Genetics, Social Class, and Education in Child Development

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Center for Neuroscience & Society
University of Pennsylvania
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How Much Can We Boost IQ and Scholastic Achievement?

ARTHUR R. JENSEN

University of California, Berkeley

Arthur Jensen argues that the failure of recent compensatory education efforts to produce lasting effects on children's IQ and achievement suggests that the premises on which these efforts have been based should be reexamined.

Jensen's infamous 1969 article in *Harvard Educational Review*

The Nature-Nurture Tension in Cognitive Development and Academic Achievement

Intelligence is mostly a matter of heredity, as we know from studies of identical twins reared apart. . . . Social programs that seek to raise I.Q. are bound to be futile. Cognitive inequalities, being written in the genes, are here to stay, and so are the social inequalities that arise from them. What I have just summarized, with only a hint of caricature, is the hereditarian view of intelligence.

—Jim Holt, *New York Times* Sunday Book Review, March 27, 2009

Identical Twins,
Separated at Birth & Reared Apart

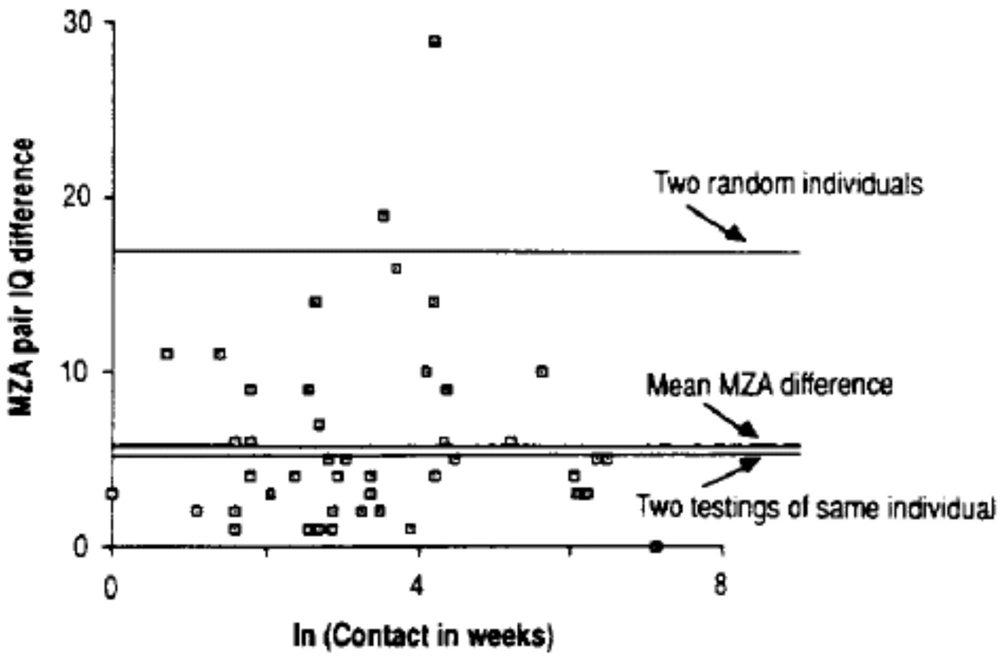


Fig. 1. The absolute value of the MZA within-pair IQ difference as a function of the natural logarithm of pair contact in weeks. The horizontal lines are the expected absolute IQ difference between two randomly selected individuals, the observed average MZA absolute difference, and the expected IQ difference between two testings of the same individual.

Rescue from extreme neglect, randomized timing

www.sciencemag.org SCIENCE VOL 318 21 DECEMBER 2007

Cognitive Recovery in Socially Deprived Young Children: The Bucharest Early Intervention Project

Charles A. Nelson III,[1]* Charles H. Zeanah,[2] Nathan A. Fox,[3]
Peter J. Marshall,[4] Anna T. Smyke,[2] Donald Guthrie[5]

Age at placement	42 months (BSID-II)			
	N	Mean	SD	SE
0–18 months	14	94.4	11.9	3.2
18–24 months	16	89.0	11.3	2.8
24–30 months	22	80.1	13.3	2.8
30+ months	9	79.7	17.1	5.7

The Gene-Environment Paradox

- “We know that potent environmental factors exist; [Classical Behavioral Genetics] suggests that they should not exist. How can this paradox be resolved?”
  - Dickens & Flynn (2001)

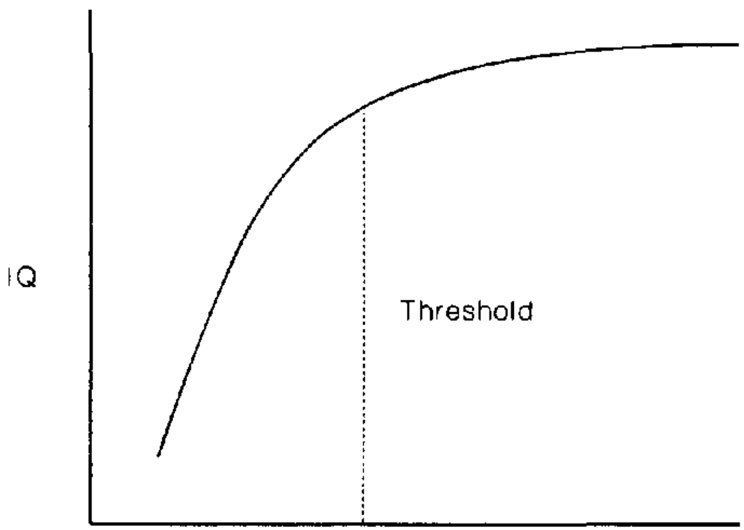
Nonlinearities in Environmental Potency?

Psychological Bulletin
1991, Vol. 110, No. 3, 392–405

0033-2909/91/$3.00

Individual and Group Differences in Adoption Studies of IQ

Eric Turkheimer
University of Virginia



Severe Privation & Neglect

Normal Range

Figure 4. **Hypothetical threshold model describing relationship between environment and IQ.**

Presidential Address

Developmental Theories for the 1990s: Development and Individual Differences

Sandra Scarr
University of Virginia

- “normal development does occur in a wide variety of human environments,
  but not in those lacking ‘average expectable’ conditions under which the species has evolved”

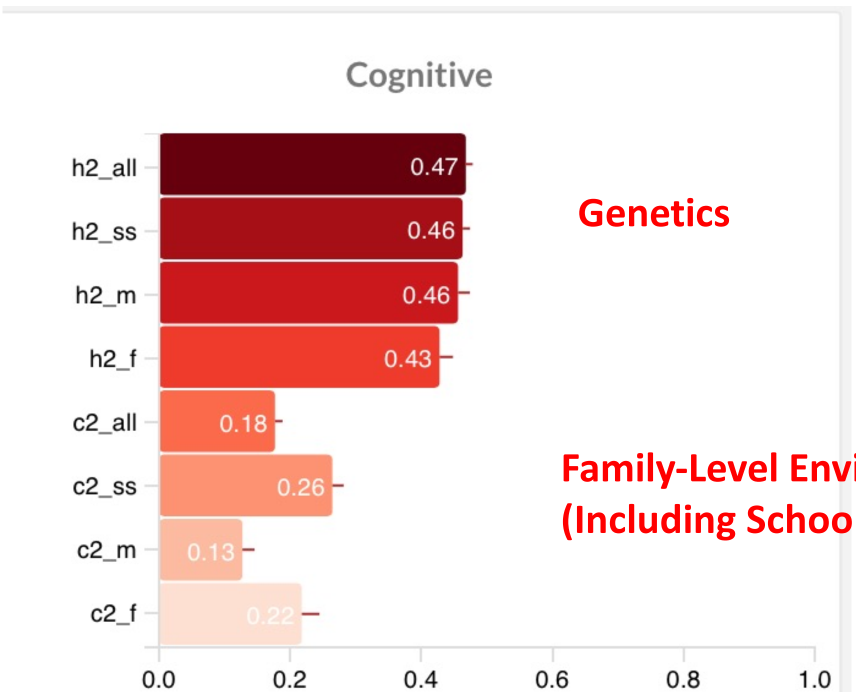
Estimates in ≈the General Population (Pedigree Analysis, Twins Reared Together)

ARTICLES

nature genetics

Meta-analysis of the heritability of human traits based on fifty years of twin studies

Tinca J C Polderman[1,10], Beben Benyamin[2,10], Christiaan A de Leeuw[1,3], Patrick F Sullivan[4–6], Arjen van Bochoven[7], Peter M Visscher[2,8,11] & Danielle Posthuma[1,9,11]



Genetics

Family-Level Environment (Including School & Neighborhood)

How Potent is the Environment in the "Normal" Range Observed in the USA?

- Goal: Test and probe socioeconomic and educational causation in a genetically-informed cohort study using a population-based sample measured on a comprehensive set of cognitive and achievement outcomes
  - Do inferences from different approaches agree?

Overview

I. Introduction to the Texas Twin Project
II. Children's cognitive and academic skills in environmental context
III. Use natural experiments to estimate causal effects of schooling on cognitive abilities the same sample for which biometric decompositions are estimated
    -Are the more shared environmental phenotypes more amenable to schooling effects?

A resource for genetically-informed research on environmental causation in child development (directed with **Paige Harden**).

(N ≈ 600)

Tiny Twins

- Ages 0-5 yrs
- Parent survey
- Focus: Early cognitive skills, socioemotional functioning, parenting
- Repeated Measures, for Observations > 1,400

(N > 1,000)

Twin Brains

- Grades 3-8 (≈ages 8-13 yrs)
- Parent/child survey, in-lab testing, school records
- Focus: Cognitive abilities, executive functions, “noncognitive skills” & academic achievement
- Salivary Hormones (reactive and diurnal)
- Hair Hormones
- DNA
- MRI on N ≈ 150

(N > 1,000)

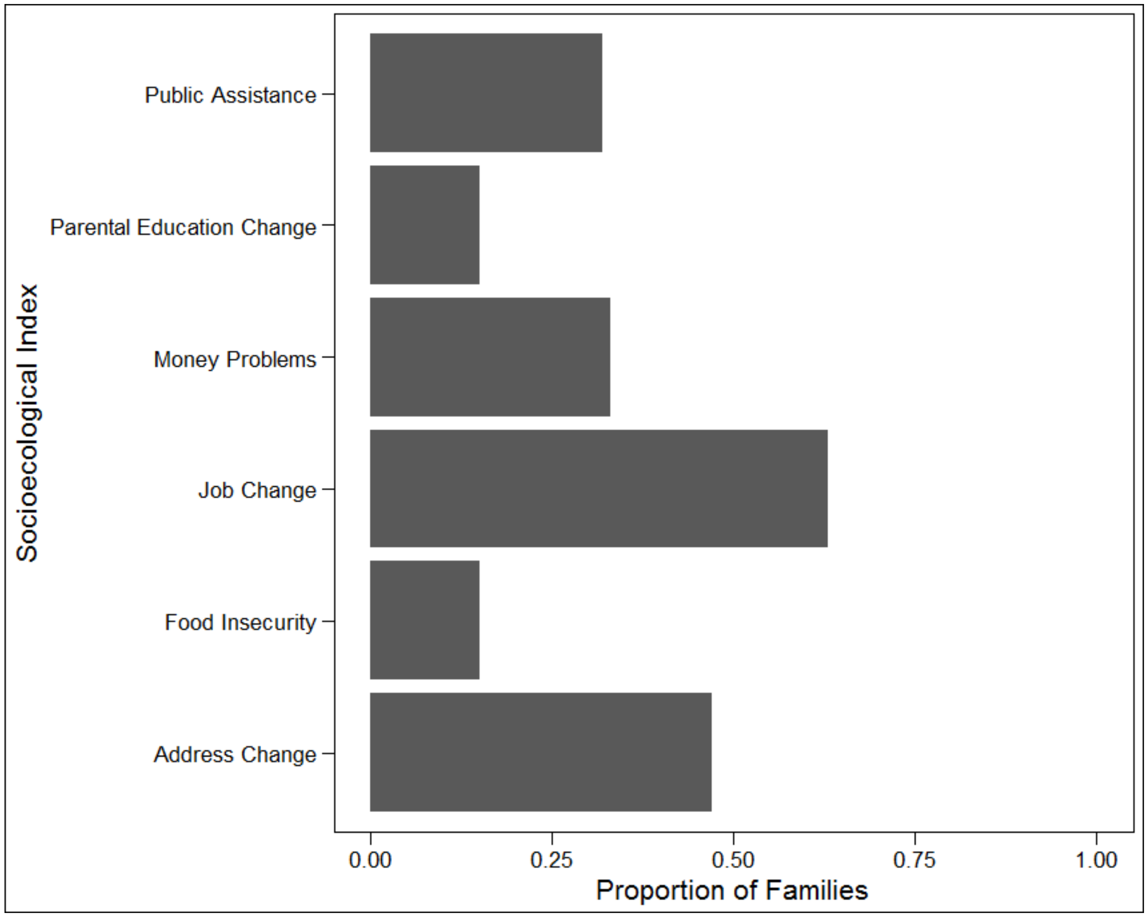
Risky Business

- High School (≈ages 14-19 yrs)
- Parent/child survey, in-lab testing, school records
- Focus: Cognitive ability, sensation seeking, delinquency, substance use
- Salivary Hormones (diurnal)
- Hair Hormones
- DNA

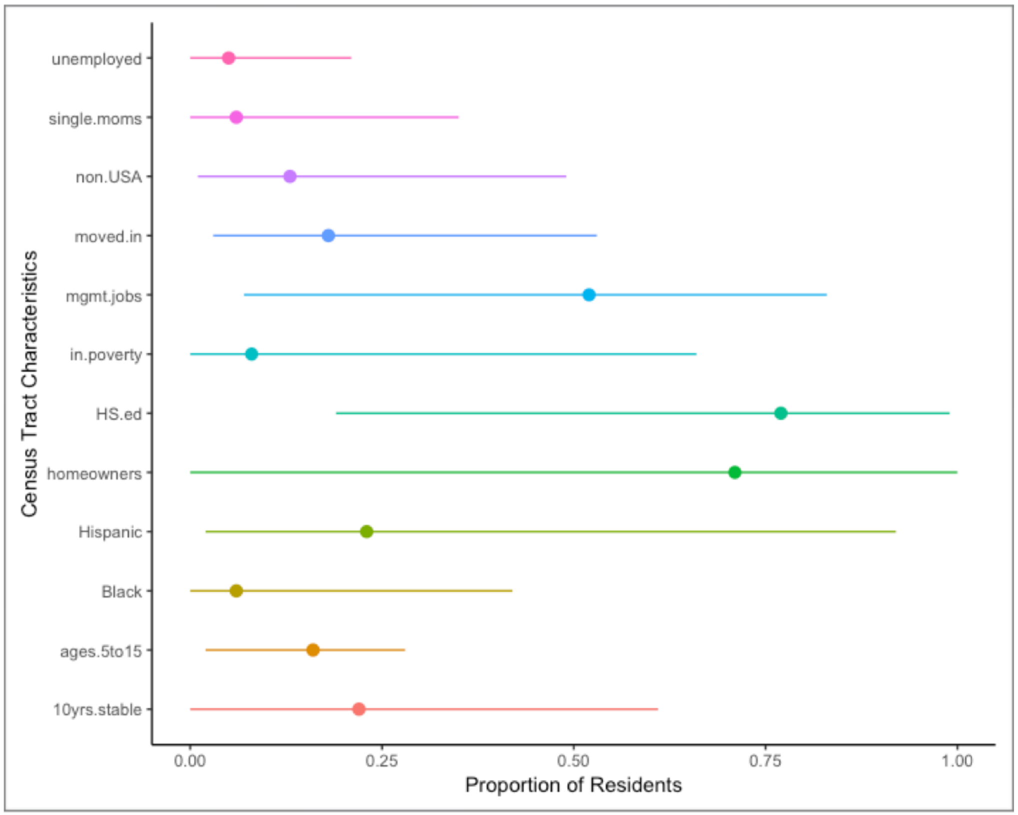
Racially & Socioeconomically Diverse: ≈ 60% White, 15% Hispanic, 8% Black

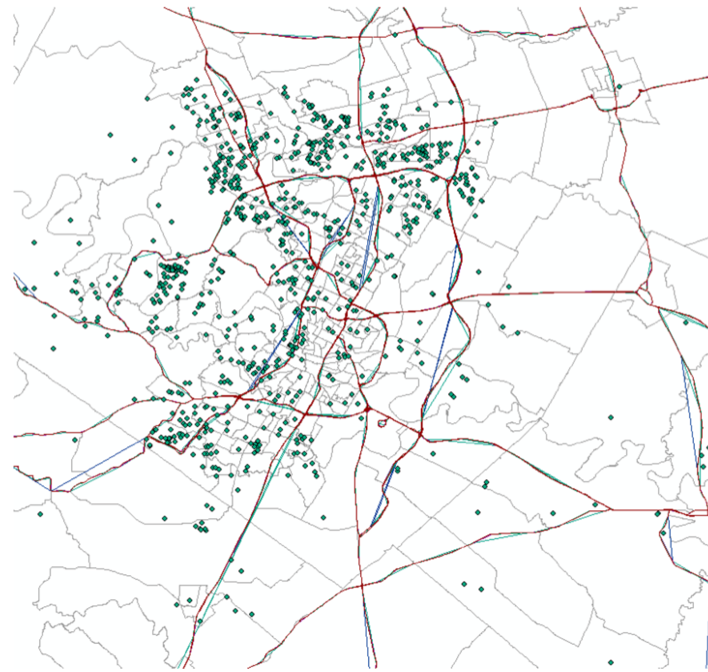
≈ One Third of Families have received needs-based public assistance (e.g. food stamps)

Family Context
(6 year event history)

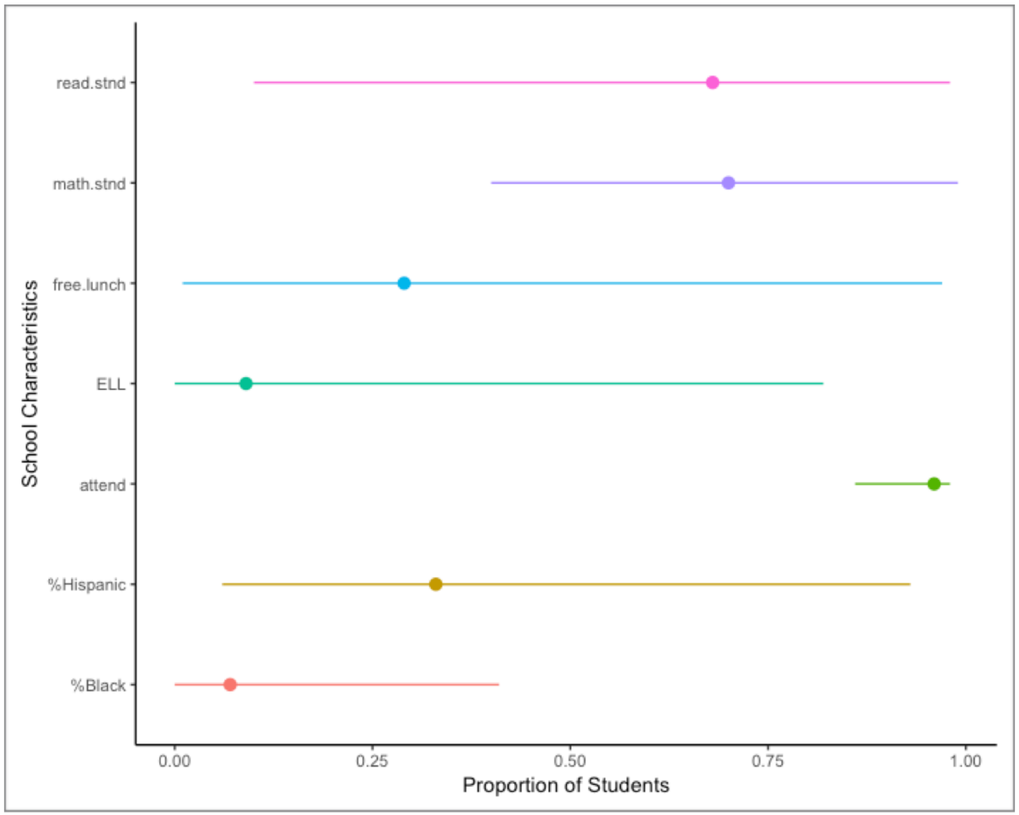


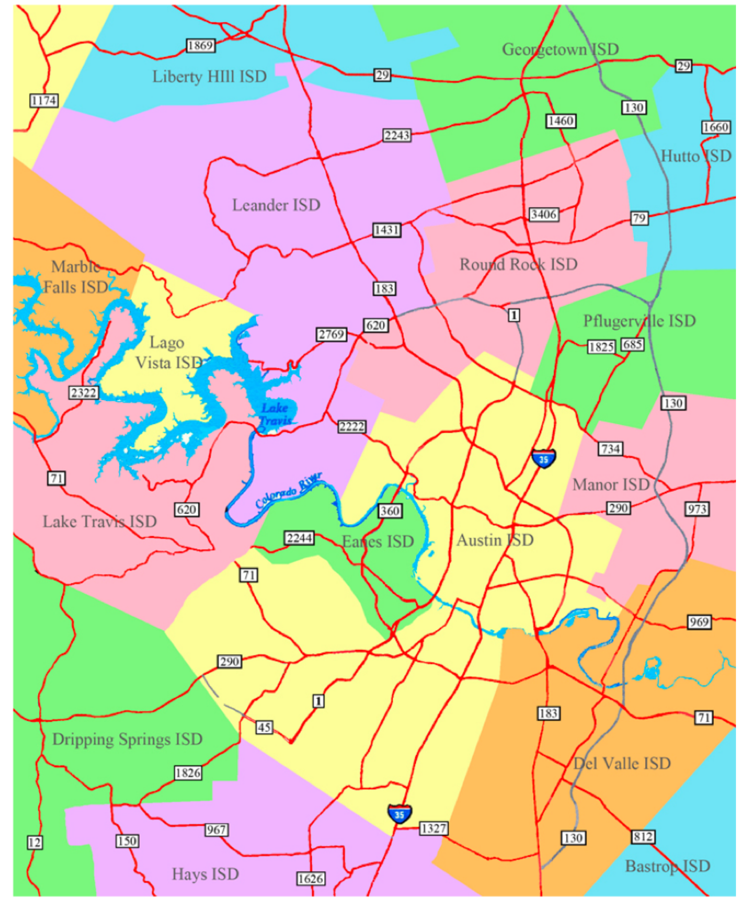
Neighborhood Characteristics (*n* = 239 Census tracts)





School Characteristics (*n* = 230 schools)





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Environmental Composites

Parent Survey
1. Low income
2. Low educational attainment
3. Financial problems
4. Public assistance
5. Food insecurity
6. Change in address, occupation, income
7. Father absence
8. Interparental conflict

1-2: Parent SES

3-7: Cumulative Adversity

8: Interparental Conflict

State Report on Schools
1. Student-teacher ratio
2. Low teacher experience
3. Low Teacher salary
4. Race/ethnicity
5. Economic disadvantage
6. English language learners
7. Student mobility
8. Math standard not met
9. Reading standard not met
10. Poor attendance

1-3: Teacher Characteristics

4-7: Student Demographics

8-10: School Performance

American Community Survey
1. Low educational attainment
2. Single motherhood
3. Low occupational status
4. Poverty
5. Recent relocation
6. Short home tenure
7. Home non-ownership
8. Few children
9. Immigrant status
10. Race
11. Ethnicity

1-4: Neighborhood SES

5-8: Residential Instability

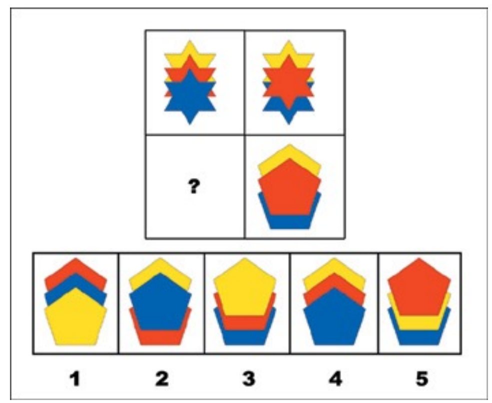
9-11: Diversity

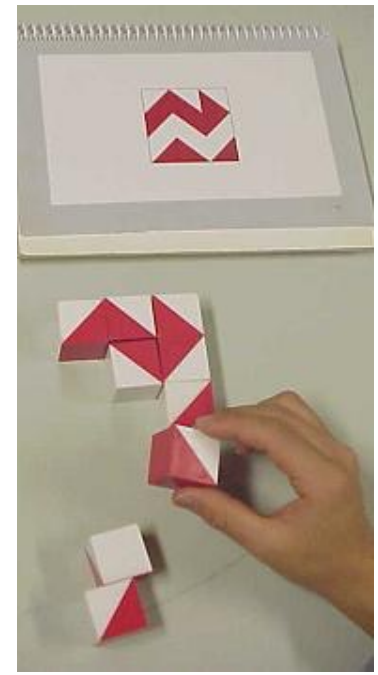
Academic Achievement (WJ-III)

- **Reading**
  - Passage comprehension
  - Word attack
  - Word identification
- **Mathematics**
  - Calculations
  - Applied problems

Intelligence (WASI-II)

- **Verbal ability**
  - Vocabulary
  - Similarities
- **Visuospatial reasoning**
  - Block Design
  - Matrix Reasoning
- **Full-scale IQ (FSIQ)**
  - M = 103, SD = 13

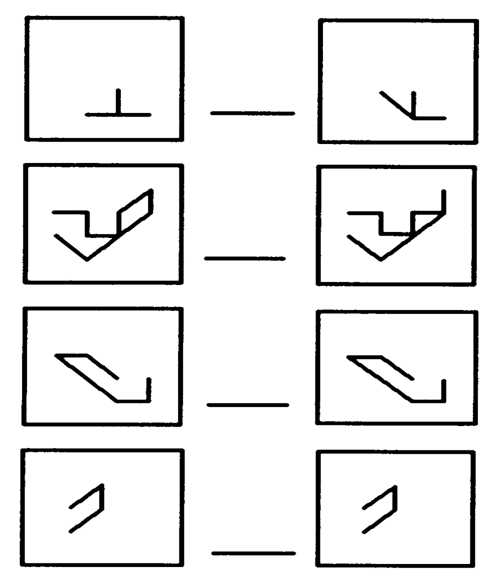




Processing Speed

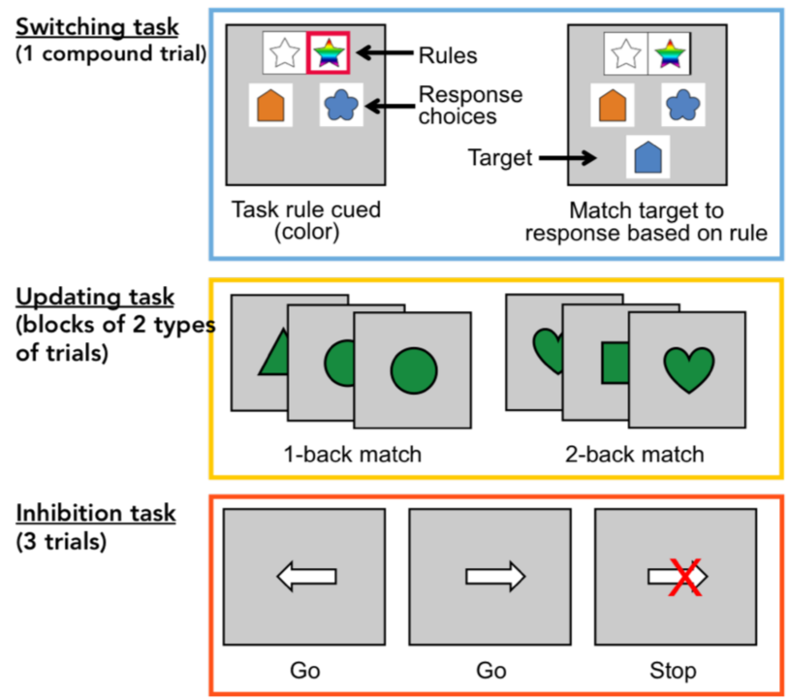
- Letter Comparison
- Pattern Comparison
- Symbol Search

Pattern Comparison:
Classify the pairs as same (S) or different (D) as quickly as possible



Executive Functions

- **Inhibition**
  - Animal Stroop
  - Mickey
  - Stop Signal
- **Switching**
  - Trail-making
  - Local-global
  - Plus-minus
- **Updating**
  - Running memory for letters
  - *n*-back
  - Keeping track
- **Working Memory**
  - Symmetry span
  - Listening recall
  - Digit span backward



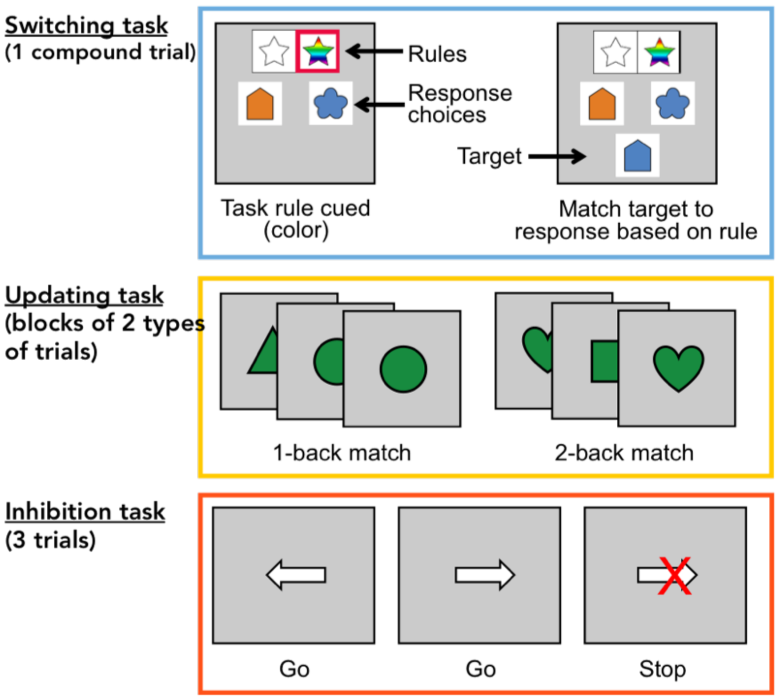
New Results

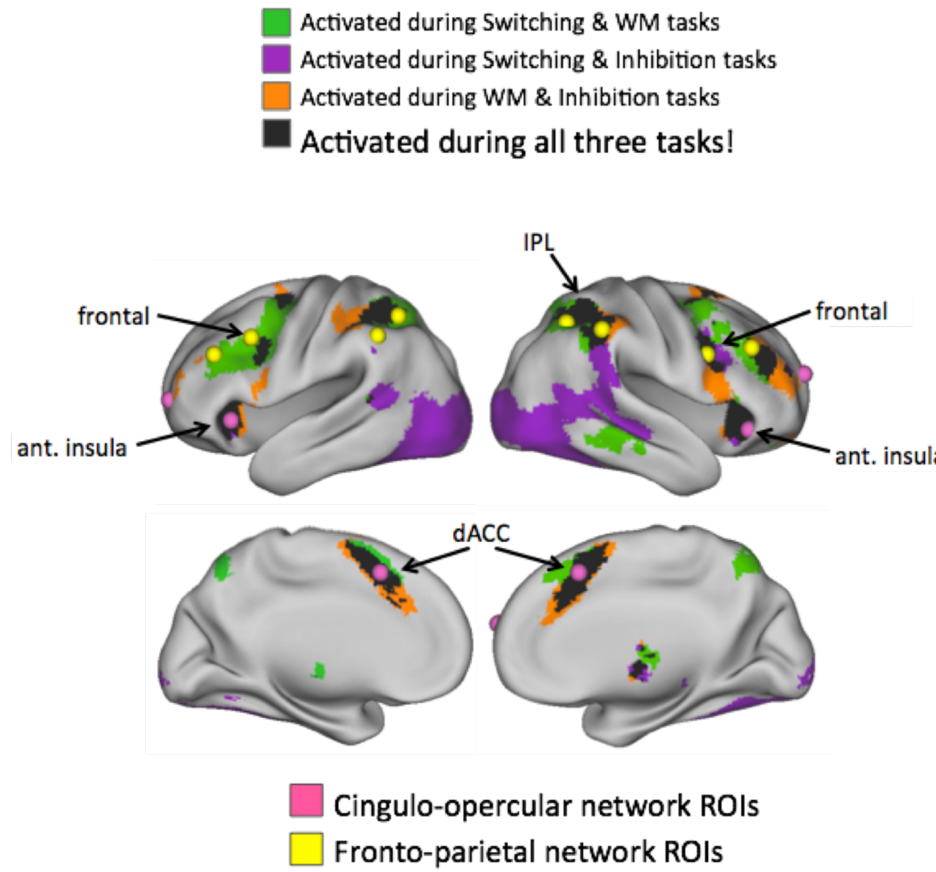
The Neural Architecture of Executive Functions Is Established by Middle Childhood

Laura E Engelhardt, Kathryn P Harden, Elliot M Tucker-Drob, Jessica A Church

doi: https://doi.org/10.1101/251447

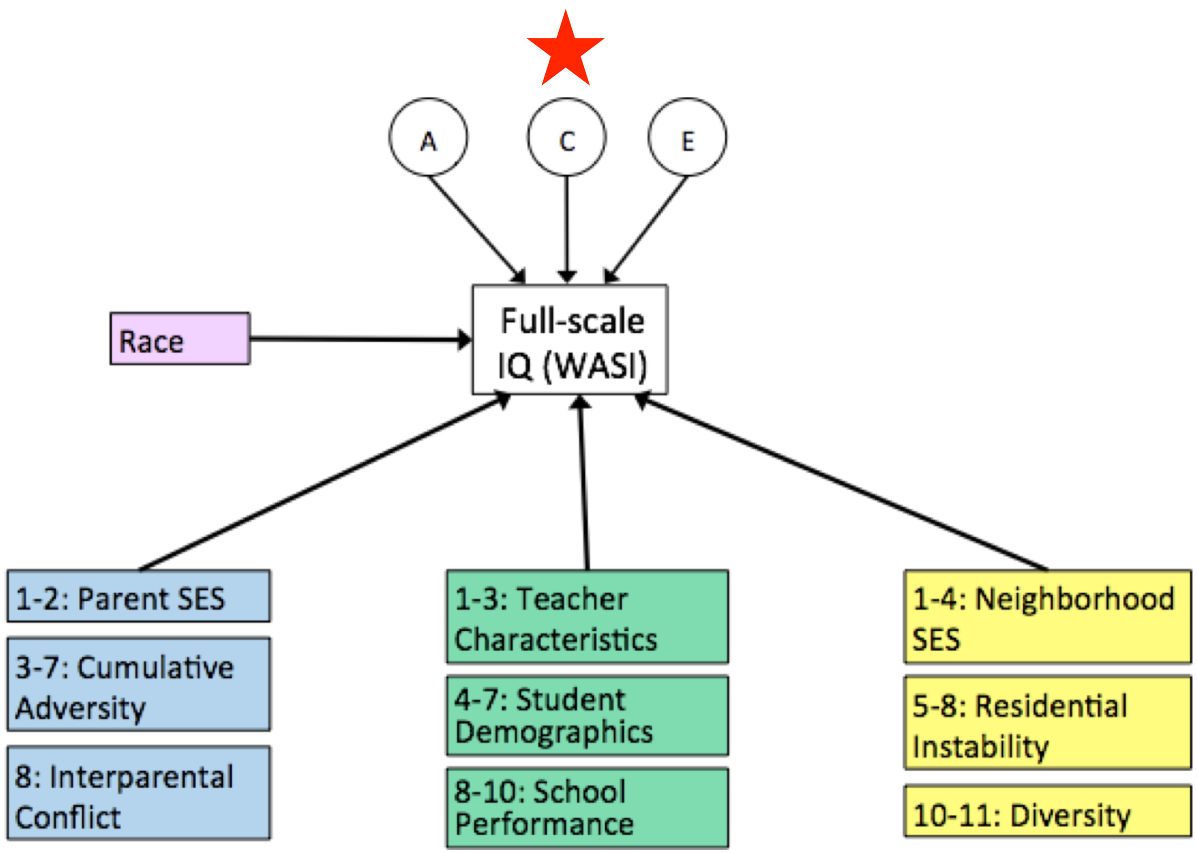
- Across EF tasks, children engage a <u>common set of regions</u> that overlaps EF networks identified in adults.



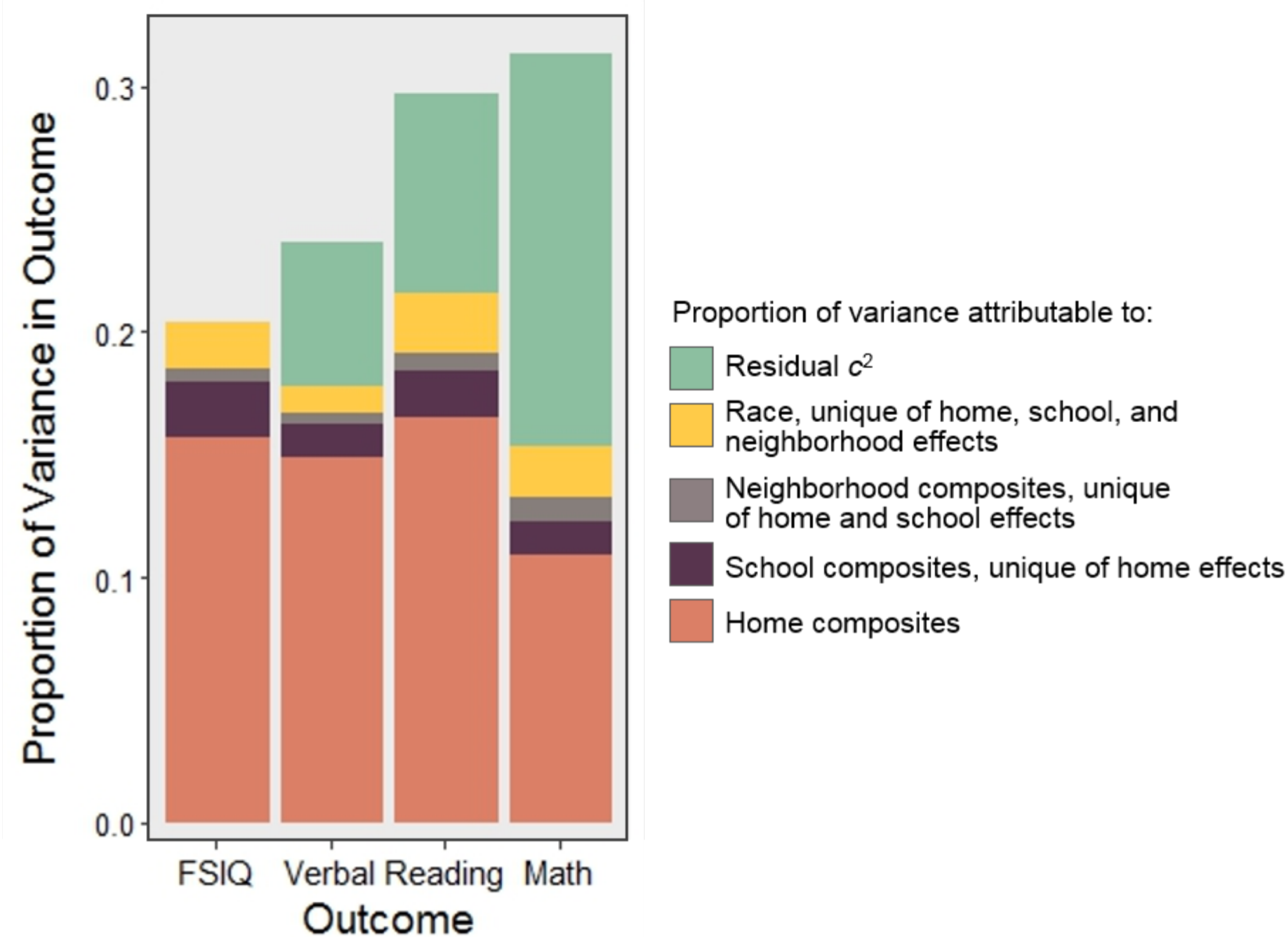


N = 117 8-13 year olds

Integrating Socioecological Measures into Twin Models



Socioecological Measures Account for much of the Shared Environmental Variance in Cognitive Ability and Academic Achievement



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Psychological Science
2015, Vol. 26(8) 1151–1163

DOI: 10.1177/0956797615577209
pss.sagepub.com
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Genes Unite Executive Functions in Childhood

Laura E. Engelhardt[1], Daniel A. Briley[1,2], Frank D. Mann[1], K. Paige Harden[1,2], and Elliot M. Tucker-Drob[1,2]
[1]Department of Psychology and [2]Population Research Center, University of Texas at Austin

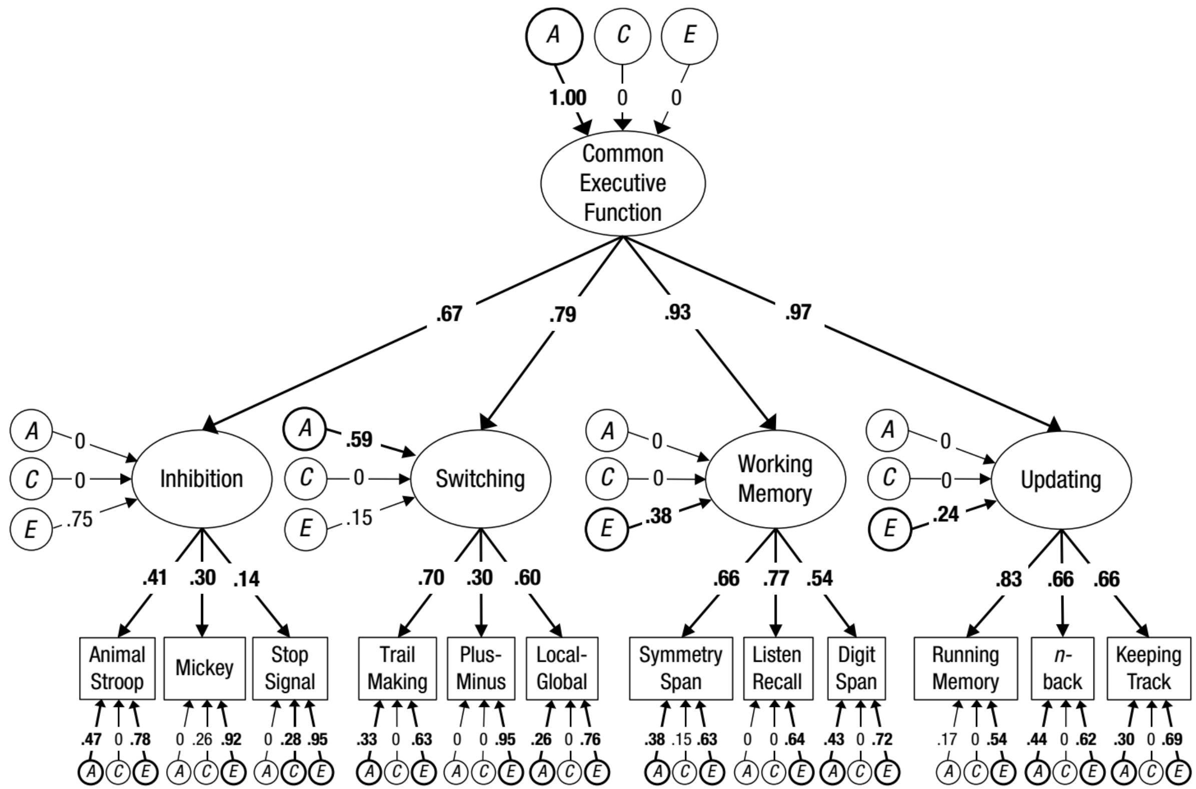

Fig. 1. Hierarchical multivariate twin model for additive genetic (*A*), shared environmental (*C*), and nonshared environmental (*E*) contributions to performance on executive-function tasks. The numbers on the arrows represent standardized factor loadings. The model controlled for age effects at the level of the first-order factors (Inhibition, Switching, Working Memory, and Updating). Because the purpose of this analysis was to understand the relative contributions of genetic and environmental influences to individual differences, as distinct from age-related differences, the loadings of the first-order factors have been standardized relative to their age-independent variance. Boldface indicates significant paths, $p < .05$.

Executive Functions as Index of Genetic Vulnerability

- By middle childhood, individual differences in EF index genetic signal with low environmental “contamination” across domains.

- Prediction from the Classical Nature vs. Nurture perspective: EFs will be highly resistant to schooling effects

Cognitive Phenotypes are Not Interchangeable

- Between-family environmental stratification in child cognition depends on the outcome. Environmental gaps widen as skills become more complex and instruction-dependent.
- No evidence that between-family environmental variation *within our sample* accounts for individual differences in EFs.
- "Missing environmentality" for reading and math achievement. (Instructional quality? Unmeasured aspect of home environment?)

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   -Are the more shared environmental phenotypes more amenable to schooling effects?

Developmental Psychology
1991, Vol. 27, No. 5, 703–722

How Much Does Schooling Influence General Intelligence and Its Cognitive Components? A Reassessment of the Evidence

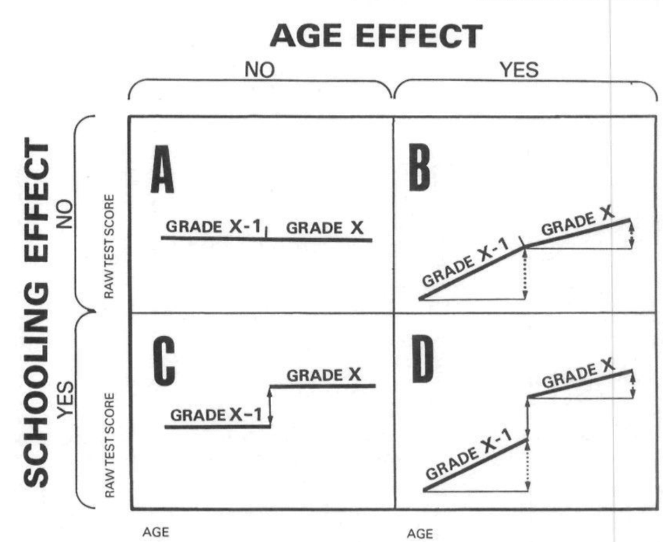
Stephen J. Ceci
Human Development and Family Studies
Cornell University

Age versus Schooling Effects on Intelligence Development

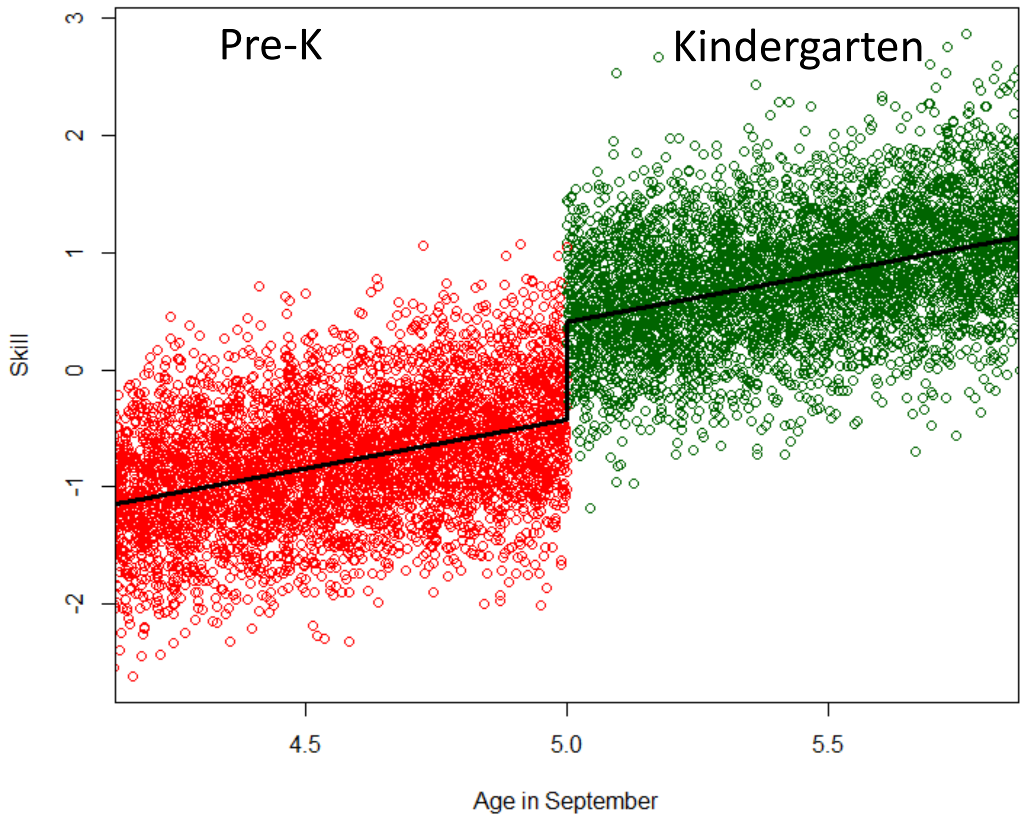
Sorel Cahan and Nora Cohen

The Hebrew University of Jerusalem

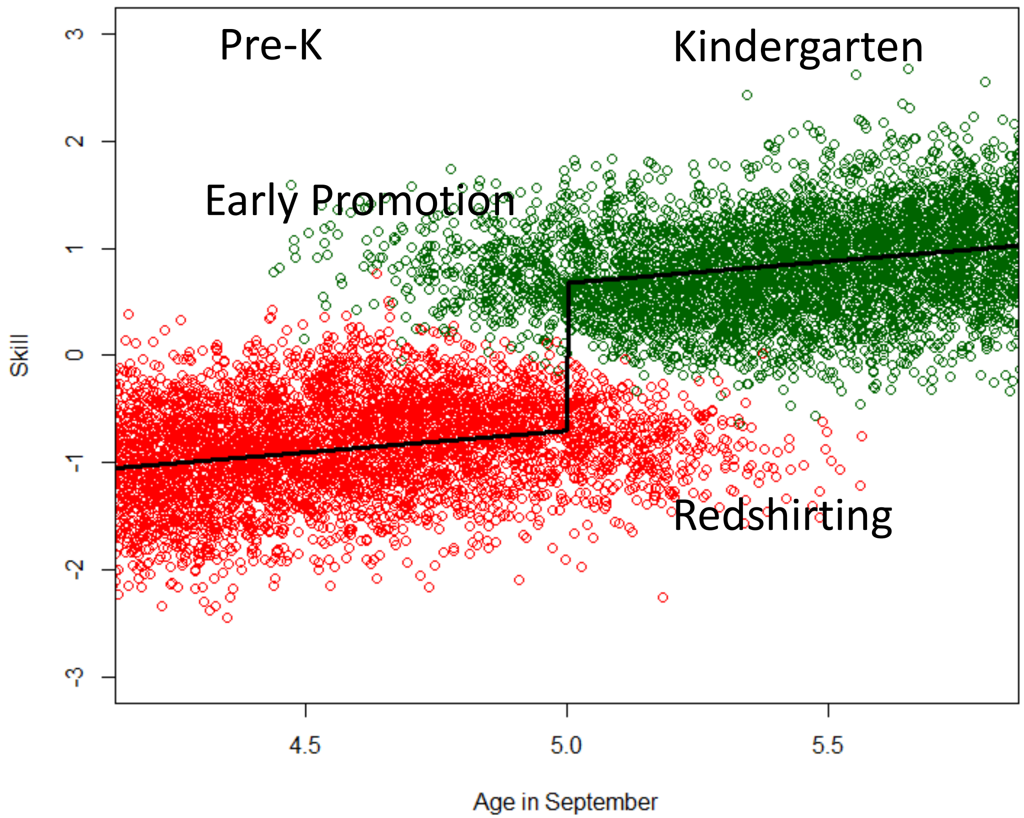
Child Development, 1989, **60**, 1239–1249.



Simulation
Sharp Regression Discontinuity

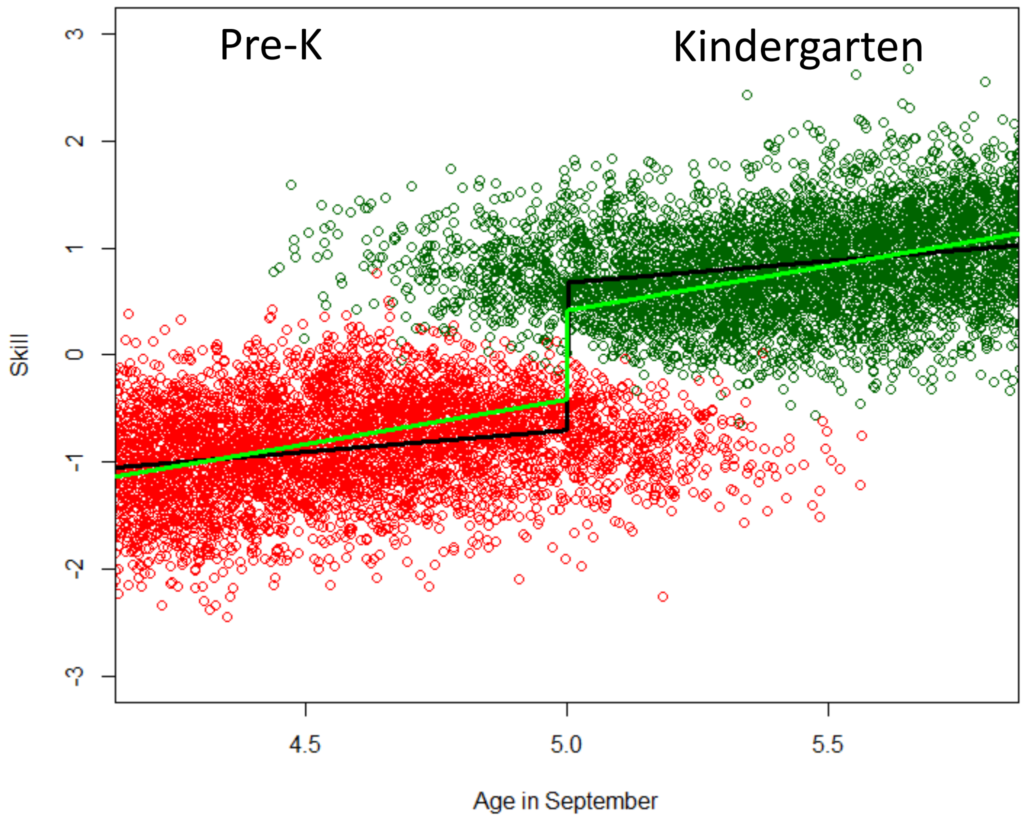


Fuzzy Regression Discontinuity, Nonrandom “Redshirting” (Much Closer to Reality)



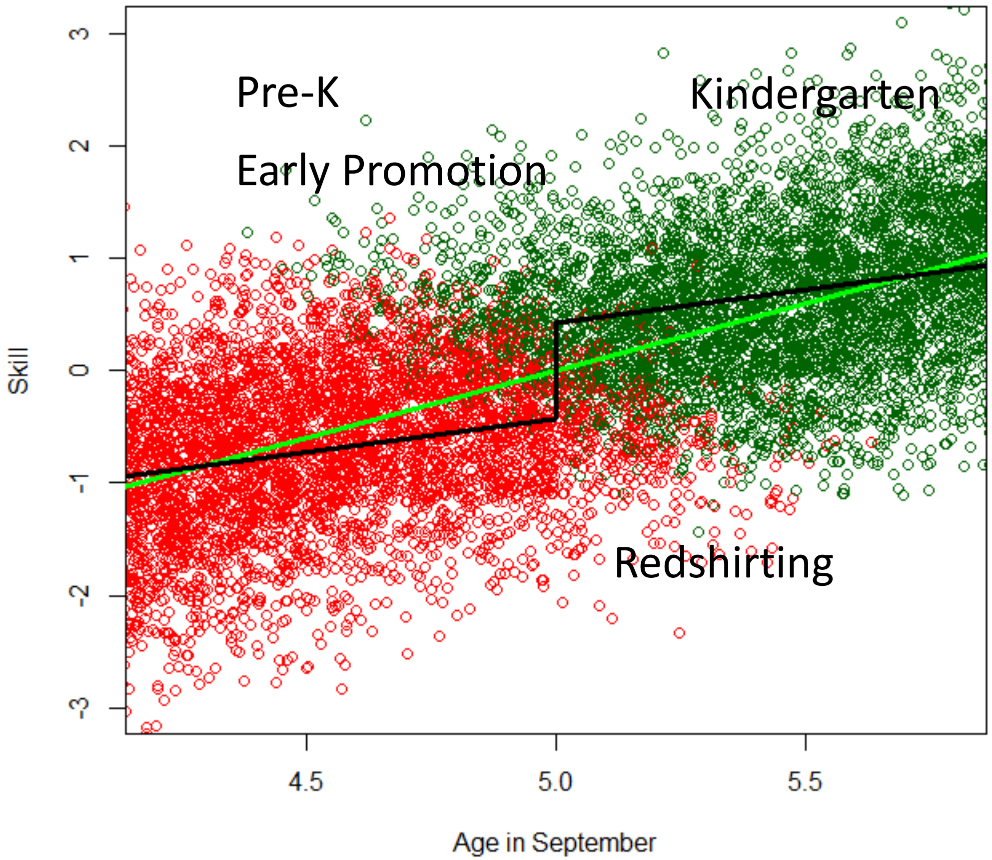
(Black line estimated based on actual grade in Sept)

Fuzzy Regression Discontinuity, Nonrandom "Redshirting" (Much Closer to Reality)



(Green Line = True Function)

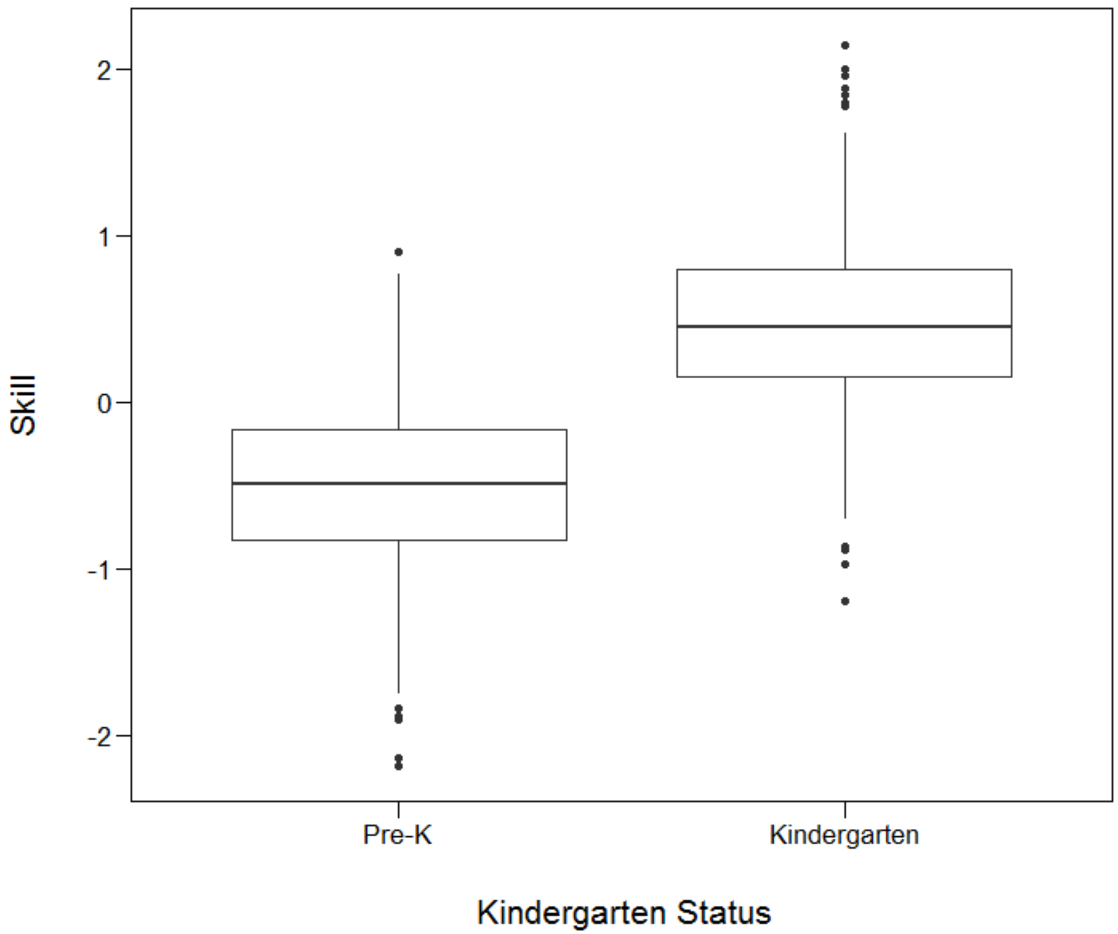
“Fuzzy” Discontinuity, no schooling effect



(Green Line = True Function)

(Black Line estimated based on actual grade in Sept)

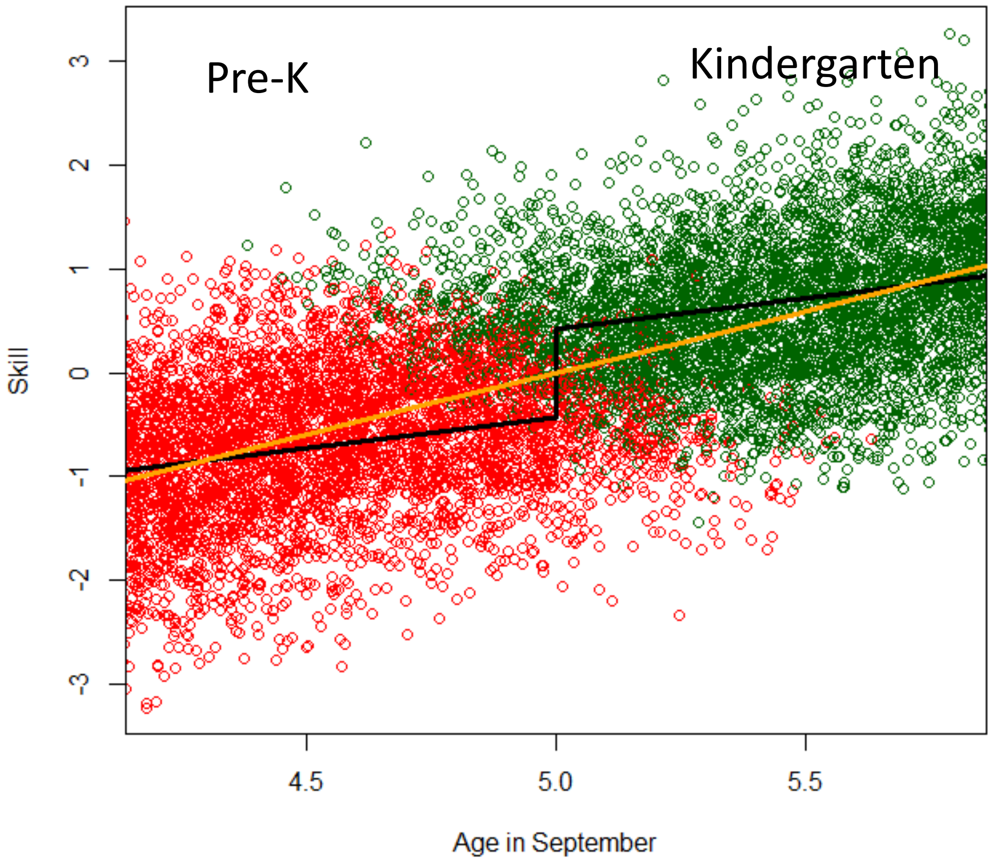
What if we just select kids within a month of the birthday cutoff (as is often done)?
Note: No Schooling Effect in the Generating model



Solution: “Intent to Treat” (Instrumental Variable Design)

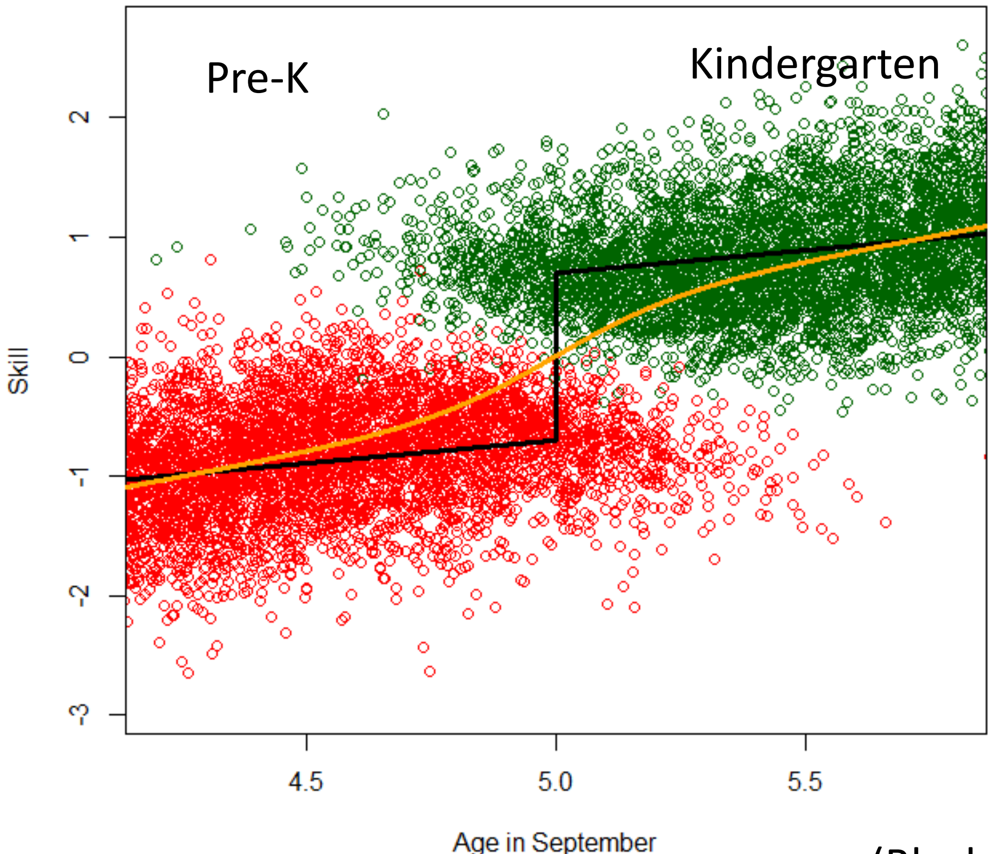
- Stage 1:
  - Create propensity scores for grade solely based on birthday (i.e. age in September) as the independent variable
    - Sigmoid (e.g. logistic) regression of Grade on Age in September
- Stage 2:
  - Use propensity scores for grade (<u>not actual grade!</u>) **and age** to predict achievement outcomes

No Schooling Effect, Nonrandom “Redshirting”



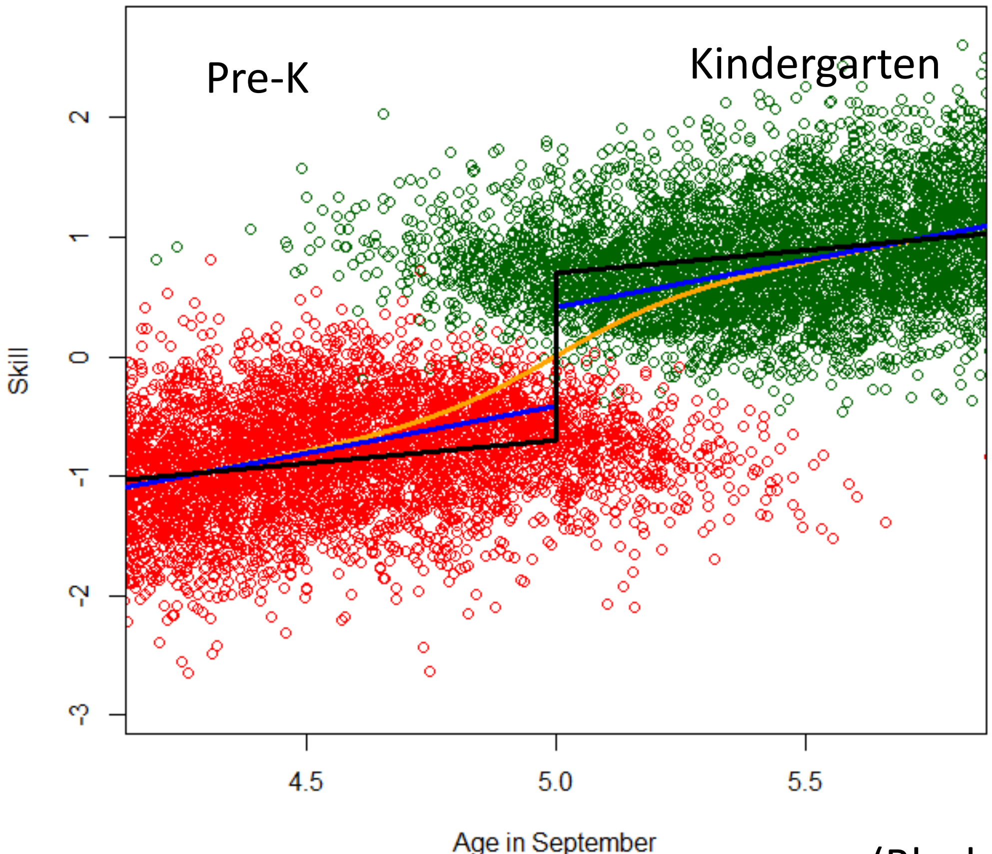
(Black Line = Biased Approach)
(Orange Line = IV Approach)

Schooling Effect, Nonrandom “Redshirting”



(Black Line = Biased Approach)
(Orange Line = IV Estimate)

Schooling Effect, Nonrandom “Redshirting”



(Black Line = Biased Approach)
(Orange Line = IV Approach)
(Blue Line = IV Inferred Effect)

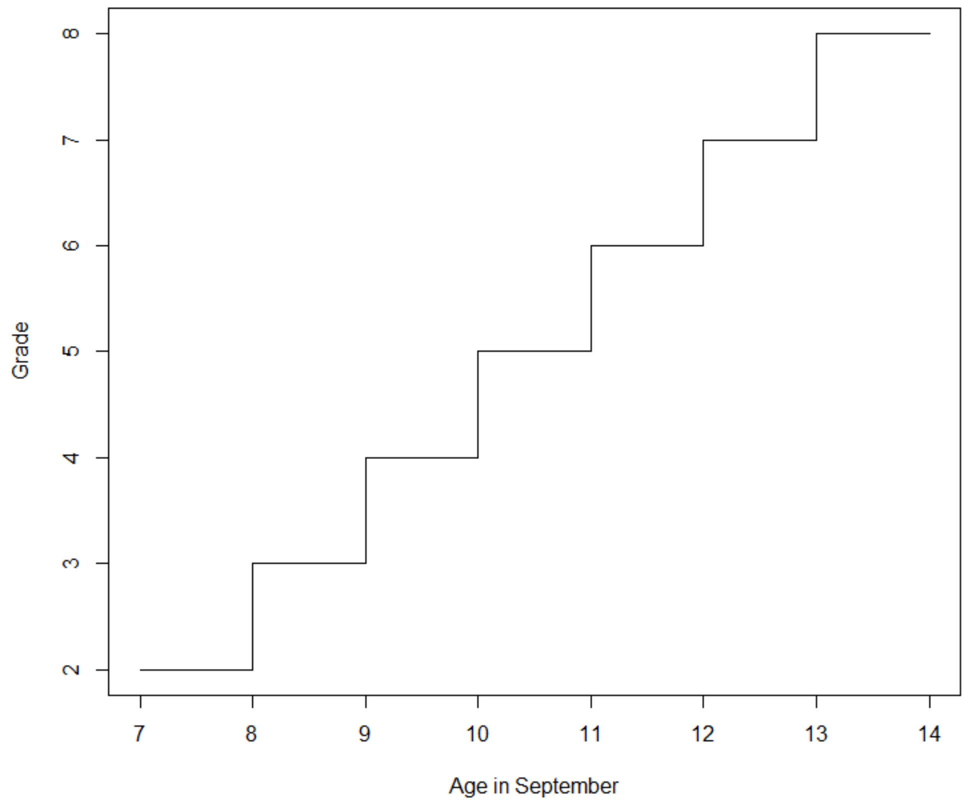
Goal

- Test for **schooling effects** on the same outcomes for which we have variance decomposition estimates in the exact same sample:
  - Reading*
  - Math*
  - Crystallized Knowledge*
  - Reasoning†
  - Processing Speed†
  - Executive Functions†

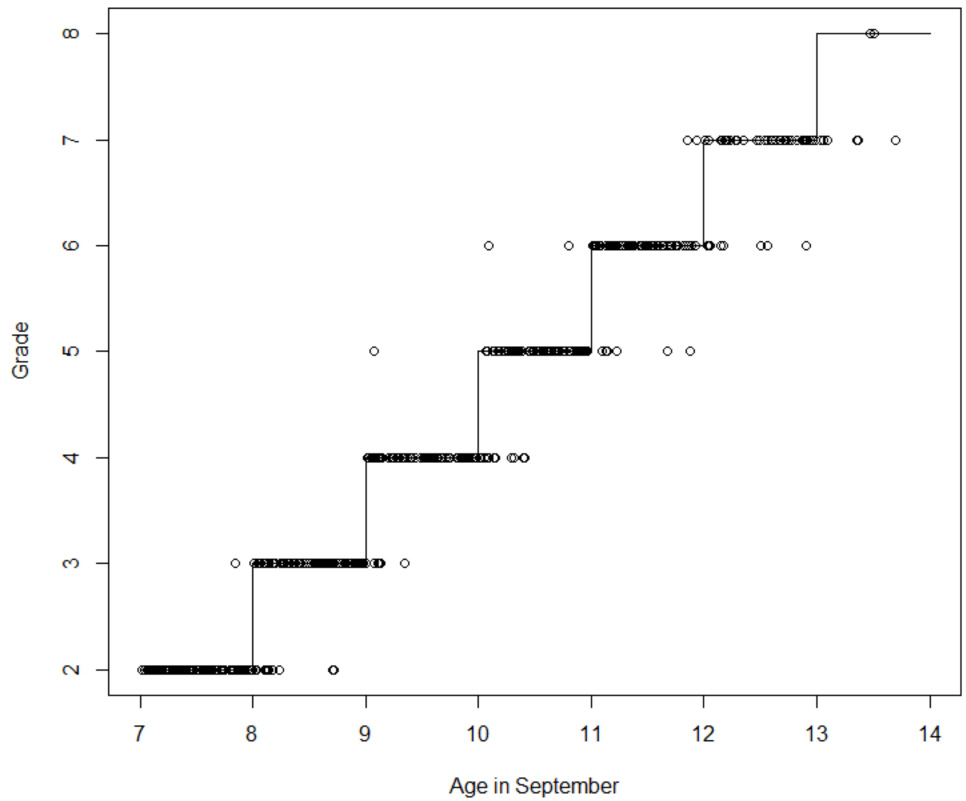
  * = appreciable shared environment estimate

  † = Negligible/nill shared environment estimate

Assigned Grade by Age in September

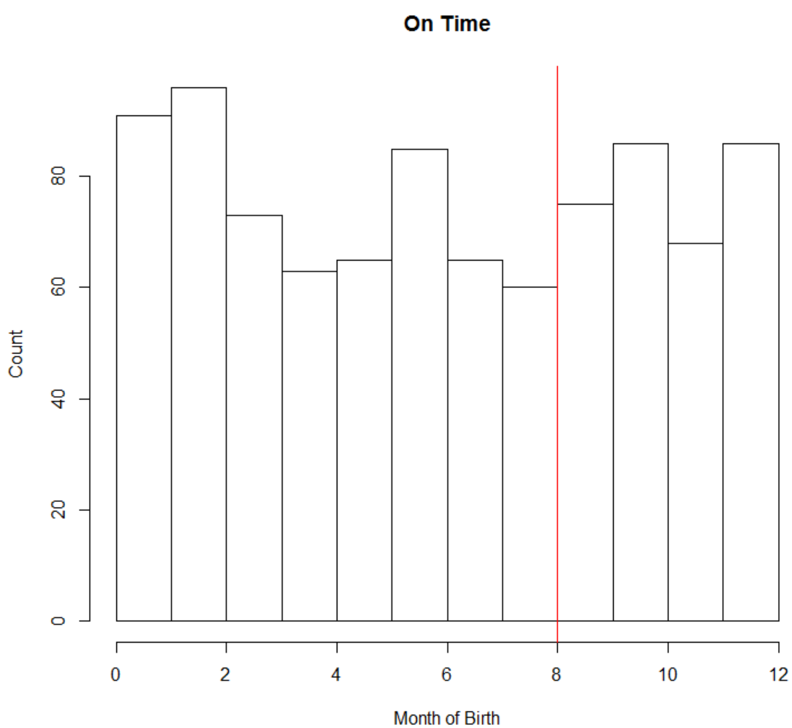


Grade Completed by Age in September

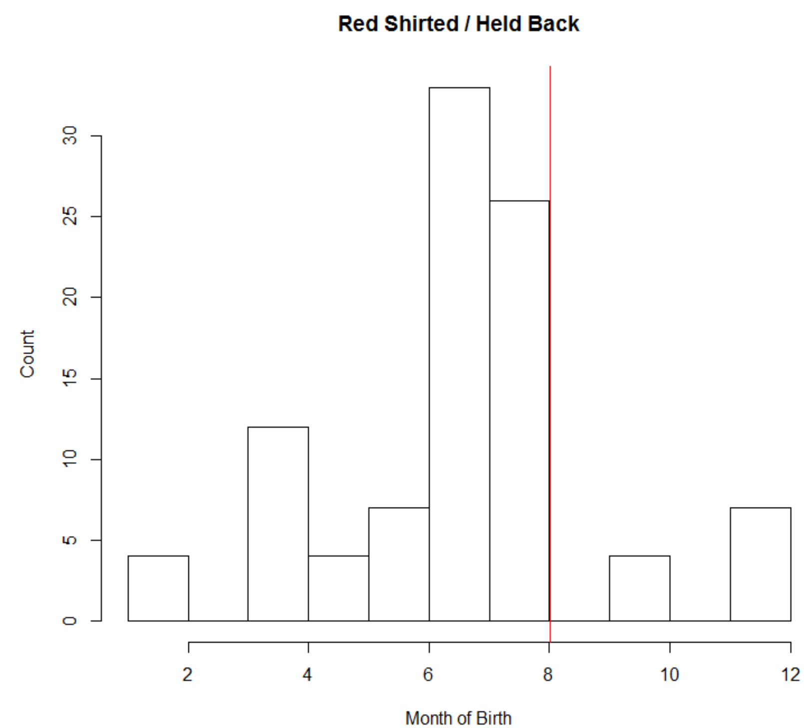


Distributions of Birth Months for Red Shirted vs. On Time Students

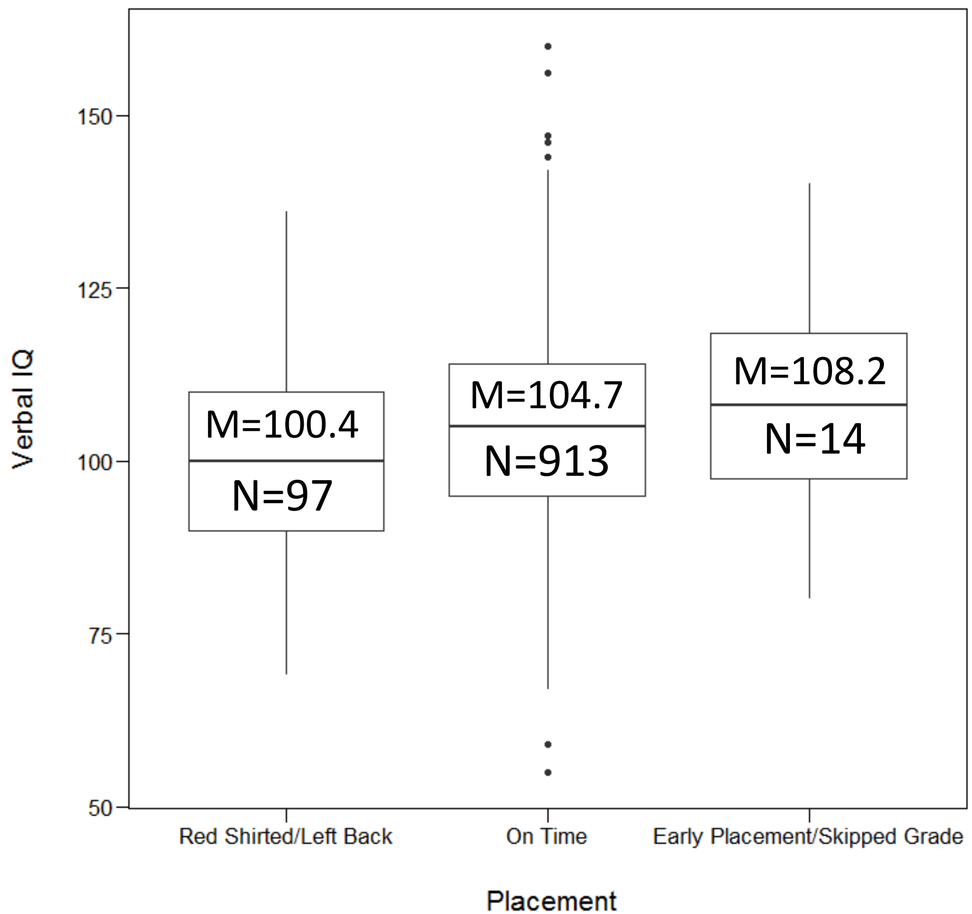
On Time (N=913)



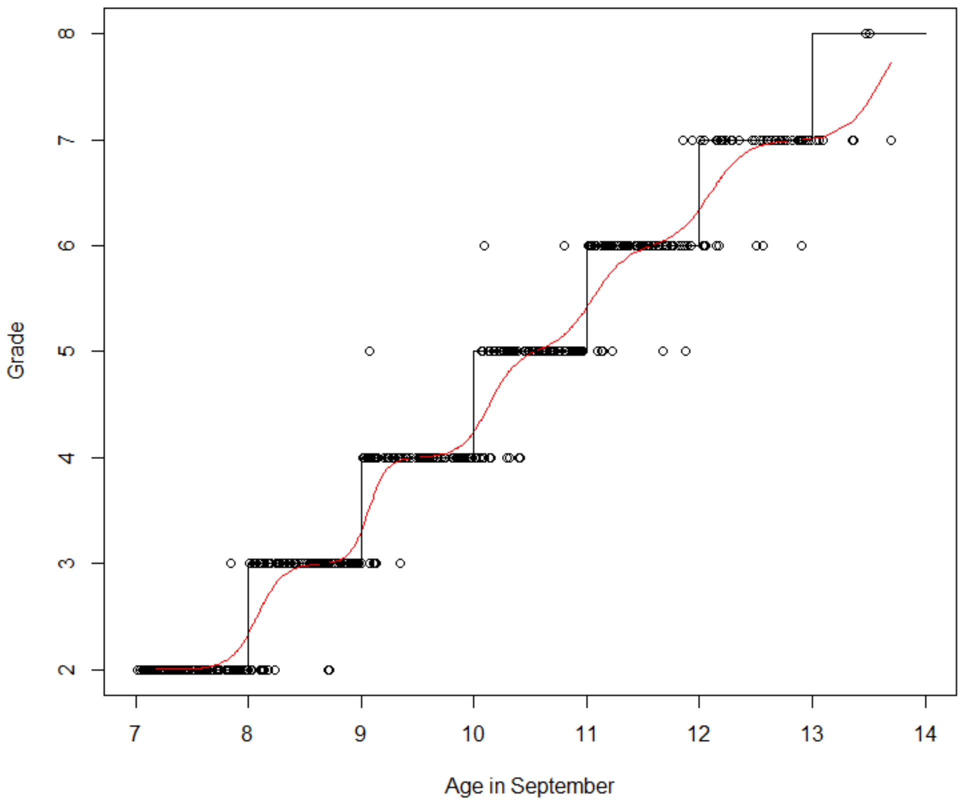
Red Shirted/Held Back (N=97)



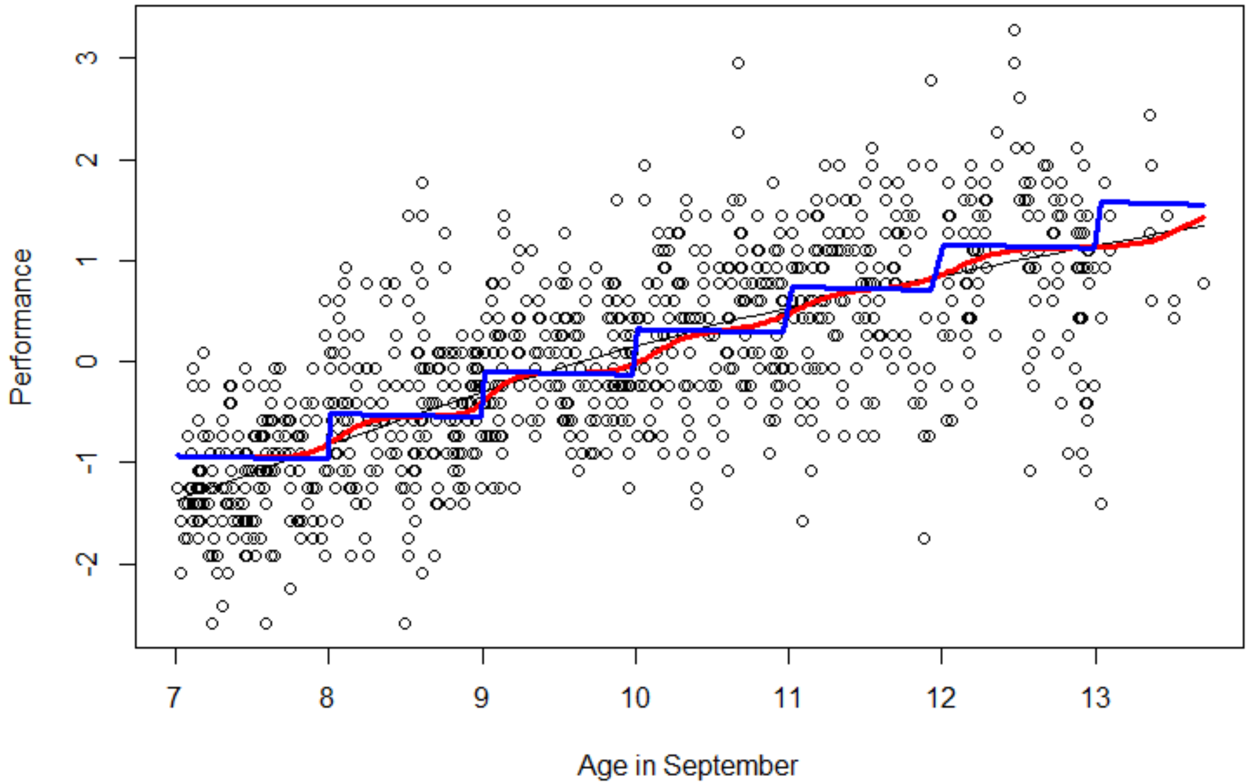
Verbal IQ by Grade Status



Grade Propensity Scores by Age



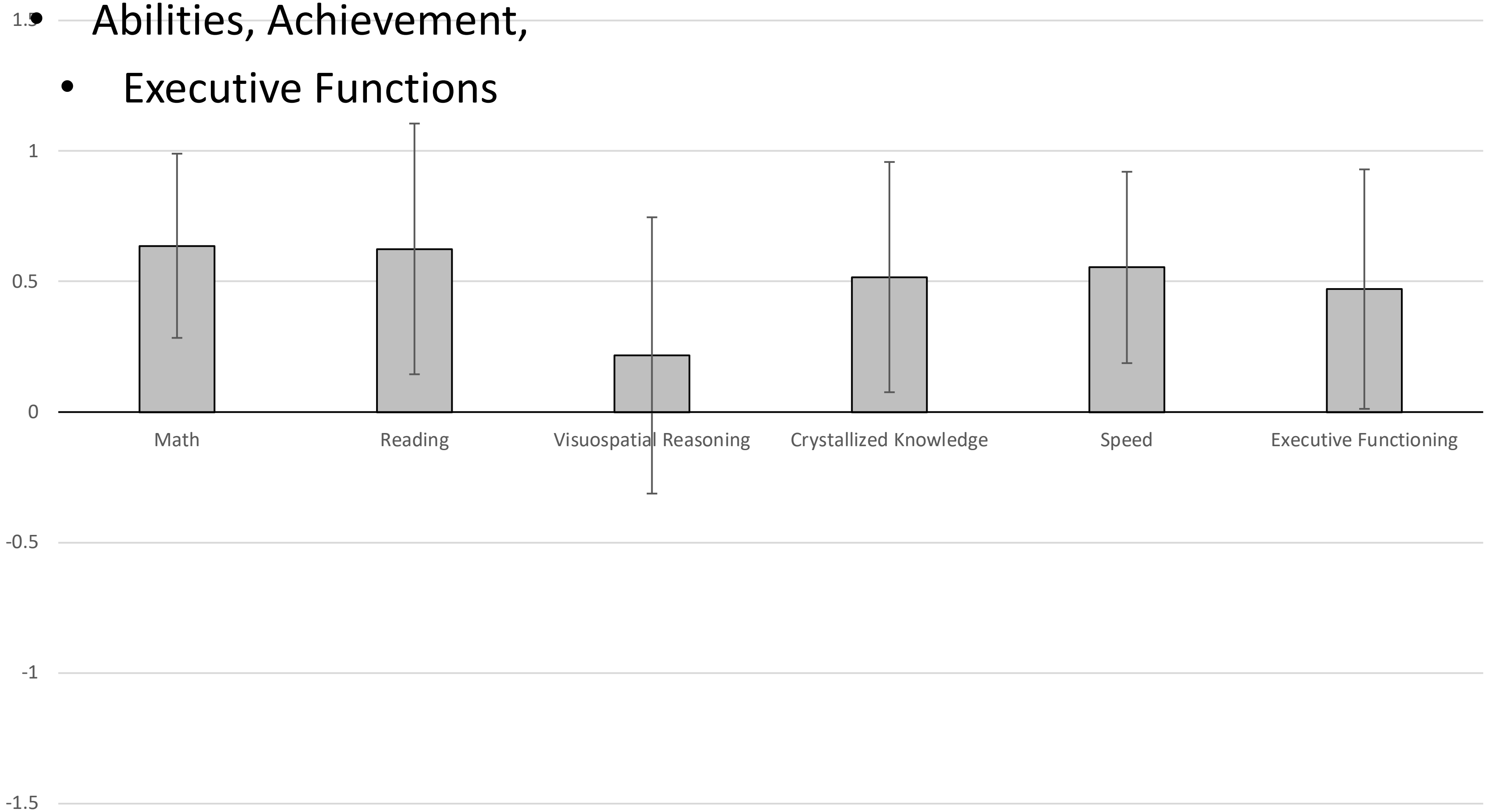
Regression Discontinuity: Math Performance



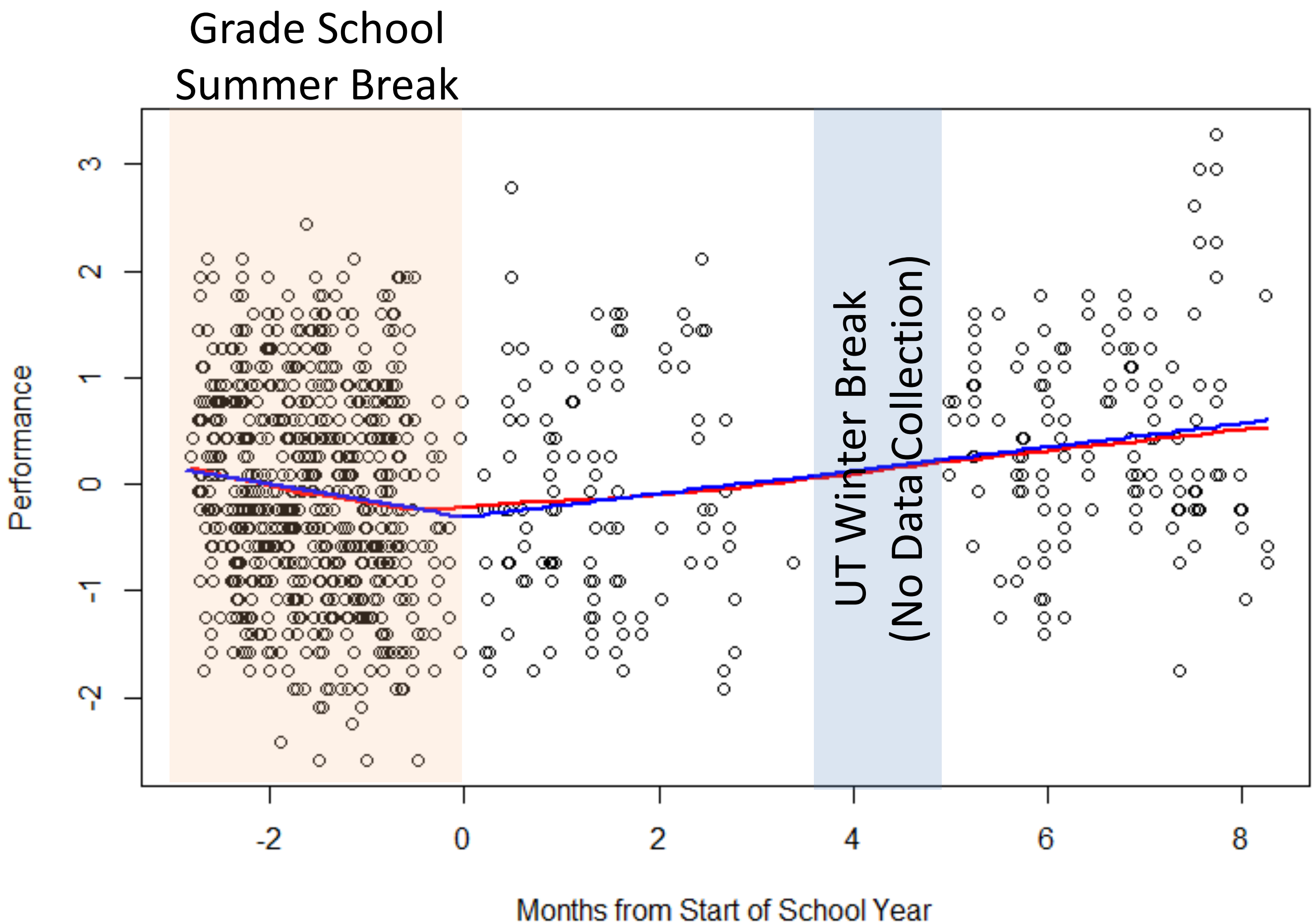
(Red="Fuzzy" Expectation, on the basis of propensity scores)
(Blue=Expectation under a perfect compliance counterfactual)

Schooling Effect (SD's per year)

- Abilities, Achievement,
- Executive Functions

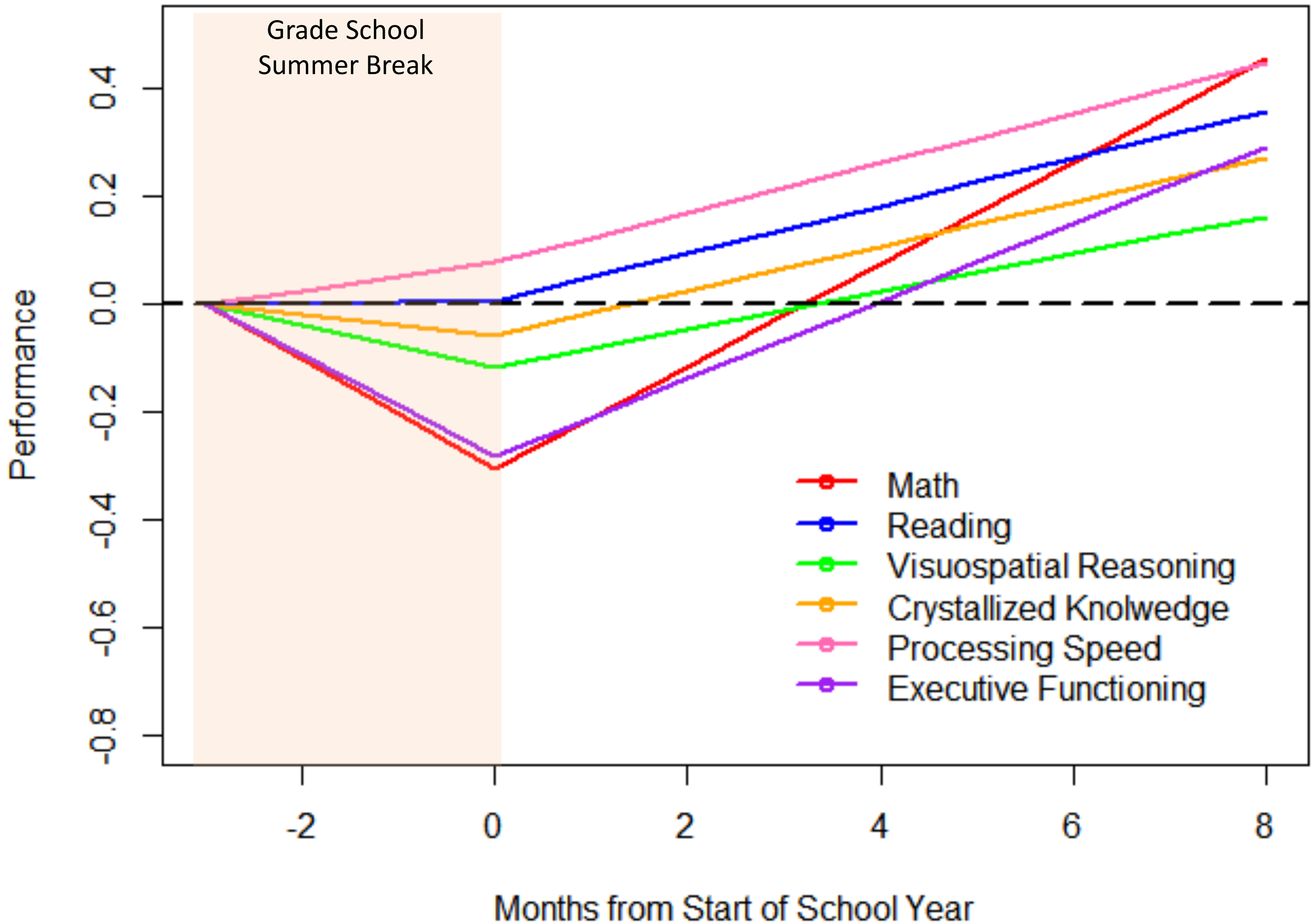


Summer Slide: Math Performance



(Red=Loess)
(Blue=Connected Linear Spline)

Summer Slide



An Apparent Paradox

- Sizable Schooling effects on EF and Speed using school-age cutoff and time-of-year analyses
- No Appreciable Shared environmental effects on either factor (after controlling for age)

Different Methods May Tap Distinct Sets of Causal Influences

- Biometric Variance decomposition tap effects of naturally occurring **variation in experience**
  – only effects variation in experience that are uncorrelated with genotypes are attributable to environmental factors
  – As has been discussed extensively elsewhere, causal effects of environments that are selected and evoked on the basis of genotype are attributable to the genetic factor
- In contrast school-age cutoff and time-of-year tap near-**universal experiences** that are close to exogenous and only a matter of timing

Is the Environment Really Impotent in the “Normal” Range Observed in the USA?

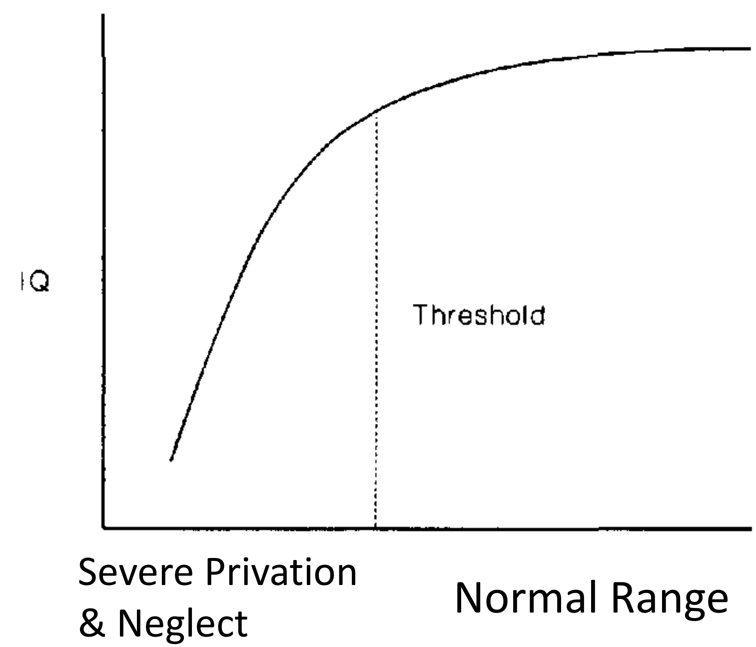


Figure 4. **Hypothetical threshold model describing relationship between environment and IQ.**

Conclusions

- Small (or nil) shared environmental effects on cognitive phenotypes do not correspond to their susceptibility to schooling effects
- Small (or nil) shared environmental on cognitive phenotypes are therefore unlikely to place constraints on the sensitivity of those phenotypes to novel social or educational policies
- Education appears to be the most consistent, robust, and durable method yet to be identified for raising cognitive abilities

Acknowledgements

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  - Laura Engelhardt
  - Margherita Malanchini
  - Stuart Ritchie
  - Paige Harden
- Portions of this research were supported by NIH grants R01HD083613, R01AG054628, R21HD081437, R21AA020588, and R21AA023322. The Population Research Center is supported by NIH grant R24HD042849.

For more on education and intelligence: