest that children's socioemotional skills were changing differentially during the kindergarten year as a function of pre-K attender status ($p < .01$). When

decomposing these estimates, we found that although teachers reported that non-attenders demonstrated improvements along this dimension of development across the kindergarten year, they did not report similar improvements in pre-K attenders' socioemotional skills.

The Different Sources of Convergence

Having found that the associations between pre-K enrollment and children's kindergarten outcomes diminished in magnitude across the school year, our next set of models attempted to identify factors associated with convergence. As can be seen in Table 2, there was little support for the notion that convergence was attributed to the different types of classrooms attended by pre-K attenders and non-attenders: None of the catch-up effect in any of the study outcomes of interest, net of child and family covariates, was attributed to classroom-wide factors in kindergarten (i.e., column 4 versus column 3). That is, non-attenders largely (but not entirely) caught-up with their classmates who attended pre-K at the age of 4 to a similar degree across *all* kindergarten classrooms.

The next set of models included children's kindergarten entry achievement (column 5), executive function (column 6), and socioemotional skills (column 7) as possible factors associated with convergence. The inclusion of these indicators captures the degree to which the benefits of pre-K diminish for attenders as compared with non-attenders who exhibit similar skills in the same kindergarten classroom. In general, these results revealed that children's kindergarten entry skills explained roughly a quarter to a third of the convergence in academic achievement and executive functioning (but not socioemotional skills). Put another way, the benefits of pre-K diminished across the kindergarten year, in part, because pre-K graduates entered kindergarten with stronger skills. Approximately three-quarters of the convergence in children's academic achievement and executive function skills remained unexplained, however.

Thus, even when pre-K attenders and non-attenders were enrolled in the same kindergarten classroom and demonstrated comparable skills at school entry, non-attenders continued to make greater gains in achievement and executive functioning, resulting in convergence.

Our final model built on earlier ones and incorporated children's individual experiences in the kindergarten classroom (i.e., teacher-child relationships, children's enjoyment of school, and children's feelings about their teacher and peers). Notably, the inclusion of these variables did not meaningfully alter the degree of convergence (i.e., column 8 vs column 7). Consequently, there was little evidence to suggest that the measured indicators of children's individual experiences in kindergarten explained why pre-K attenders made fewer gains in kindergarten as compared with their non-attending classmates.

Supplemental Analyses

Our analyses of children's individual experiences only considered their relationships and feelings about their peers and teachers. This is of note because there are, of course, other markers of individual experiences that matter. Thus, we estimated additional models for a subset of children for whom we had other markers of individual experience. More specifically, for a subset of 975 children (483 pre-K attenders and 492 non-attenders), we collected time-sampled data on individual children's exposure to academic instruction and their participation in different types of activity settings (i.e., teacher-directed instruction, child-selected activities, and routines) in kindergarten. It is important to note that these 975 children were representative of the larger sample and all results reported above were quantitatively similar when replicated with this subset of children (see Supplemental Table 1). Children's individual classroom experiences were measured with the Behavioral Coding System, which was adapted from the NICHD Study of Early Child Care and Youth Development Classroom Observation System and Observational

Record of the Caregiving Environment (McCartney et al., 2007) and informed by work by Ritchie et al. (2001). Scores on the BCS represent the proportion of intervals that target children were observed experiencing each setting or behavior and, on average, children spent roughly 65% of the day in academic instruction; 76% of the day in teacher-directed instruction; 5% of the day in free play; and 19% of the day in routines. When we included these additional individual-level classroom experiences in our models, we again, found no meaningful change in the degree of convergence (see Supplemental Table 1).

Discussion

Ensuring that young children enter kindergarten ready to learn has been of great research and policy interest. By all accounts, pre-K programs have helped achieve this goal (e.g., Duncan & Magnuson, 2013; Phillips et al., 2017; Yoshikawa et al., 2013); however, there have been lingering questions as to whether contemporary and scaled-up pre-K programs provide children with enduring benefits as they progress throughout their educational careers. To this end, there has been increasing attention to the impacts of children's experiences after pre-K. It is with this backdrop that we sought to: (a) assess the persisting benefits of pre-K for children from low-income and ethnically diverse families as they transition to elementary school; and (b) understand the role of children's experiences in kindergarten on their gains in skills across the year. In doing so, several important themes emerged that we discuss in more detail below.

To begin, we found clear evidence indicating that the benefits of pre-K persist throughout the kindergarten year. On average, pre-K graduates continued to outperform their non-attending peers by roughly 20% of a standard deviation through the end of the kindergarten year. At the same time, however, when looking at the magnitude of these associations over time, we found that the associations between pre-K enrollment and improved school readiness skills diminished

between the fall and spring of kindergarten, primarily because non-attenders who entered school for the first time in kindergarten made larger learning gains as compared with their classmates with pre-K experiences. Such diminishing associations also have been documented in national evaluations of early childhood education (e.g., Ansari, 2018; Bassok et al., 2018; Magnuson et al., 2007) in addition to studies from Tennessee (Lipsey et al., 2018), Head Start (Puma et al., 2012), and other early childhood interventions (Protzko, 2015, 2016), and are perhaps to be expected. Of note, however, is that we were able to examine a broad set of outcomes (as opposed to just math and literacy) and these associations diminished by roughly a quarter of a standard deviation between the fall and spring of kindergarten. Put another way, a little over half of the original advantage associated with attending pre-K at the age of 4, relative to not attending, appeared gone seven to eight months later.

The detected convergence was largest for more constrained skills (i.e., discrete skills that are likely to be a specific focus of instruction), such as letter word identification (roughly 80%), and smallest for unconstrained skills, such as vocabulary and general knowledge skills (roughly 45%). Accordingly, although the results clearly indicate that the benefits of pre-K persist at least 12 months after program completion, these results also support the view that targeting malleable skills that would develop absent of pre-K (or other types of early intervention) is insufficient for generating sizable long-term benefits, in part because many of these skills are likely to develop rapidly among non-attenders shortly after school entry (Bailey et al., 2017; Paris, 2005). That is, for the benefits of pre-K to persist, these benefits must be sizable, the skills children learn in pre-K must matter in relation to learning subsequent skills, and these skills should *not* develop at a fast rate among non-attenders upon kindergarten entry.

The results from the present investigation also contribute to the literature by examining

the role of children's subsequent classroom experiences in kindergarten in accounting for convergence. Notably, the addition of classroom fixed effects, which accounts for all observed and unobserved between-classroom variation (e.g., process quality, structural quality, classroom composition), and children's individual experiences in kindergarten did *not* change the estimated convergence of pre-K for the study outcomes. That is, the convergence documented in this study, above and beyond that attributed to children's skill levels, was *not* attributed to the different types of kindergarten classrooms attended by pre-K attenders and non-attenders nor was it attributed to the relationships children had with their teachers and peers. And in supplemental analyses, we found that convergence was also *not* attributed to individual children's exposure to different types of instructional content and groupings.

Finally, only a quarter of the convergence reported in this study between the fall and spring of kindergarten was attributable to a ceiling effect of some sort. If hypothesis regarding constraints on student learning was more fully supported, then we would expect that this ceiling or constraint would be present both for children whose skills were boosted by pre-K as well as non-attenders with similar skills at kindergarten entry; therefore, the inclusion of classroom fixed effects and children's post pre-K skills in models should have largely (or fully) accounted for the convergence. Instead, we found some greater support for the pre-existing differences hypothesis (Bailey et al., 2016; Bailey, 2019): Non-attenders in the same kindergarten classroom as pre-K graduates who demonstrated comparable academic, executive function, and socioemotional skills at kindergarten entry gained more than pre-K graduates during the kindergarten year, and this difference was approximately three-quarters of the convergence effect. These estimates regarding the importance of children's preexisting differences closely mirror the findings and estimates reported by Bailey and colleagues (2016). Unfortunately, as part of the present

investigation, we could not thoroughly test the pre-existing differences hypotheses and pinpoint what preexisting differences or processes underlie this convergence because we did not have data on our sample of non-attenders in the year before kindergarten. Although we cannot test what these pre-existing differences represent, what these results would appear to suggest is that even though children's skills are susceptible to improvement as a result of pre-K, their longer-term outcomes are likely impacted by factors that are outside the scope of early schooling. But when taken together with the work of Bailey and colleagues (2016), these findings highlight the importance of collecting both data on pre-K attenders and non-attenders in the year prior to kindergarten as well as the types of data necessary (either in pre-K or at kindergarten entry) in order to more fully test the different reasons surrounding the converging benefits of early program participation.

When taken as a whole, the findings reported herein are both similar to a number of studies that report that classroom processes do not account for convergence (Bailey et al., 2016; Bassok et al., 2018; Claessens et al., 2014; Jenkins et al., 2018), but differ from a number of other studies that suggest that subsequent classroom and school experiences do matter in accounting for longer-term benefits of early education (Ansari & Pianta, 2018; Currie & Thomas, 2000; Swain et al., 2015; Johnson & Jackson, 2017; Wolf, 2019; Zhai et al., 2012). Although there is no one explanation for these discrepancies, it is important to acknowledge that there are only a few studies to date that have examined these questions and the few studies in this area have defined children's subsequent classrooms experiences in a variety of ways. The above is of note because it is possible that not any one aspect of children's subsequent experiences matters enough to sustain (or explain) early program benefits, but that having high quality experiences across multiple domains matters (e.g., attending high quality schools with high

quality teachers; Pearman et al. 2020). With that said, a recent meta-analysis by Bailey and colleagues (2020) indicates that studies in this area need large sample sizes with strong causal identification strategies to reliably test these possibilities. Consequently, it will be important that future studies use adequately powered samples to evaluate systematically the number of potentially relevant classroom processes that may help sustain (or reduce) early learning gains. In the meantime, however, our findings that variation both between and within classroom environments did not greatly influence the diminishment of the pre-K attendees' advantage brings into focus the ongoing debates surrounding fadeout. Although it is intuitive that what happens after pre-K graduation matters and that the benefits of pre-K are contingent on subsequent learning environments, our hypotheses have been far too simplistic regarding the fadeout of pre-K effects and, in going forward, will require careful attention.

Despite these contributions to the literature, the current investigation has a number of limitations that should be acknowledged. Primarily, the design of this study was not experimental and, consequently, the results reported herein should be interpreted with caution as they do not imply causation. However, our sampling design, which required that non-attenders be income-eligible for pre-K and be enrolled in the same kindergarten classroom (or school) as pre-K attenders helps mitigate some of these concerns. Second, although the outcome assessments used in the present study maps onto what prior pre-K evaluations have used (e.g., Barnett et al., 2018; Lipsey et al., 2018; Puma et al., 2012), they do not map directly onto the curricula in use or the instructional focus at the classroom level. As such, the use of these assessments may mask program effects that might be detected if the assessments used were more proximal to children’s classroom experiences.

The reliability of our survey measures of children’s enjoyment of school and their

feelings about their teachers and peers were also at the lower bound of acceptability. However, these specific measures have been put through rigorous psychometric analyses, demonstrating both factorial and convergent validity as well as invariance across diverse groups of children (see Ruzek et al., 2020), providing greater confidence in their use. In moving forward, it will also be important to study other student outcomes, such as placement in special education, school attendance, school retention, school grades, and disciplinary infractions. Doing so will allow for a more holistic understanding of the benefits of pre-K. It will also be critical that studies go beyond testing whether the benefits of pre-K persist, and that studies more carefully consider *why* these benefits persist or diminish over time. As part of this effort, future studies should consider the role of other developmental contexts, including the ways in which time-varying differences in the home environment contribute to the persistence and convergence of pre-K outcomes.

In conclusion, the results reported herein appear confirm two patterns of results detected in a number of studies - the benefits of pre-K indeed do persist through the end of kindergarten, and a substantial share of these benefits diminish in the year after program exit. In short, the differential benefits converge. Moreover, it does *not* appear that children's experiences in kindergarten contribute to convergence, at least in this study sample. For future studies to understand why pre-K graduates demonstrate fewer gains in kindergarten as compared with their peers who are just entering school for the first time will require closer and more comprehensive inspection of children's experiences in the year after program completion.

References

Ansari, A. (2018). The persistence of preschool effects from early childhood through adolescence. *Journal of Educational Psychology, 110,* 952-973. doi: 10.1037/edu0000255

Ansari, A., & Pianta, R. C. (2018). Variation in the long-term benefits of child care: The role of classroom quality during middle childhood. *Developmental Psychology, 54,* 1854-1867. doi: 10.1037/dev0000513

Ansari, A., & Purtell, K. M. (2018). What happens next? Delivering on the promise of preschool. *Early Childhood Research Quarterly, 45,* 177-182. doi:10.1016/j.ecresq.2018.02.015

Ansari, A., Pianta, R. C., Whittaker, J. E., Vitiello, V. E., & Ruzek, E. (2020). Enrollment in public pre-kindergarten and school readiness skills at kindergarten entry: Differential associations by home language, income, and program characteristics. *Early Childhood Research Quarterly.*

Bailey, D., Duncan, G. J., Odgers, C. L., & Yu, W. (2017). Persistence and fadeout in the impacts of child and adolescent interventions. *Journal of Research on Educational Effectiveness*, *10*, 7–39. doi:10.1080/19345747.2016.1232459

Bailey, D. H., Nguyen, T., Jenkins, J. M., Domina, T., Clements, D. H., & Sarama, J. S. (2016). Fadeout in an early mathematics intervention: Constraining content or preexisting differences?. *Developmental psychology*, *52*(9), 1457.

Bailey, D. (2019). Explanations and Implications of Diminishing Intervention Impacts Across Time. In *Cognitive Foundations for Improving Mathematical Learning* (pp. 321-346). Academic Press.

Bailey, D. H., Jenkins, J. M., & Alvarez-Vargas, D. (2020). Complementarities between early educational intervention and later educational quality? A systematic review of the sustaining

environments hypothesis. *Developmental Review*, *56*, 100910

Barnett, W. S., Jung, K., Friedman-Krauss, A., Frede, E. C., Nores, M., Hustedt, J. T., ... & Daniel-Echols, M. (2018). State prekindergarten effects on early learning at kindergarten entry: An analysis of eight state programs. *AERA Open*, *4*, 2332858418766291.

Bassok, D., Gibbs, C. R., & Latham, S. (2018). Preschool and children's outcomes in elementary school: Have patterns changed nationwide between 1998 and 2010? *Child Development.* Advance online publication. doi: 10.1111/cdev.13067

Bassok, D., Latham, S., & Rorem, A. (2016). Is kindergarten the new first grade?. *AERA Open*, *2*, 2332858415616358.

Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child development*, *78*(2), 647-663.

Cadima, J., Verschueren, K., Leal, T., & Guedes, C. (2016). Classroom interactions, dyadic teacher–child relationships, and self–regulation in socially disadvantaged young children. *Journal of Abnormal Child Psychology*, *44*, 7-17.

Camilli, G., Vargas, S., Ryan, S., & Barnett, W. S. (2010). Meta-analysis of the effects of early education interventions on cognitive and social development. *Teachers College Record, 112*, 579-620.

Campbell, F. A., & Ramey, C. T. (1994). Effects of early intervention on intellectual and academic achievement: A follow-up study of children from low-income families. Child Development, 65, 684–698. http://dx .doi.org/10.2307/1131410

Carlson, S. M. (2005). Developmentally sensitive measures of executive function in preschool children. *Developmental Neuropsychology*, *28*, 595-616. doi:10.1207/s15326942dn2802_3

Cash, A. H., Ansari, A., Grimm, K. J., & Pianta, R. C. (2019). Power of two: Impact of two years of high quality teacher-child interactions. *Early Education and Development, 30,* 60-81. doi: 10.1080/10409289.2018.1535153

Claessens, A., Engel, M., & Curran, F. C. (2014). Academic content, student learning, and the persistence of preschool effects. *American Educational Research Journal, 51*, 403–434. doi:10.3102/ 0002831213513634

Clements, D. H., Sarama, J., Wolfe, C. B., & Spitler, M. E. (2013). Longitudinal evaluation of a scale-up model for teaching mathematics with trajectories and technologies: Persistence of effects in the third year. *American Educational Research Journal, 50,* 812–850. doi:10.3102/ 0002831212469270

Coley, R. L., Votruba-Drzal, E., Collins, M., & Cook, K. D. (2016). Comparing public, private, and informal preschool programs in a national sample of low-income children. *Early Childhood Research Quarterly, 36*, 91-105. doi:10.1016/j.ecresq.2015.11.002

Crosnoe, R., Purtell, K. M., Davis-Kean, P., Ansari, A., & Benner, A. D. (2016). The selection of children from low-income families into preschool. *Developmental Psychology, 52*, 599--*612.* doi: 10.1037/dev0000101.

Currie, J., & Thomas, D. (2000). School quality and the longer-term effects of Head Start. The *Journal of Human Resources, 35,* 755–774. doi:10.2307/146372

Duncan, S. E., & De Avila, E. A. (1998). *PreLAS 2000.* Monterey, CA: CTB/McGraw-Hill.

Duncan, G. J., & Magnuson, K. (2013). Investing in preschool programs. *The Journal of Economic Perspectives, 27*, 109-132. doi: 10.1257/jep.27.2.109

Engel, M., Claessens, A., & Finch, M. A. (2013). Teaching students what they already know? The (mis) alignment between mathematics instructional content and student knowledge in

kindergarten. *Educational Evaluation and Policy Analysis*, *35*, 157-178.

Forry, N. D., Davis, E. E., & Welti, K. (2013). Ready or not: Associations between participation in subsidized child care arrangements, pre-kindergarten, and Head Start and children's school readiness. *Early Childhood Research Quarterly*, *28*, 634-644. doi.org:10.1016/j.ecresq.2013.03.009

Friedman-Krauss, A., Barnett, W. S., Weisenfeld, G. G., Kasmin, R., DiCrecchio, N., Horowitz, M. (2018). *The state of preschool 2017.* New Brunswick, NJ: National Institute for Early Education Research.

Hamre, B. K., & Pianta, R. C. (2001). Early teacher–child relationships and the trajectory of children's school outcomes through eighth grade. *Child Development*, *72*, 625-638.

Hightower, A. D. (1986). The Teacher–Child Rating Scale: A brief objective measure of elementary children's school problem behaviors and competencies. *School Psychology Review*, 15, 393-409

Jenkins, J. M., Watts, T. W., Magnuson, K., Gershoff, E. T., Clements, D. H., Sarama, J., & Duncan, G. J. (2018). Do high-quality kindergarten and first-grade classrooms mitigate preschool fadeout?. *Journal of Research on Educational Effectiveness*, 11, 339-374. doi: 10.1080/19345747.2018.1441347

Johnson, R. C., & Jackson, C. K. (2017). *Reducing inequality through dynamic complementarity: Evidence from Head Start and public school spending* (NBER working paper No. 23489). Cambridge, MA: National Bureau of Economic Research.

Li, W., Leak, J., Duncan, G. J., Magnuson, K., Schindler, H., & Yoshikawa, H. (2020). *Is timing everything? How early childhood education program impacts vary by starting age, program duration and time since the end of the program.* Working Paper. National Forum on Early

Childhood Policy and Programs, Meta-analytic Database Project. Boston, MA: Center on the Developing Child, Harvard University.

Lipsey, M. W., Farran, D. C., & Durkin, K. (2018). Effects of the Tennessee Prekindergarten Program on children's achievement and behavior through third grade. *Early Childhood Research Quarterly, 45,* 155-176. doi: 10.1016/j.ecresq.2018.03.005

Magnuson, K. A., Ruhm, C., & Waldfogel, J. (2007). Does prekindergarten improve school preparation and performance?. *Economics of Education Review*, *26*, 33-51. doi:10.1016/j.econedurev.2005.09.008

Mantzicopoulos, P., Patrick, H., & Samarapungavan, A. (2008). Young children's motivational beliefs about learning science. *Early Childhood Research Quarterly*, *23*(3), 378-394.

McClelland, M. M., Cameron, C. E., Connor, C. M., Farris, C. L., Jewkes, A. M., & Morrison, F. J. (2007). Links between behavioral regulation and preschoolers' literacy, vocabulary, and math skills. *Developmental Psychology*, *43*, 947-959. doi: 10.1037/0012-1649.43.4.947

Montrosse-Moorhead, B., Dougherty, S. M., La Salle, T. P., Weiner, J. M., & Dostal, H. M. (2019). The overall and differential effects of a targeted prekindergarten program: Evidence from Connecticut. *Early Childhood Research Quarterly*, *48*, 134-145.

National Institute of Child Health and Human Development, Early Child Care Research Network (2003). Does amount of time spent in child care predict socioemotional adjustment during the transition to kindergarten?. *Child Development*, *74*, 976-1005. doi.org/10.1111/1467-8624.00582

Nurmi, J.-E., & Aunola, K. (2005). Task-motivation during the first school years: A person-oriented approach to longitudinal data. *Learning and Instruction*, *15*, 103–122. https://doi.org/10.1016/j.learninstruc.2005.04.009

Papadopoulou, E., & Gregoriadis, A. (2017). Young children's perceptions of the quality of teacher–child interactions and school engagement in Greek kindergartens. *Journal of Early Childhood Research*, *15*(3), 323-335.

Paris, S. G. (2005). Reinterpreting the development of reading skills. *Reading Research Quarterly, 40,* 184–202. doi:10.1598/RRQ.40.2.3

Phillips, D., Lipsey, M. W., Dodge, K.A., Haskins, R., Bassok, D., Burchinal, M. R., Duncan, G. J… Weiland, C. (2017). *Puzzling it out: The current state of scientific knowledge on pre-Kindergarten effects. A consensus statement.* Washington, DC: Brookings Institution.

Pianta, R. C. (2001). *Student-teacher relationship scale: Professional manual*. Psychological Assessment Resources.

Pianta, R. C., Whittaker, J. E., Vitiello, V. E, Ansari, A., & Ruzek, E. (2018). Classroom processes and practices in public pre-K programs: Describing and predicting educational opportunities in the early learning sector. *Early Education and Development, 29,* 797-813. doi: 10.1080/10409289.2018.1483158

Protzko, J. (2015). The environment in raising early intelligence: A meta-analysis of the fadeout effect. *Intelligence, 53,* 202-210.

Protzko, J. (2016). Does the raising IQ-raising g distinction explain the fadeout effect?. *Intelligence, 56,* 65-71.

Puma, M., Bell, S., Cook, R., Heid, C., Broene, P., Jenkins, F., ... & Downer, J. (2012). *Third grade follow-up to the Head Start Impact Study: Final report.* Washington, DC: U.S. Department of Health and Human Services.

Ruzek, E., Jirout, J., Schenke, K., Vitiello, V., Whittaker, J. V., & Pianta, R. (2020). Using self report surveys to measure PreK children's academic orientations: A psychometric

evaluation. *Early Childhood Research Quarterly*, *50*, 55-60. doi.org/10.1016/j.ecresq.2018.10.012

Schweinhart, L. J., Montie, J., Xiang, Z., Barnett, W. S., Belfield, C. R., & Nores, M. (2005). *Lifetime effects: The High/Scope Perry Preschool study through age 40.* Ypsilanti, MI: High/Scope Press

Smith-Donald, R., Raver, C. C., Hayes, T., & Richardson, B. (2007). Preliminary construct and concurrent validity of the Preschool Self-regulation Assessment (PSRA) for field-based research. *Early Childhood Research Quarterly*, *22*, 173-187. doi: 10.1016/j.ecresq.2007.01.002

StataCorp. (2009). *Stata User's Guide, Release 11.* College Station, TX: Stata Press.

Swain, W. A., Springer, M. G., & Hofer, K. G. (2015). Early grade teacher effectiveness and pre-K effect persistence: Evidence from Tennessee. *AERA Open*, *1*. doi: 10.1177/2332858415612751

Valeski, T. N., & Stipek, D. J. (2001). Young children's feelings about school. *Child Development*, *72*, 1198-1213. doi: 10.1111/1467-8624.00342

Weiland, C., & Yoshikawa, H. (2013). Impacts of a prekindergarten program on children's mathematics, language, literacy, executive function, and emotional skills. *Child Development*, *84*, 2112-2130. doi: 10.1111/cdev.12099

Willoughby, M. T., Blair, C. B., & The Family Life Project Investigators. (2016). Measuring executive function in early childhood: A case for formative measurement. *Psychological Assessment*, *28*, 319-330. doi: 10.1037/pas0000152

Wolf, S. (2019). Year 3 follow-up of the 'Quality Preschool for Ghana' interventions on child development. *Developmental Psychology*, *55*, 2587 –2602. doi:10.1037/dev0000843

Woodcock, R. W., McGrew, K. S., & Mather, N. (2001). *Woodcock-Johnson III tests of*

achievement. Itasca, IL: Riverside Publishing.

Woodcock, R. W., & Sandoval, A. F. M. (1996). *Batería Woodcock-Muñoz: Pruebas de habilidad cognitiva-revisada*. Riverside Publishing Company.

Yoshikawa, H., Weiland, C., Brooks-Gunn, J., Burchinal, M., Espinosa, L. M., Gormley, W. T., . . . Zaslow, M. J. (2013). *Investing in our future: The evidence base on preschool education.* New York, NY: Foundation for Child Development.

Zachrisson, H. D., Dearing, E., Lekhal, R., & Toppelberg, C. O. (2013). Little evidence that time in child care causes externalizing problems during early childhood in Norway. *Child Development*, *84*, 1152-1170. doi: 10.1111/cdev.12040

Zhai, F., Raver, C. C., & Jones, S. M. (2012). Academic performance of subsequent schools and impacts of early interventions: Evidence from a randomized controlled trial in Head Start settings. *Children and Youth Services Review, 34*, 946–954. doi: 10.1016/j.childyouth .2012.01.026

Table 1.
Demographic Characteristics of the pre-K and no-pre-K samples

Variable	Non-pre-K attender			Pre-K attender			Sig. diff.
	M	SD	Prop. missing	M	SD	Prop. missing	
Kindergarten entry outcomes							
Academic achievement							
WJ-III Letter-Word Identification	89.89	15.53	0.07	96.13	12.41	0.06	***
WJ-III Picture Vocabulary	85.67	13.42	0.16	88.91	10.74	0.07	***
WJ-III Applied Problems	91.10	14.00	0.09	97.05	11.74	0.07	***
WJ-III Quantitative Concepts	86.99	14.97	0.10	90.68	13.61	0.07	***
WJ-III Academic Knowledge	81.57	15.41	0.14	86.92	13.22	0.07	***
Executive functioning							
Pencil Tap	0.78	0.30	0.07	0.86	0.23	0.06	***
Backward Digit Span	1.49	0.83	0.07	1.61	0.86	0.07	***
Head Toes Knees Shoulders	36.46	27.08	0.07	44.68	27.91	0.06	***
Socioemotional skills							
Frustration Tolerance	3.39	0.95	0.28	3.36	0.97	0.29	
Task Orientation	3.17	1.04	0.28	3.33	1.06	0.29	***
Peer Social Skills	3.89	0.86	0.28	3.92	0.88	0.29	
Conduct Problems	1.72	0.85	0.28	1.85	0.90	0.29	**
Kindergarten exit outcomes							
Academic achievement							
WJ-III Letter-Word Identification	103.09	13.53	0.10	103.74	12.48	0.10	
WJ-III Picture Vocabulary	86.67	12.22	0.11	89.07	10.18	0.10	***
WJ-III Applied Problems	99.48	13.62	0.11	101.56	12.98	0.10	***
WJ-III Quantitative Concepts	94.60	12.35	0.10	95.70	11.31	0.10	*
WJ-III Academic Knowledge	85.65	14.68	0.12	88.56	12.81	0.11	***
Executive functioning							
Pencil Tap	0.90	0.20	0.10	0.93	0.16	0.10	***
Backward Digit Span	2.02	1.08	0.10	2.21	1.09	0.10	***
Head Toes Knees Shoulders	51.14	27.47	0.10	55.66	26.36	0.10	***
Socioemotional skills							
Frustration Tolerance	3.48	0.98	0.31	3.37	0.99	0.32	*
Task Orientation	3.37	1.09	0.31	3.40	1.09	0.32	
Peer Social Skills	4.06	0.84	0.31	3.98	0.87	0.32	
Conduct Problems	1.70	0.86	0.31	1.85	0.93	0.32	***
Child experiences in kindergarten							
Child closeness with teacher	3.89	0.92	0.28	4.03	0.83	0.30	***
Child conflict with teacher	1.45	0.73	0.28	1.53	0.79	0.30	*
Child feelings about teacher	2.56	0.46	0.40	2.56	0.46	0.42	
Child feelings about classmates	2.51	0.49	0.40	2.47	0.51	0.42	
Child enjoyment of school	2.56	0.52	0.40	2.46	0.58	0.42	***
Child characteristics							
Child age at kindergarten entry	5.41	0.32	0.00	5.45	0.29	0.00	**
Child male	0.48		<0.01	0.50		0.00	

Child White	0.12		0.01	0.10		0.01	
Child Hispanic	0.64		0.01	0.60		0.01	*
Child Black	0.08		0.01	0.17		0.01	***
Child Asian/other	0.16		0.01	0.14		0.01	
Child home language English	0.15		<0.01	0.20		0.01	***
Child home language Spanish	0.61		<0.01	0.57		0.01	*
Child home language Other	0.25		<0.01	0.23		0.01	
Family characteristics							
Household income-to-needs ratio	1.13	0.72	0.20	1.07	0.73	0.30	
Household size	5.07	1.54	0.03	4.84	1.42	0.20	***
Household members under 18	2.59	1.27	0.03	2.56	1.18	0.20	
Parent married	0.56		0.04	0.50		0.22	**
Parent living with partner	0.15		0.04	0.19		0.22	**
Parent separated or widowed	0.10		0.04	0.13		0.22	
Parent never married	0.19		0.04	0.19		0.22	
Parent age	33.47	7.10	0.13	34.15	7.10	0.29	*
Parent years of education	11.78	3.72	0.05	11.74	3.70	0.22	
Parent hours of employment	25.87	15.21	0.09	27.10	13.97	0.24	
Sample size	1,247			1,334			

Notes. Proportions may not sum to 1.00 due to rounding.
*** $p < .001$.
** $p < .01$.
* $p < .05$.

Table 2.
Associations between pre-K attendance and children's early learning and development in kindergarten.

Outcome	Benefits of pre-K in the…		Convergence in the benefits of pre-K	Convergence in the benefits of pre-K when adjusting for…				
	Fall of kindergarten	Spring of kindergarten		Kindergarten classroom wide factors	Kindergarten entry academic achievement	Kindergarten entry executive function	Kindergarten entry SEL skills	Children's individual experiences in kindergarten
Academic achievement composite	0.52 ***	0.22 ***	-0.30 ***	-0.32 ***	-0.25 ***	-0.25 ***	-0.24 ***	-0.24 ***
	(0.04)	(0.04)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
WJ-III Letter-Word Identification	0.53 ***	0.11 **	-0.42 ***	-0.44 ***	-0.30 ***	-0.30 ***	-0.29 ***	-0.29 ***
	(0.04)	(0.04)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)
WJ-III Picture Vocabulary	0.36 ***	0.20 ***	-0.16 ***	-0.16 ***	-0.14 ***	-0.14 ***	-0.15 ***	-0.15 ***
	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
WJ-III Applied Problems	0.48 ***	0.21 ***	-0.27 ***	-0.30 ***	-0.15 ***	-0.16 ***	-0.16 ***	-0.15 ***
	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
WJ-III Quantitative Concepts	0.36 ***	0.14 ***	-0.23 ***	-0.24 ***	-0.24 ***	-0.24 ***	-0.23 ***	-0.23 ***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
WJ-III Academic Knowledge	0.43 ***	0.23 ***	-0.21 ***	-0.24 ***	-0.15 ***	-0.16 ***	-0.15 ***	-0.15 ***
	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Executive functioning composite	0.34 ***	0.20 ***	-0.14 ***	-0.15 ***	-0.13 ***	-0.12 **	-0.10 *	-0.10 *
	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	0.04
Pencil Tap	0.31 ***	0.11 *	-0.20 ***	-0.22 ***	-0.14 *	-0.08	-0.06	-0.06
	(0.04)	(0.04)	(0.05)	(0.06)	(0.07)	(0.06)	(0.06)	(0.06)
Backward Digit Span	0.18 ***	0.19 ***	0.01	-0.01	0.02	-0.04	-0.02	-0.02
	(0.04)	(0.04)	(0.04)	(0.06)	(0.06)	(0.05)	(0.05)	(0.05)
Head Toes Knees Shoulders	0.29 ***	0.15 ***	-0.14 ***	-0.14 **	-0.13 *	-0.12 **	-0.10 *	-0.11 *
	(0.04)	(0.04)	(0.04)	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)
Socioemotional skills composite	0.02	-0.10 *	-0.12 **	-0.09 *	-0.08	-0.08	-0.14 ***	-0.12 **
	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Frustration Tolerance	-0.00	-0.10	-0.10 *	-0.08	-0.06	-0.06	-0.10 *	-0.08
	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)
Task Orientation	0.16 ***	0.01	-0.15 ***	-0.14 **	-0.11 *	-0.11 *	-0.14 ***	-0.13 **
	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.05)	(0.04)	(0.04)
Peer Social Skills	0.01	-0.09	-0.11 *	-0.09	-0.05	-0.05	-0.11 *	-0.09
	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Conduct Problems	0.10	0.15 **	0.05	0.02	-0.01	-0.01	0.09	0.07

	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)

Notes. All models controlled for child age, child gender, child race/ethnicity, home language, parent years of education, parent work hours, parent marital status, income-to-needs-ratio, household size, number of children under 18 in the household, and parent age and time between assessments. Additionally, all focal continuous variables have been standardized to have a mean of 0 and standard deviation of 1, and thus, estimates correspond to effect sizes. Estimates in parentheses correspond to standard errors and adjust for classroom level clustering. The fall and spring models include children's performance on each assessment at either the fall or spring of kindergarten. The convergence in the benefits of pre-K models are based on a difference in difference framework and consider how much pre-K attenders gained in kindergarten as compared with non-attenders. Each subsequent model builds on this convergence model and includes a series of new variables in the regression equation. The kindergarten classroom wide factors model incorporates classroom fixed effects. The kindergarten entry achievement, executive function, and socioemotional skills models incorporate children's kindergarten entry scores on these benchmarks (along with classroom fixed effects). The final convergence model incorporates indicators for children's relationships with their teachers (closeness and conflict) along with children's feelings about their teachers, peers, and their school liking (along with classroom fixed effects and children's kindergarten entry skills).
*** $p < .001$. ** $p < .01$. * $p < .05$.

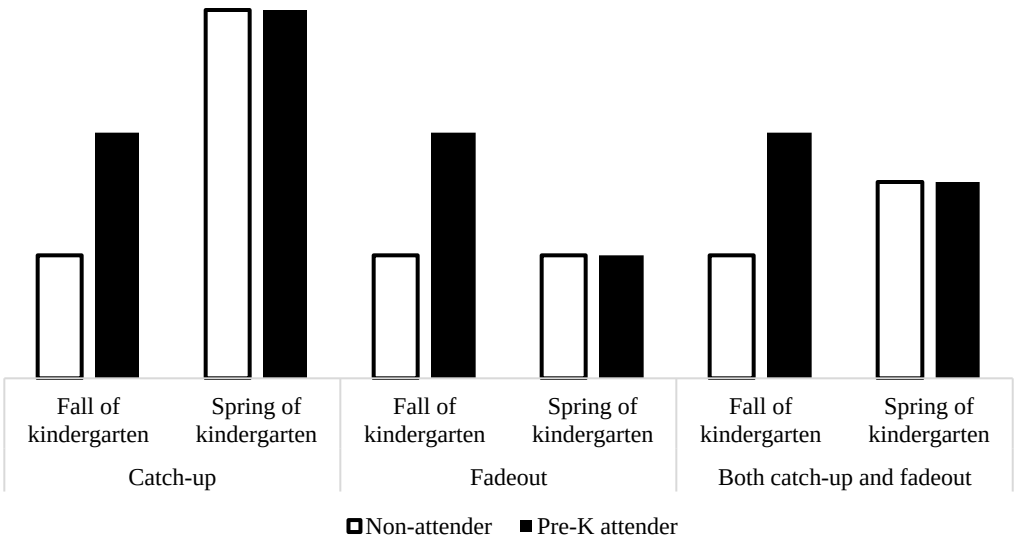

Figure 1. *An illustration of the different sources of convergence in the early benefits of pre-K.*

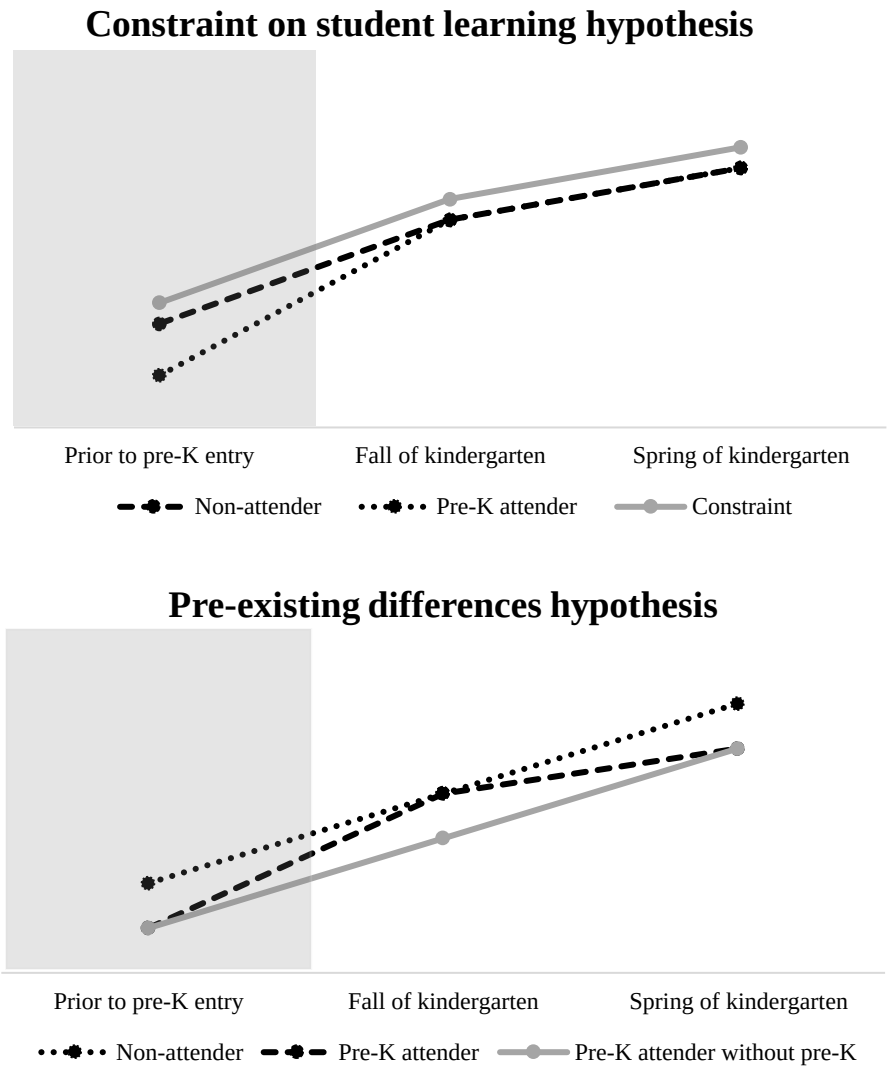

Figure 2. *An illustration of the constraint on student learning hypothesis (top panel) and pre-existing differences hypothesis (bottom panel) for higher achieving non-attenders. The grey line in the left panel corresponds to an imposed limit or constraint on higher achieving children. The grey line in the right panel corresponds to the learning trajectory of a pre-K attender if they did not receive pre-K. Although the current study does not have data on all children prior to kindergarten entry, the grey blocks correspond to what children's outcomes would look like in light of both hypotheses if data were available. The above figure is adapted from Bailey and colleagues (2016).*