The Acquisition of Academic and Executive Functioning Skills During Early Elementary School: Contrasting the Role of Constrained and Unconstrained Prekindergarten Skills

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Introduction

Background
- Questions have been raised about whether the skills often promoted in pre-k programs predict the acquisition of the skills needed for school success (e.g. Farran & Lipsey, 2017)
- The skills children learn can be categorized as constrained or unconstrained (Snow & Matthews, 2016)
  - Constrained: finite, learned quickly and easily
  - Unconstrained: large domains acquired through experience
- There is concern that early education may focus too much on constrained skills and not enough on unconstrained skills

Limitations of Existing Work
- Focus on one or a small subset of skills at a single timepoint
  - School-related skills tend to be moderately to highly correlated
  - Does not allow for an examination of how early skills relate to gains in children's skills

The Present Study

- Explores the end of pre-k skills that are important for predicting the level of skills children have upon entering kindergarten and gains in skills through the end of first grade
- Two main hypotheses:
  1. A skill within a given domain will be the best predictor of that outcome at the start of kindergarten
  2. Unconstrained skills (i.e., vocabulary, executive functioning, and learning behaviors) will be the best predictors of gains in skills over time

Method

- Longitudinal cohort study with children from 6 rural NC counties
  - 63 randomly-selected NC Pre-K classrooms in 45 settings
  - 455 randomly-selected children

- Children's skills were assessed each fall and spring
  - Children's skills from the spring of pre-k were used as predictors
  - Outcomes included children's skills from the fall of kindergarten to the spring of first grade

- Measures
  - Woodcock-Johnson Tests of Achievement III – Math, literacy, and vocabulary
  - NIH Toolbox – Executive function (cognitive flexibility and inhibitory control)
  - Learning Behaviors Scale

Descriptive Statistics

Table 1

Descriptive Statistics for Sample Characteristics and Pre-K Skills

	N	Proportion	-
Demographics			
Child Sex			
Male	230	0.51	-
Female	225	0.49	-
Race/Ethnicity			
White	109	0.24	-
Black	134	0.30	-
Hispanic/Latino	192	0.42	-
Other	19	0.04	-
Language			
English Only	260	0.57	-
Dual Language Learner	195	0.53	-
Household Income (< $30,000)	198	0.54	-
Household Income (> $30,000)	170	0.46	-

	N	Mean	Std. Deviation
Maternal Education	452	12.25	2.44
Classroom Quality			
CLASS Pre-K	451	4.35	0.59
CLASS K	346	4.60	0.60
CLASS Grade 1	242	4.36	0.62
Pre-K Assessments			
WJ AP - Math	438	406.87	22.11
WJ LW - Decoding	439	339.39	23.58
WJ PV - Vocabulary	433	459.50	17.31
Cognitive Flexibility	417	19.64	13.13
Inhibitory Control	428	26.66	11.81
Learning Behaviors	424	1.71	0.34

Mean of WJ Applied Problems Over Time

Mean of WJ Letter Word Identification Over Time

Mean of WJ Picture Vocabulary Over Time

Mean of Cognitive Flexibility Over Time
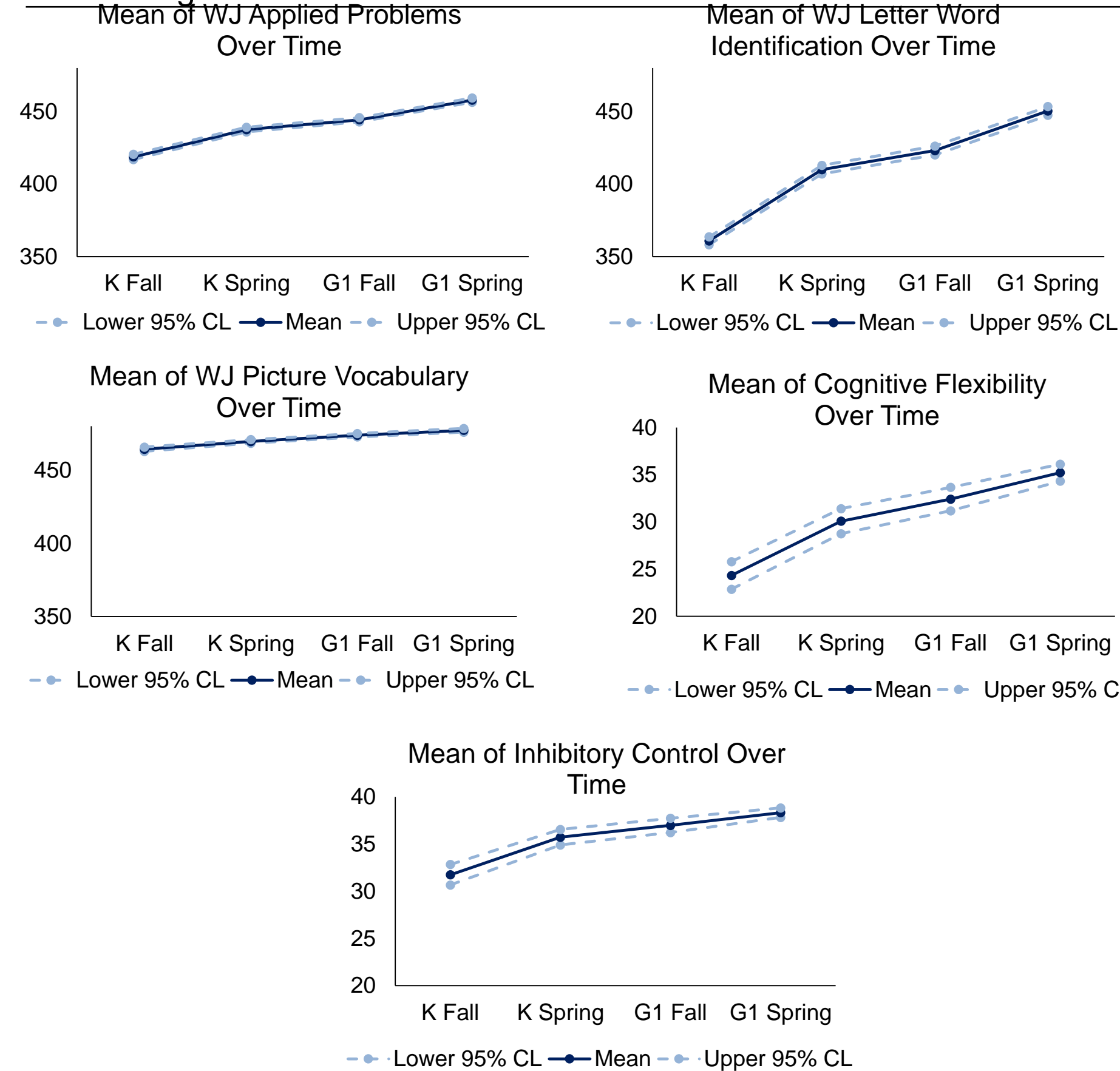

Mean of Inhibitory Control Over Time

Figure 1. Gains in child outcomes from the start of kindergarten to the end of first grade.

Analyses

- Hierarchical linear modeling (HLM) examined children's skill trajectories across four time points
- Multiple imputation to handle missing data
- Reduced form equation:

$$Y_{ij} = (B_0 + B_1 Grade_{ij} + B_2 Grade^2_{ij} + B_3 <PrekSkills>_j + B_4 <Covariates>_j +$$

$$B_5 <Pre\text{-}K\ Skills>_j * Grade_{ij} + B_6 <Pre\text{-}Skills>_j * Grade^2_{ij} + B_7 Quality_{ij}) +$$

$$(u_{0j} + u_{1j} Grade_{ij} + u_{2j} Grade^2_{ij}) + r_{ij}$$

Results

Table 2

Pre-Kindergarten Skills Predicting Child Outcomes at the Beginning of Kindergarten and Change Over Time

	Child Outcomes				
	WJ AP – Math	WJ LW – Decoding	WJ PV - Vocabulary	Cognitive Flexibility	Inhibitory Control
	B(se)	B(se)	B(se)	B(se)	B(se)
Intercept	420.05***(0.65)	363.68***(1.04)	464.80***(0.39)	3.35***(0.10)	4.54***(0.08)
Pre-K Skills					
WJ AP – Math	0.59***(0.08)	0.16(0.14)	0.10*(0.05)	0.01(0.01)	0.02+(0.01)
WJ LW – Decoding	0.09(0.07)	1.18***(0.11)	-0.00(0.04)	-0.00(0.01)	-0.01(0.01)
WJ PV – Vocabulary	0.21***(0.06)	0.21*(0.10)	0.71***(0.04)	0.02**(0.01)	0.00(0.01)
Cognitive Flexibility	0.56(0.38)	0.41(0.57)	0.29(0.22)	0.25***(0.05)	-0.01(0.04)
Inhibitory Control	1.68***(0.36)	1.52**(0.57)	-0.07(0.22)	0.11*(0.05)	0.29***(0.04)
Learning behaviors	6.57**(2.24)	5.71(3.49)	0.64(1.30)	0.61*(0.32)	1.17***(0.26)
Grade	16.54*(0.78)	44.53***(1.22)	5.74***(0.49)	0.85*(0.13)	0.74***(0.12)
Pre-K Skills					
WJ AP*grade	-0.10(0.10)	0.34*(0.15)	-0.01(0.06)	0.03*(0.02)	0.00(0.01)
WJ LW*grade	-0.06(0.09)	-0.41***(0.12)	-0.04(0.05)	-0.00(0.01)	0.01(0.01)
WJ PV*grade	-0.16*(0.07)	-0.12(0.10)	-0.21***(0.04)	-0.03*(0.01)	-0.02(0.01)
CF*grade	-0.06(0.42)	0.17(0.68)	-0.08(0.26)	-0.16*(0.08)	-0.02(0.06)
IC*grade	-0.20(0.42)	1.44*(0.66)	0.45*(0.26)	-0.12(0.08)	-0.14*(0.06)
Learning*grade	0.75(2.68)	9.78*(3.84)	-1.01(1.52)	0.51(0.45)	-0.15(0.37)
Grade²	-1.44*(0.25)	-5.51***(0.37)	-0.53*(0.15)	-0.05(0.04)	-0.05(0.04)
Pre-K Skills					
WJ AP*grade²	0.02(0.03)	-0.10*(0.05)	0.00(.02)	-0.01*(.01)	-0.00(0.00)
WJ LW*grade²	0.01(0.03)	0.10*(0.04)	0.02(0.02)	0.00(0.00)	-0.00(0.00)
WJ PV*grade²	0.03(0.02)	0.05*(0.03)	0.05***(0.01)	0.01*(0.00)	0.01(0.00)
CS*grade²	0.01(0.13)	-0.06(0.20)	0.02(0.08)	0.03(0.03)	0.02(0.02)
IC*grade²	-0.01(0.13)	-0.40*(0.20)	-0.11(0.08)	0.04(0.02)	0.03(0.02)
Learning*grade²	-0.54(0.85)	-2.62*(1.19)	0.27(0.48)	-0.25(0.15)	-0.04(0.12)

Note: WJ = Woodcock Johnson, AP = Applied Problems, LW = Letter Word, PV = Picture Vocabulary, CF = cognitive flexibility, IC = inhibitory control, Learning = learning behaviors; grade coded as 0 for fall of kindergarten, 1 for spring of kindergarten, 2 for fall of grade 1, and 3 for spring of grade 1; Covariates included child sex, race, and whether they were a dual language learner, mother's years of education, household income, and classroom quality as measured by the Classroom Assessment Scoring System.

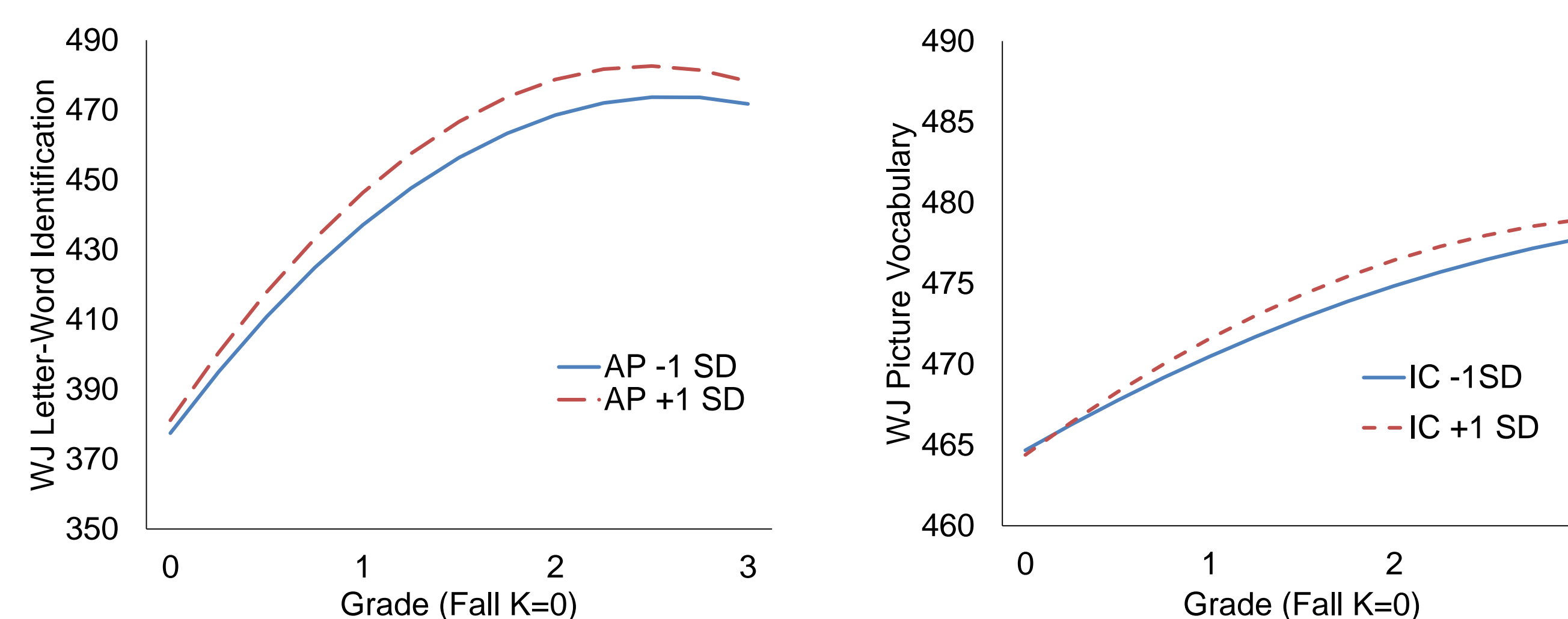+ p < .1; * p < .05; ** p < .01; *** p < .001

Figure 2. Pre-k skills predicting gains over time. The figures illustrate how greater pre-k math skill related to greater gains in letter word-identification while greater pre-k inhibitory control related to greater gains in vocabulary. Greater gains in letter-word identification were also predicted by greater inhibitory control and learning behaviors (not shown).

Results

Hypothesis 1:
- Within a given domain, pre-k skills consistently related to kindergarten entry skills

Hypothesis 2:
- Little evidence to suggest that unconstrained skills are better predictors of children's gains over time than constrained skills
  - Higher math, inhibitory control, and learning behaviors ➔ Greater gains in decoding
  - Higher inhibitory control ➔ Greater gains in vocabulary
- Across domains, two patterns emerged for gains over time:
  - Substantial gains that level off
  - Moderate linear gains
- Within a domain, starting with higher skills tended to relate to slower growth over time

Conclusions

- Three main findings from the study:
  1. Early skills within a given domain predicted outcomes in that same domain
  2. Starting with higher skills in a given area tended to relate to slower gains in that area
  3. No consistent evidence to suggest that unconstrained skills consistently related to greater gains

- Limitations include the measures of the constrained and unconstrained skills, the small set of available covariates, and an inability to make causal conclusions based on the analyses

- Overall, both constrained and unconstrained skills appear to play a role in child outcomes, suggesting a need for a more balanced research approach toward considering their impact

- More work is needed to examine:
  - How constrained and unconstrained skills relate to children's gains over time
  - Whether it is beneficial to place more emphasis on unconstrained skills in early education

References

Farran, D. C., & Lipsey, M. W. (2017). Misrepresented evidence doesn't serve pre-K programs well. Retrieved from https://www.brookings.edu/blog/education-plus-development/2017/02/24/misrepresented-evidence-doesnt-serve-pre-k-programs-well/

Snow, C. E., & Matthews, T. J. (2016). Reading and language in the early grades. *The Future of Children, 26*, 57-74.