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

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Today’s Talk


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

- $ScienceAchievement_i = \beta_0 + \beta_1 Female_i + \beta_2 Black_i + \beta_3 Hispanic_i + \beta_4 Asian_i + \beta_5 OtherRace_i + e_i$

- **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

![Graph showing science achievement gaps by race/ethnicity and gender for kindergarten and first grade.](image-url)
<table>
<thead>
<tr>
<th></th>
<th>Kindergarten</th>
<th>1st Grade</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Female</strong></td>
<td>-0.0147</td>
<td>-0.0623**</td>
<td>-0.00343</td>
<td>-0.0658***</td>
<td>-0.0268</td>
<td>-0.0251</td>
<td>-0.0369^</td>
</tr>
<tr>
<td></td>
<td>(0.0196)</td>
<td>(0.0194)</td>
<td>(0.0197)</td>
<td>(0.0172)</td>
<td>(0.0151)</td>
<td>(0.0162)</td>
<td>(0.0165)</td>
</tr>
<tr>
<td><strong>Black</strong></td>
<td>-0.815***</td>
<td>-0.818***</td>
<td>-0.615***</td>
<td>-0.535***</td>
<td>-0.686***</td>
<td>-0.562***</td>
<td>-0.498***</td>
</tr>
<tr>
<td></td>
<td>(0.0571)</td>
<td>(0.0609)</td>
<td>(0.0479)</td>
<td>(0.0431)</td>
<td>(0.0526)</td>
<td>(0.0448)</td>
<td>(0.0417)</td>
</tr>
<tr>
<td><strong>Hispanic</strong></td>
<td>-0.937***</td>
<td>-0.782***</td>
<td>-0.695***</td>
<td>-0.595***</td>
<td>-0.691***</td>
<td>-0.592***</td>
<td>-0.521***</td>
</tr>
<tr>
<td></td>
<td>(0.0450)</td>
<td>(0.0410)</td>
<td>(0.0409)</td>
<td>(0.0425)</td>
<td>(0.0486)</td>
<td>(0.0448)</td>
<td>(0.0402)</td>
</tr>
<tr>
<td><strong>Asian</strong></td>
<td>-0.551***</td>
<td>-0.293***</td>
<td>-0.628***</td>
<td>-0.643***</td>
<td>-0.695***</td>
<td>-0.674***</td>
<td>-0.695***</td>
</tr>
<tr>
<td></td>
<td>(0.0586)</td>
<td>(0.0507)</td>
<td>(0.0561)</td>
<td>(0.0629)</td>
<td>(0.0568)</td>
<td>(0.0605)</td>
<td>(0.0605)</td>
</tr>
<tr>
<td><strong>Other Race</strong></td>
<td>-0.203**</td>
<td>-0.132*</td>
<td>-0.155*</td>
<td>-0.118*</td>
<td>-0.145*</td>
<td>-0.119</td>
<td>-0.106</td>
</tr>
<tr>
<td></td>
<td>(0.0654)</td>
<td>(0.0515)</td>
<td>(0.0754)</td>
<td>(0.0591)</td>
<td>(0.0651)</td>
<td>(0.0612)</td>
<td>(0.0675)</td>
</tr>
<tr>
<td>Composite SES Measure (STD)</td>
<td>0.407***</td>
<td>0.169***</td>
<td>0.132***</td>
<td>0.0151</td>
<td>0.0171</td>
<td>0.0127</td>
<td></td>
</tr>
<tr>
<td>Fall Kindergarten Math Score (STD)</td>
<td>0.526***</td>
<td>0.380***</td>
<td>0.356***</td>
<td>0.0111</td>
<td>0.0153</td>
<td>0.0152</td>
<td></td>
</tr>
<tr>
<td>Fall Kindergarten Reading Score (STD)</td>
<td>0.473***</td>
<td>0.188***</td>
<td>0.162***</td>
<td>0.0116</td>
<td>0.0144</td>
<td>0.0147</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.391***</td>
<td>0.374***</td>
<td>0.330***</td>
<td>0.257***</td>
<td>0.334***</td>
<td>0.272***</td>
<td>0.256***</td>
</tr>
<tr>
<td></td>
<td>(0.0274)</td>
<td>(0.0258)</td>
<td>(0.0270)</td>
<td>(0.0222)</td>
<td>(0.0272)</td>
<td>(0.0228)</td>
<td>(0.0234)</td>
</tr>
<tr>
<td>School Fixed Effects</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.182</td>
<td>0.147</td>
<td>0.268</td>
<td>0.433</td>
<td>0.393</td>
<td>0.447</td>
<td>0.460</td>
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<tr>
<td>Observations</td>
<td>10,050</td>
<td>10,050</td>
<td>10,050</td>
<td>10,050</td>
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<td>10,050</td>
<td>10,050</td>
</tr>
</tbody>
</table>
Science, Mathematics, and Reading Achievement Gaps by Race/Ethnicity and Gender for Kindergarten

![Graph showing science, math, and reading achievement gaps by race/ethnicity and gender for kindergarten students. The graph includes comparisons for Female-Male, Black-White, Hispanic-White, Asian-White, and Other Race-White.]
RQ 2: How does early elementary science test performance vary by family income?
Analytic Approach

- \( ScienceAchievement_i = \beta_0 + \beta_1 Income_i + e_i \)

- 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 compared to reading or mathematics?
Analytic Approach

\[ \text{Achievement\_Difference}_i = \beta_0 + \beta_1 \text{Black}_i + \beta_2 \text{Hispanic}_i + \beta_3 \text{Asian}_i + \beta_4 \text{OtherRace}_i + e_i \]

Where \text{Achievement\_Difference} is either

- Science Achievement – Mathematics Achievement
- Science Achievement – Reading Achievement
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

<table>
<thead>
<tr>
<th></th>
<th>No Controls</th>
<th>Inquisitiveness</th>
<th>Dialogue with Adults</th>
<th>Socio-Economic Status</th>
<th>Language &amp; Immigration to Nature &amp; the Outdoors</th>
<th>Exposure to Nature &amp; the Outdoors</th>
<th>Reading Activities</th>
<th>Activities in the Home</th>
<th>Activities out of the Home</th>
<th>Type of Pre-Kindergarten Childcare</th>
<th>All Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>-0.437***</td>
<td>-0.424***</td>
<td>-0.479***</td>
<td>-0.444***</td>
<td>-0.414***</td>
<td>-0.405***</td>
<td>-0.382***</td>
<td>-0.420***</td>
<td>-0.427***</td>
<td>-0.441***</td>
<td>-0.391***</td>
</tr>
<tr>
<td></td>
<td>(0.0536)</td>
<td>(0.0528)</td>
<td>(0.0482)</td>
<td>(0.0486)</td>
<td>(0.0559)</td>
<td>(0.0509)</td>
<td>(0.0471)</td>
<td>(0.0516)</td>
<td>(0.0421)</td>
<td>(0.0525)</td>
<td>(0.0447)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>-0.483***</td>
<td>-0.467***</td>
<td>-0.496***</td>
<td>-0.405***</td>
<td>-0.186***</td>
<td>-0.434***</td>
<td>-0.455***</td>
<td>-0.480***</td>
<td>-0.398***</td>
<td>-0.483***</td>
<td>-0.206***</td>
</tr>
<tr>
<td></td>
<td>(0.0356)</td>
<td>(0.0356)</td>
<td>(0.0367)</td>
<td>(0.0340)</td>
<td>(0.0318)</td>
<td>(0.0340)</td>
<td>(0.0351)</td>
<td>(0.0366)</td>
<td>(0.0467)</td>
<td>(0.0367)</td>
<td>(0.0342)</td>
</tr>
<tr>
<td>Asian</td>
<td>-0.798***</td>
<td>-0.780***</td>
<td>-0.792***</td>
<td>-0.770***</td>
<td>-0.467***</td>
<td>-0.757***</td>
<td>-0.761***</td>
<td>-0.775***</td>
<td>-0.656***</td>
<td>-0.796***</td>
<td>-0.420***</td>
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<tr>
<td></td>
<td>(0.0536)</td>
<td>(0.0542)</td>
<td>(0.0532)</td>
<td>(0.0544)</td>
<td>(0.0583)</td>
<td>(0.0522)</td>
<td>(0.0542)</td>
<td>(0.0545)</td>
<td>(0.0565)</td>
<td>(0.0565)</td>
<td>(0.0599)</td>
</tr>
<tr>
<td>Other Race</td>
<td>-0.0546</td>
<td>-0.0529</td>
<td>-0.0972</td>
<td>-0.0607</td>
<td>-0.0198</td>
<td>-0.0460</td>
<td>-0.0371</td>
<td>-0.0540</td>
<td>-0.0328</td>
<td>-0.0533</td>
<td>-0.0650</td>
</tr>
<tr>
<td></td>
<td>(0.0704)</td>
<td>(0.0701)</td>
<td>(0.0711)</td>
<td>(0.0619)</td>
<td>(0.0673)</td>
<td>(0.0694)</td>
<td>(0.0687)</td>
<td>(0.0678)</td>
<td>(0.0525)</td>
<td>(0.0704)</td>
<td>(0.0587)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.207***</td>
<td>-0.500</td>
<td>0.0604</td>
<td>-0.336***</td>
<td>0.166</td>
<td>-0.176*</td>
<td>0.0555</td>
<td>-0.145</td>
<td>0.216***</td>
<td>0.175***</td>
<td>-0.588</td>
</tr>
<tr>
<td></td>
<td>(0.0229)</td>
<td>(0.2706)</td>
<td>(0.1315)</td>
<td>(0.0903)</td>
<td>(0.0966)</td>
<td>(0.0756)</td>
<td>(0.1549)</td>
<td>(0.1699)</td>
<td>(0.0321)</td>
<td>(0.0320)</td>
<td>(0.3591)</td>
</tr>
</tbody>
</table>

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