Early Elementary Science Test Score Gaps: Differences by Race/Ethnicity, Gender, and Language Backgrounds

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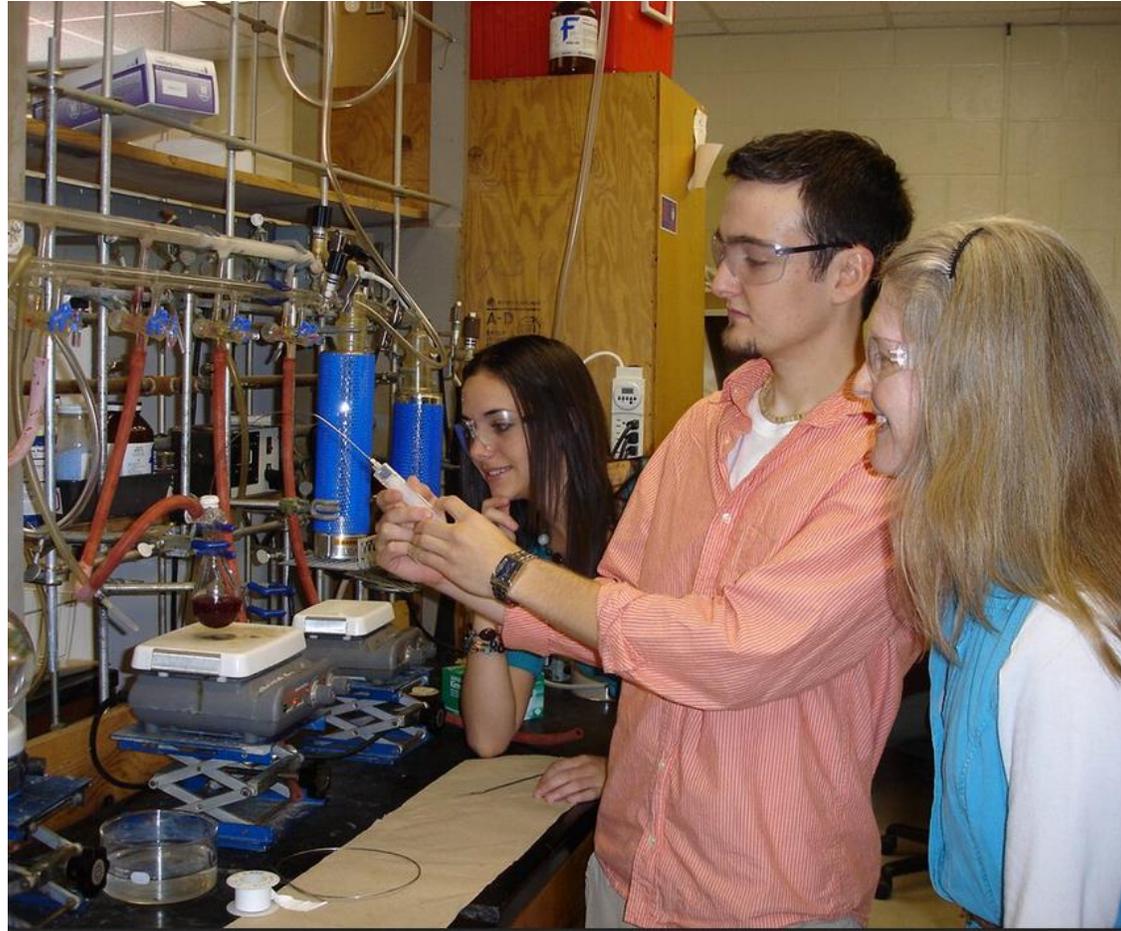
Today's Talk

- Curran, F. C. & Kellogg, A. T. (2016). Understanding Science Achievement Gaps by Race/Ethnicity and Gender in Kindergarten and First Grade. *Educational Researcher*, *45*(5), 273-282.

- Curran, F.C. (2017). Income-Based Disparities in Early Elementary School Science Achievement. *The Elementary School Journal, 118*(2), 207-231.

- Curran, F.C. & Kitchin, J. (2018). Why are the early elementary race/ethnicity test score gaps in science larger than those in reading or mathematics? National evidence on the importance of language and immigration context in explaining the gap-in-gaps. *Science Education*. Online First.

Motivation

- Test score gaps by race and income are persistent (i.e. Coleman, 1966; Reardon, 2011)

- Such gaps begin early and can change in the earliest years (i.e. Fryer & Levitt, 2004; Hart & Risley, 2003)

- To date, research focused on mathematics and English language arts (Sonnenschein & Sun, 2016)

Motivation

- Science is an important subject (Langdon et al., 2011)
  - Personal
  - Societal
  - Economic
  - Social/Political

- Disparities in science participation exist in higher grades and workforce (Beede et al., 2011; Hrabowski et al., 2011; U.S. News, 2015)

- Yet, we know little about science test score gaps in the earliest grades

Prior Literature

- NAEP (4th grade) and ECLS-K:98-99 (3rd grade)

- -0.25 SD Female-Male

- -1.0 SD Black-White gap

- -0.30 SD Asian-White gap

(Kohlhaas et al., 2010; Morgan et al., 2016; Quinn & Cooc, 2015)

Prior Literature

- Gaps can change as students move through school (Fryer & Levitt, 2004)

- Science receives less emphasis in pre-k and elementary school (Bassok, Latham, & Rorem, 2016; Bowdon & Desimone, 2014)

Research Questions

- RQ 1: How does early elementary science test performance vary by race/ethnicity and gender?

- RQ 2: How does early elementary science test performance vary by family income?

- RQ 3: What explains the wider race/ethnicity gaps in science as compared to reading or mathematics?

Theoretical Framework

- **Ecological systems theory**
  - Science test performance influenced by different contexts
    - Individual
    - Home
    - School
    - Parents
    - Extracurriculars

(Bronfenbrenner, 1979; Bronfenbrenner & Ceci, 1994; Bronfenbrenner & Morris, 1998)

Data

- Early Childhood Longitudinal Study of 2011 (ECLS-K:2011)

- Nationally representative longitudinal study of 18,000+ kindergartners in 2010-11

- Includes surveys of parents, teachers, school leaders as well as direct assessments of academic achievement

Data

- Science test performance – Spring of K; covers physical, life, environmental, and scientific inquiry

- Race/ethnicity – Mutually exclusive categories of White, Black, Hispanic, Asian, and other.

- Gender – male/female

- Family income – Categorical measure

Analytic Approach

- Descriptive and correlational analyses

- Ordinary least squares regression

- School fixed effects

Findings

- Science gaps by race and family income are present in K

- Black, Hispanic, but also Asian students lag White students in science test performance

- The Asian-White gap narrows as students move to 1st grade

- No significant differences by gender in K

- Gaps in science by race and family income tend to be larger than the corresponding mathematics and English language arts gaps

- The difference in science and math/LA gaps by race are explained in part by language/immigration contexts

RQ 1: How does early elementary science test performance vary by race/ethnicity and gender?

Analytic Approach

- *ScienceAchievement$_i$* = β$_0$ + β$_1$*Female$_i$* + β$_2$*Black$_i$* + β$_3$*Hispanic$_i$* + β$_4$*Asian$_i$* + β$_5$*OtherRace$_i$* + *e$_i$*

- Covariates
  - Socioeconomic status composite
  - Fall math and reading achievement
  - School fixed effects

Science Achievement Gaps by Race/Ethnicity and Gender for Kindergarten and First Grade

Coefficients and Standard Errors from Regressions Predicting Standardized Spring Kindergarten and First Grade Science Achievement

	Kindergarten	1st Grade	Covariate Adjusted Kindergarten Models						
	1	2	3	4	5	6	7	8	9
Female	-0.0147	-0.0623**	-0.0158	-0.00343	-0.0658***	-0.0268	-0.0251	-0.0369*	-0.0444**
	(0.0196)	(0.0194)	(0.0197)	(0.0172)	(0.0151)	(0.0162)	(0.0165)	(0.0175)	(0.0145)
Black	-0.815***	-0.818***	-0.615***	-0.535***	-0.686***	-0.562***	-0.498***	-0.548***	-0.334***
	(0.0571)	(0.0609)	(0.0479)	(0.0431)	(0.0526)	(0.0448)	(0.0417)	(0.0479)	(0.0370)
Hispanic	-0.937***	-0.782***	-0.695***	-0.595***	-0.691***	-0.592***	-0.521***	-0.551***	-0.283***
	(0.0450)	(0.0410)	(0.0409)	(0.0425)	(0.0486)	(0.0448)	(0.0402)	(0.0342)	(0.0274)
Asian	-0.551***	-0.293***	-0.628***	-0.643***	-0.695***	-0.674***	-0.695***	-0.374***	-0.472***
	(0.0586)	(0.0507)	(0.0561)	(0.0629)	(0.0568)	(0.0605)	(0.0605)	(0.0441)	(0.0364)
Other Race	-0.203**	-0.132*	-0.155*	-0.118*	-0.145*	-0.119	-0.106	-0.113**	-0.113***
	(0.0654)	(0.0515)	(0.0754)	(0.0591)	(0.0651)	(0.0612)	(0.0675)	(0.0423)	(0.0331)
Composite SES Measure (STD)			0.407***				0.169***		0.132***
			(0.0151)				(0.0171)		(0.0127)
Fall Kindergarten Math Score (STD)				0.526***		0.380***	0.356***		0.334***
				(0.0111)		(0.0153)	(0.0152)		(0.0138)
Fall Kindergarten Reading Score (STD)					0.473***	0.188***	0.162***		0.201***
					(0.0116)	(0.0144)	(0.0147)		(0.0133)
Constant	0.391***	0.374***	0.330***	0.257***	0.334***	0.272***	0.256***	0.290***	0.171***
	(0.0274)	(0.0258)	(0.0270)	(0.0222)	(0.0272)	(0.0228)	(0.0234)	(0.0139)	(0.0117)
School Fixed Effects								X	X
R^2	0.182	0.147	0.268	0.433	0.393	0.447	0.460	0.048	0.346
Adjusted R^2								0.048	0.345
Observations	10,050	10,050	10,050	10,050	10,050	10,050	10,050	10,050	10,050

Science, Mathematics, and Reading Achievement Gaps by Race/Ethnicity and Gender for Kindergarten
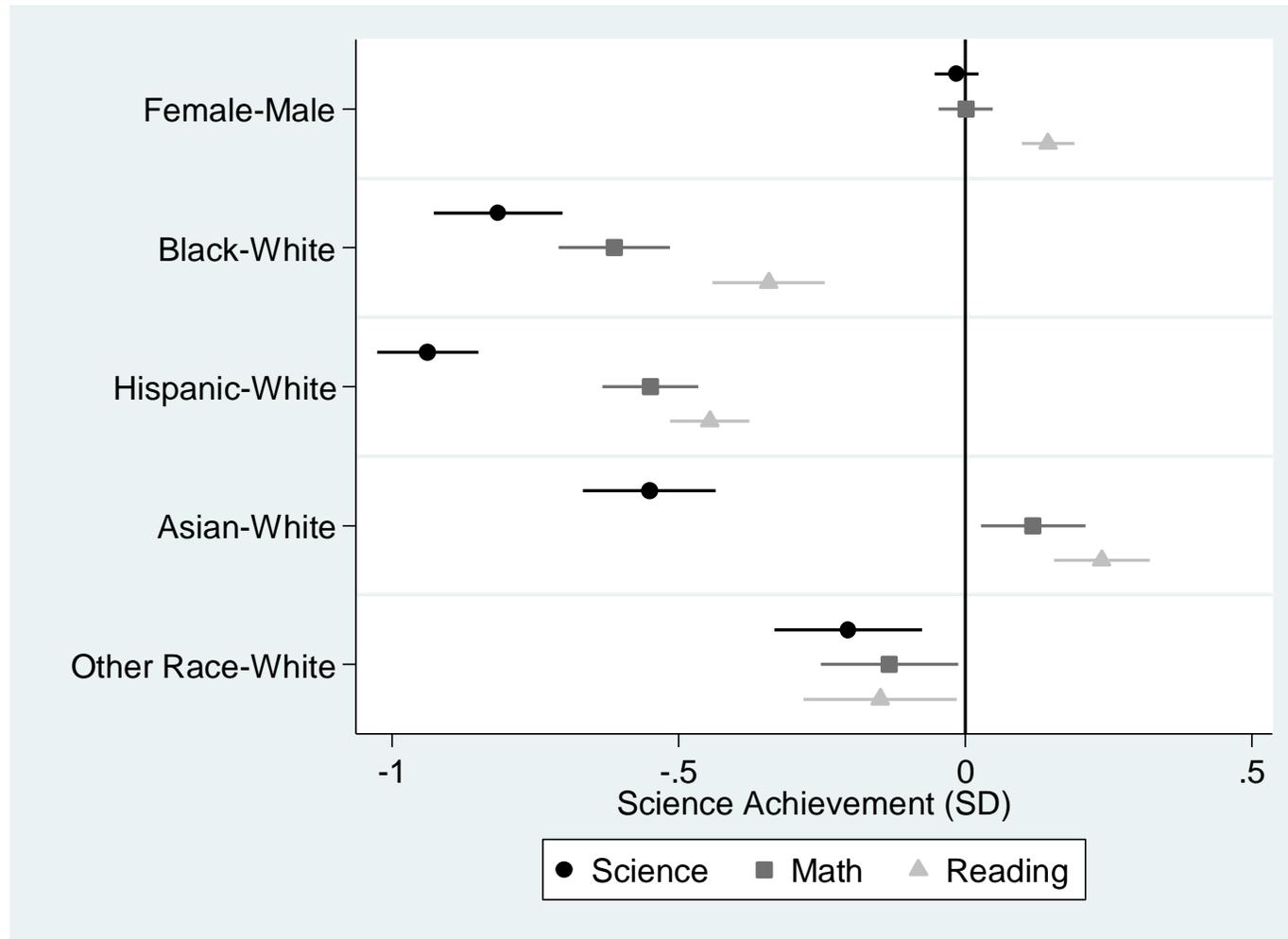
RQ 2: How does early elementary science test performance vary by family income?

Analytic Approach

- *ScienceAchievement*$_i$ = β$_0$ + β$_1$*Income*$_i$ + *e*$_i$

- Covariates
  - Student race/ethnicity
  - Out of school activities
  - Parental education
  - School fixed effects

Income-based science achievement gap in spring of kindergarten without controls and with race/ethnicity, out-of-school activities, parental education, and school fixed effect adjustments.
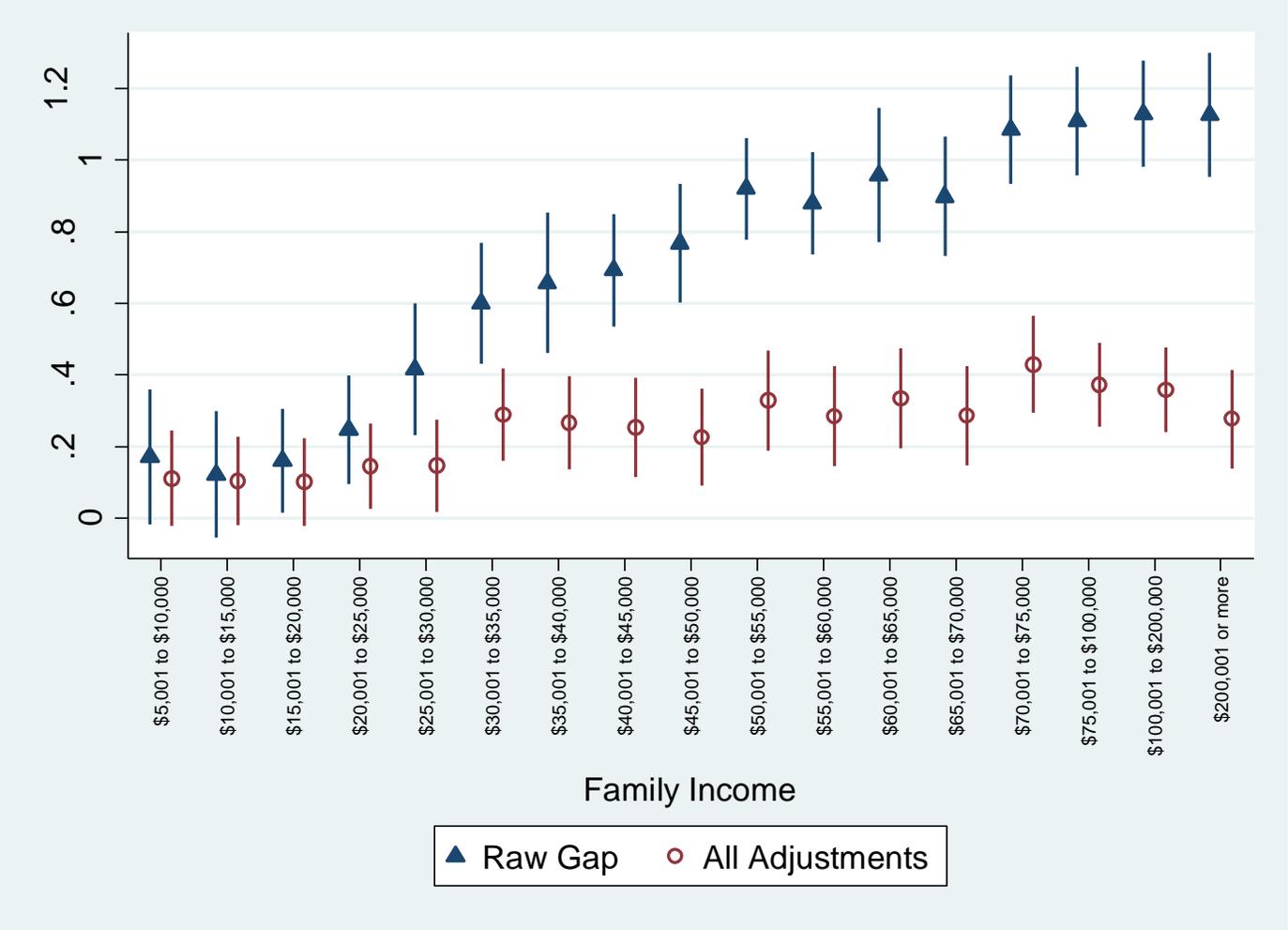
Coefficients from regressions predicting spring kindergarten achievement in science, mathematics, and reading from family income
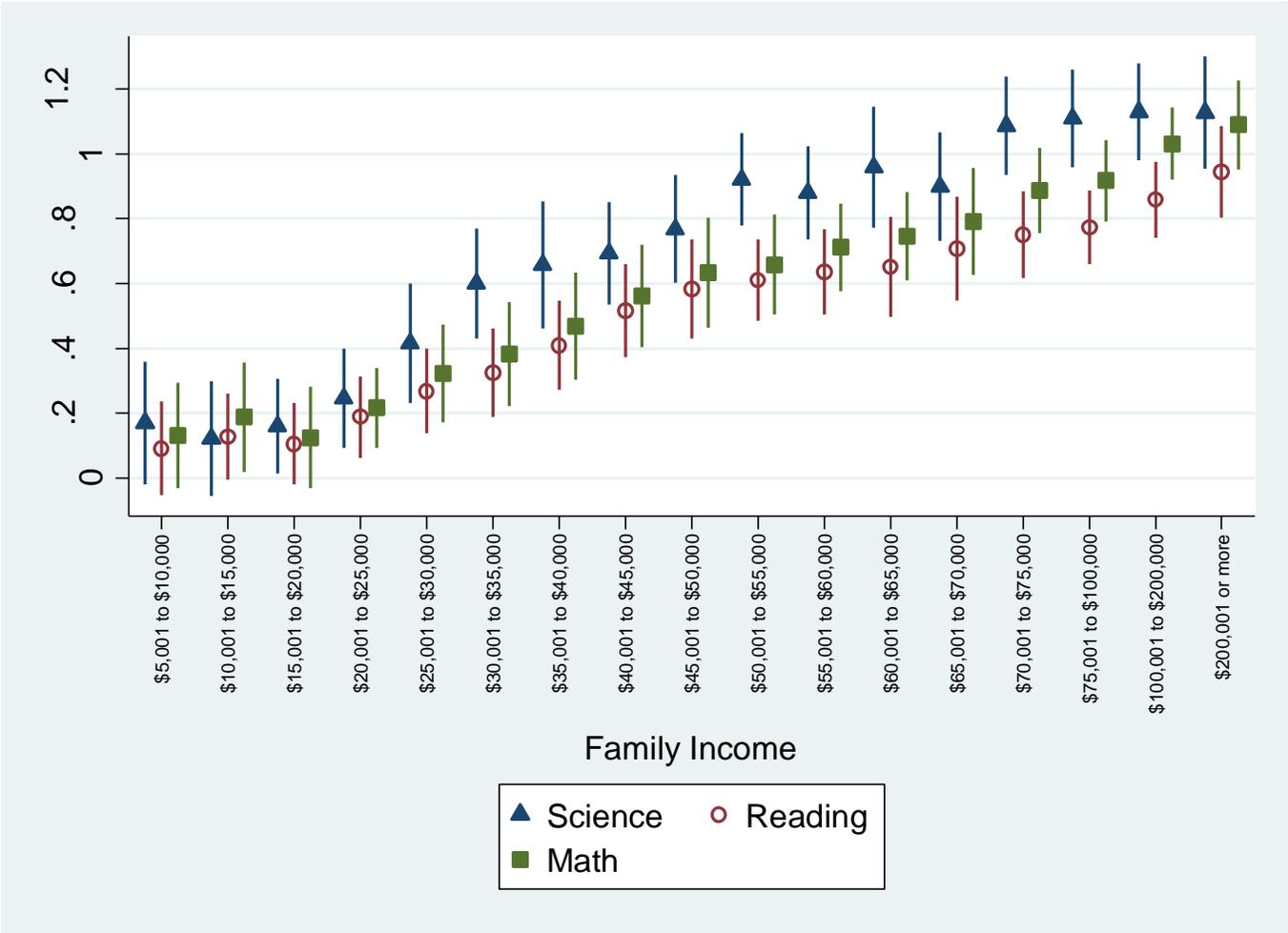
RQ 3: What explains the wider race/ethnicity gaps in science as compared to reading or mathematics?
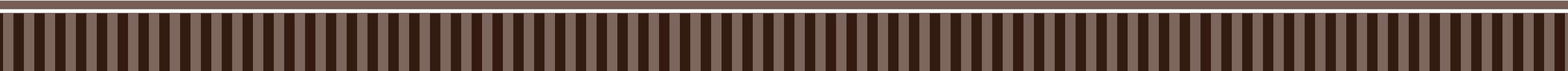
Analytic Approach

- $Achievement\_Difference_i = \beta_0 + \beta_1 Black_i + \beta_2 Hispanic_i + \beta_3 Asian_i + \beta_4 OtherRace_i + e_i$

- Where *Achievement_Difference* is either
    - Science Achievement – Mathematics Achievement
    - Science Achievement – Reading Achievement

Analytic Approach

- Covariates:
  - Dialogue with adults
  - Exposure to nature/outdoors and science activities
  - Socio-economic status
  - Language and immigration
  - Reading activities
  - Inquisitiveness
  - Early childhood education
  - Other extracurricular activities

Estimated Standardized Reading-Science Gaps in Spring of Kindergarten

					Thematic buckets controlled for in each specification						
	No Controls	Inquisitiveness	Dialogue with Adults	Socio-Economic Status	Language & Immigration	Exposure to Nature & the Outdoors	Reading Activities	Activities in the Home	Activities out of the Home	Type of Pre-Kindergarten Childcare	All Controls
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Black	-0.437***	-0.424***	-0.479***	-0.444***	-0.414***	-0.405***	-0.382***	-0.420***	-0.427***	-0.441***	-0.391***
	(0.0536)	(0.0528)	(0.0482)	(0.0486)	(0.0559)	(0.0509)	(0.0471)	(0.0516)	(0.0421)	(0.0525)	(0.0447)
Hispanic	-0.483***	-0.467***	-0.496***	-0.405***	-0.186***	-0.434***	-0.455***	-0.480***	-0.398***	-0.483***	-0.206***
	(0.0356)	(0.0356)	(0.0367)	(0.0340)	(0.0318)	(0.0340)	(0.0351)	(0.0366)	(0.0467)	(0.0367)	(0.0342)
Asian	-0.798***	-0.780***	-0.792***	-0.770***	-0.467***	-0.757***	-0.761***	-0.775***	-0.656***	-0.796***	-0.420***
	(0.0536)	(0.0542)	(0.0532)	(0.0544)	(0.0583)	(0.0522)	(0.0542)	(0.0545)	(0.0565)	(0.0537)	(0.0599)
Other Race	-0.0546	-0.0529	-0.0972	-0.0607	-0.0198	-0.0460	-0.0371	-0.0540	-0.0328	-0.0553	-0.0650
	(0.0704)	(0.0701)	(0.0711)	(0.0619)	(0.0673)	(0.0694)	(0.0687)	(0.0678)	(0.0525)	(0.0704)	(0.0587)
Constant	0.207***	-0.500	0.0604	-0.336***	0.166	-0.176*	0.0555	-0.145	0.216***	0.175***	-0.588
	(0.0229)	(0.2706)	(0.1315)	(0.0903)	(0.0966)	(0.0756)	(0.1549)	(0.1699)	(0.0321)	(0.0320)	(0.3591)
Observations	10,565	10,565	10,565	10,565	10,565	10,565	10,565	10,565	10,565	10,565	10,565

Notes: Standard errors in parentheses. All estimates weighted to account for the complex survey design of the ECLS-K. * $p<0.05$. ** $p<0.01$. *** $p<0.001$
Coefficients on Hispanic and Asian indicators in column 5 and 11 are significantly ($p<0.05$) different from that in column 1 on a Welch's t-test. All other coefficients are statistically indistinguishable from those in the uncontrolled model (column 1).

Estimated Standardized Math-Science Gaps in Spring of Kindergarten

					Thematic buckets controlled for in each specification						
	No Controls	Inquisitiveness	Dialogue with Adults	Socio-Economic Status	Language & Immigration	Exposure to Nature & the Outdoors	Reading Activities	Activities in the Home	Activities out of the Home	Type of Pre-Kindergarten Childcare	All Controls
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Black	-0.182***	-0.172***	-0.240***	-0.221***	-0.163***	-0.166***	-0.157***	-0.185***	-0.191***	-0.198***	-0.212***
	(0.0410)	(0.0398)	(0.0401)	(0.0379)	(0.0427)	(0.0404)	(0.0381)	(0.0413)	(0.0421)	(0.0403)	(0.0428)
Hispanic	-0.384***	-0.369***	-0.401***	-0.331***	-0.0945*	-0.353***	-0.355***	-0.385***	-0.398***	-0.396***	-0.147***
	(0.0471)	(0.0459)	(0.0481)	(0.0421)	(0.0380)	(0.0436)	(0.0442)	(0.0463)	(0.0467)	(0.0474)	(0.0420)
Asian	-0.640***	-0.624***	-0.635***	-0.609***	-0.358***	-0.617***	-0.614***	-0.612***	-0.656***	-0.638***	-0.334***
	(0.0554)	(0.0556)	(0.0543)	(0.0546)	(0.0568)	(0.0541)	(0.0566)	(0.0558)	(0.0565)	(0.0548)	(0.0548)
Other Race	-0.0255	-0.0244	-0.0686	-0.0493	-0.000536	-0.0200	-0.0179	-0.0283	-0.0328	-0.0320	-0.0673
	(0.0527)	(0.0525)	(0.0564)	(0.0479)	(0.0513)	(0.0526)	(0.0547)	(0.0509)	(0.0525)	(0.0521)	(0.0502)
Constant	0.152***	-0.580*	0.162	-0.331***	0.0316	-0.0975	-0.0921	-0.224	0.216***	0.129***	-0.561
	(0.0213)	(0.2439)	(0.1160)	(0.0911)	(0.0725)	(0.0802)	(0.1047)	(0.1446)	(0.0321)	(0.0264)	(0.3031)
Observations	10,565	10,565	10,565	10,565	10,565	10,565	10,565	10,565	10,565	10,565	10,565

Notes: Standard errors in parentheses. All estimates weighted to account for the complex survey design of the ECLS-K. * p<0.05. ** p<0.01. *** p<0.001 Coefficients on Hispanic and Asian indicators in column 5 and 11 are significantly ($p<0.05$) different from that in column 1 on a Welch's t-test. All other coefficients are statistically indistinguishable from those in the uncontrolled model (column 1).

Test Score Gaps by Subject with and Without Controls for Language/Immigration
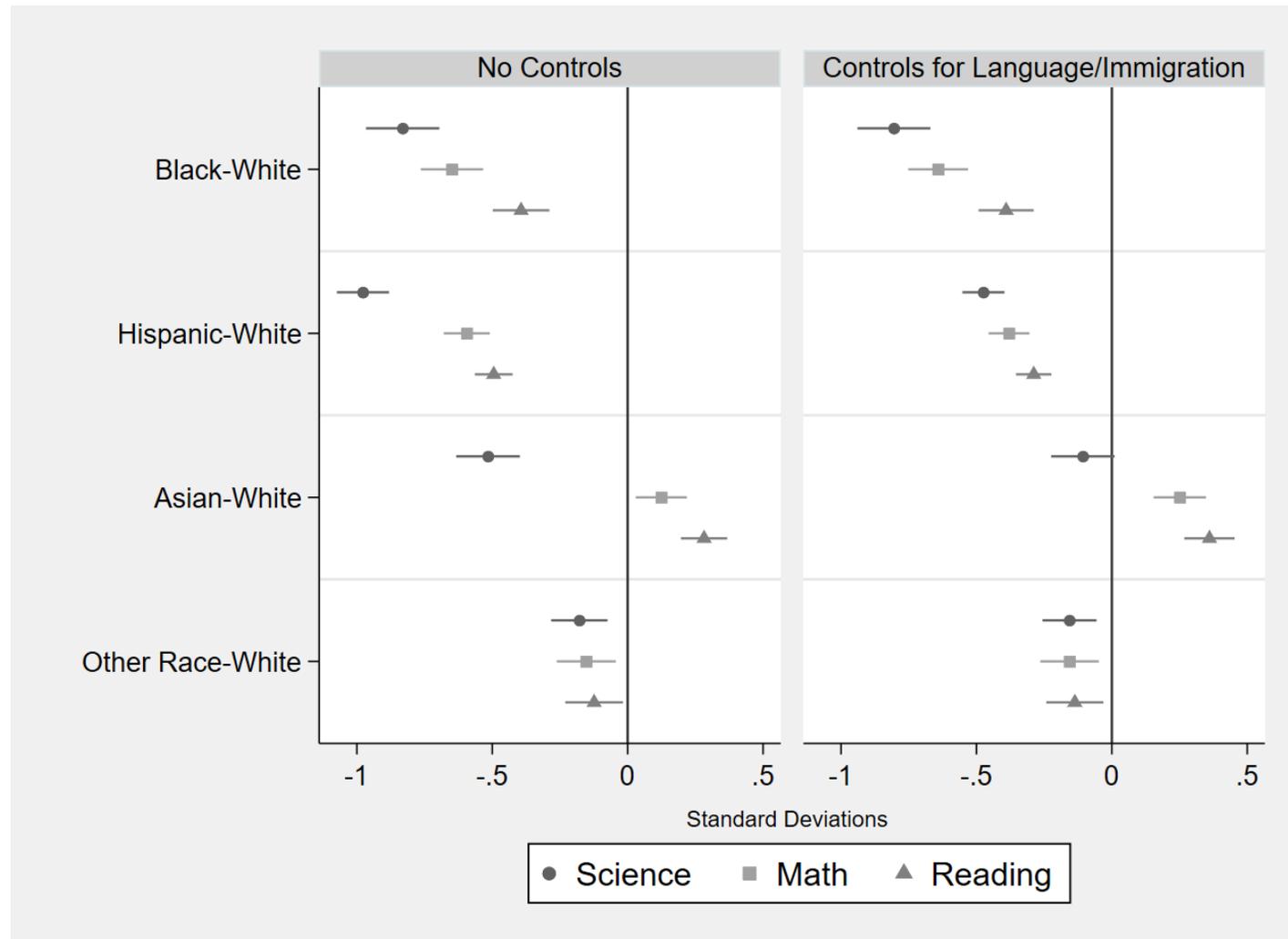
Probing Further

- Primary parent's proficiency with English and whether the parent was born outside of the US were the strongest predictors of the gap-in-gaps

- Possible Explanations:
  - Bilingual profile effects
  - Cultural discontinuities with science learning environments
  - Linguistic and cultural biases of assessments

Findings

- Science gaps by race and family income are present in K

- Black, Hispanic, but also Asian students lag White students in science test performance

- The Asian-White gap narrows as students move to 1st grade

- No significant differences by gender

- Gaps in science by race and family income tend to be larger than the corresponding mathematics and English language arts gap

- The difference in science and math/LA gaps by race are explained in part by language/immigration contexts

Implications

- Need for increased emphasis on early science learning opportunities

- Policies and interventions that provide such opportunities to more disadvantaged groups

- Increase in cross-cutting instruction of science content in elementary school

Future Research

- Examining influence of science instruction in early grades on science achievement gains and equity in science

- Qualitative work on home and early formal schooling science instruction

Thanks!

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