

Gene-by-Preschool Interaction on the Development of Early Externalizing Problems

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“Much debate has surrounded what might be regarded as *a core developmental question of the modern age*: How does the early non-maternal child-care experience affect child development?”

Belsky (2011, p. 1)

The Classical Behavioral-Genetic Perspective

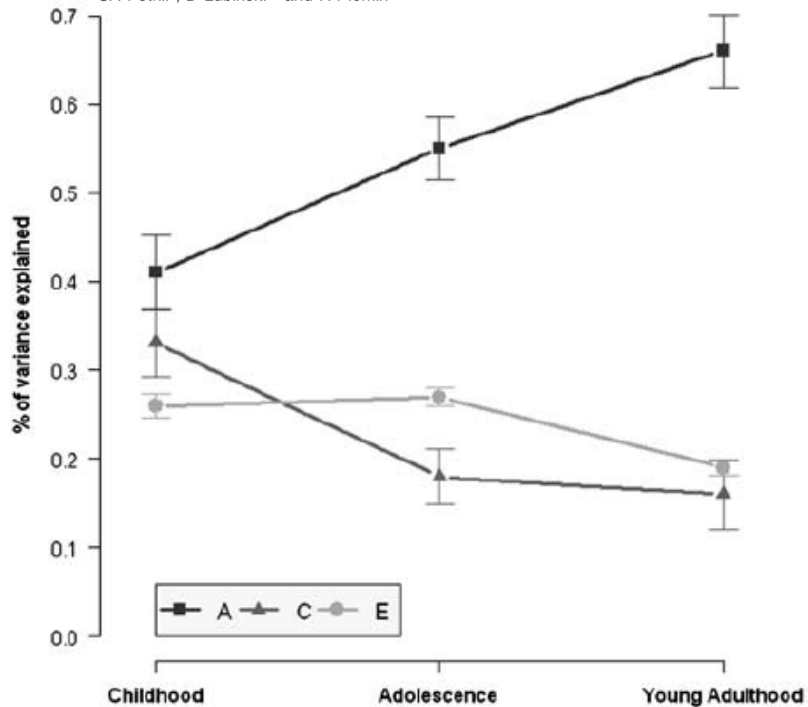
“One view is that because development is largely shaped by genes rather than by experience, the effects of non-maternal child care, like the effects of care provided by mothers, will be rather minimal once a basic threshold of care that is “good enough” has been provided.”

–Belsky, 2011, p. 1

The Heritability Paradox

The heritability of general cognitive ability increases linearly from childhood to young adulthood (2009)

CMA Haworth¹, MJ Wright², M Luciano², NG Martin², EJC de Geus³, CEM van Beijsterveldt², M Bartels³, D Posthuma^{3,4,5}, DI Boomsma³, OSP Davis¹, Y Kovas¹, RP Corley⁶, JC DeFries⁶, JK Hewitt⁶, RK Olson⁶, S-A Rhea⁶, SJ Wadsworth⁶, WG Iacono⁷, M McGue⁷, LA Thompson⁸, SA Hart⁹, SA Petrill⁹, D Lubinski¹⁰ and R Plomin¹



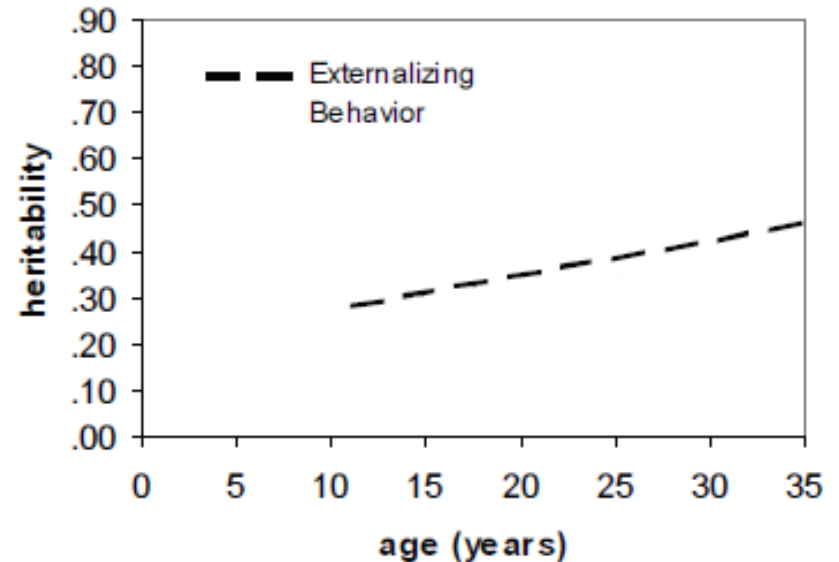
Age-Related Changes in Heritability of Behavioral Phenotypes Over Adolescence and Young Adulthood: A Meta-Analysis (2007)

Sarah E. Bergen,^{1,2} Charles O. Gardner,^{1,3} and Kenneth S. Kendler^{1,2,3}

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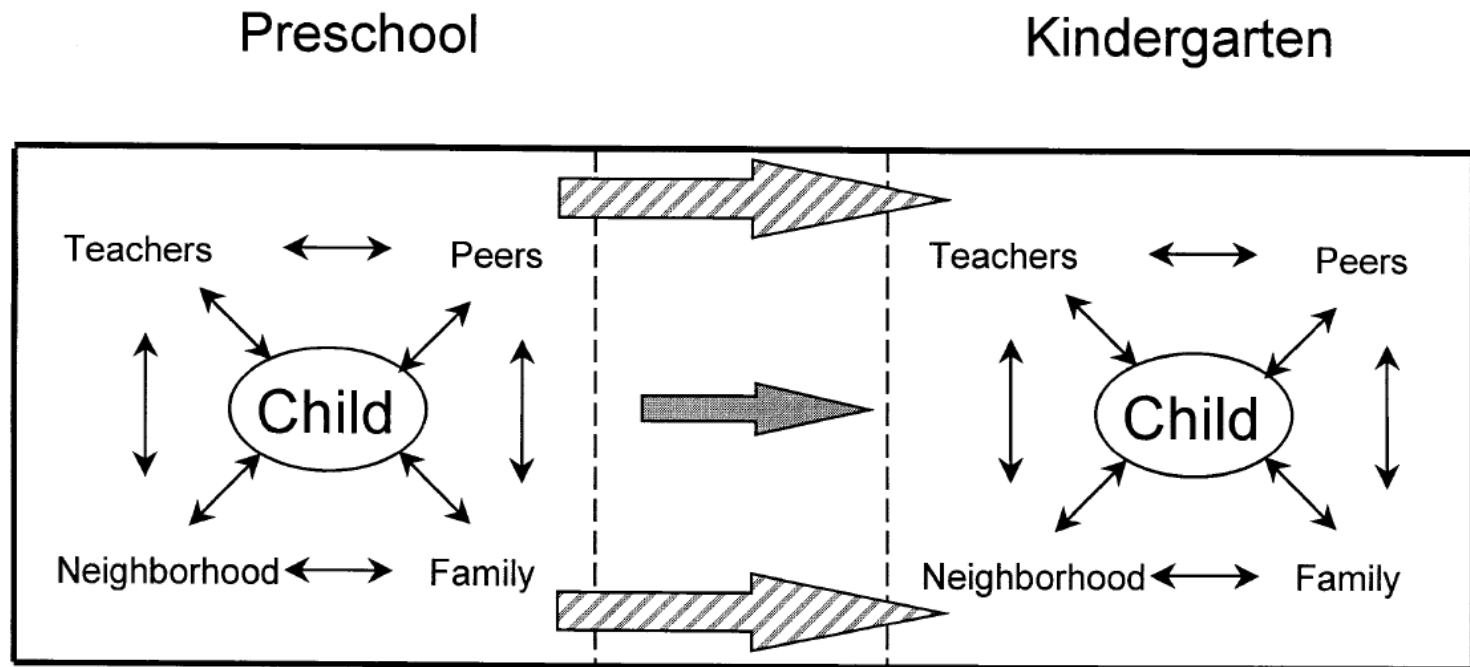


An Interactionist Hypothesis

- Experiences accrued over development may serve to enhance genetic differences.
 - Genetic differences in responses to environmental inputs
 - “reaction norms” -Waddington (1957)
 - Genetically influenced traits that lead children to differentially select, evoke, and attend to social and educational experiences
 - “person-environment correlations” -Scarr & McCartney (1983)
 - “proximal processes” –Bronfenbrenner & Ceci (1994)

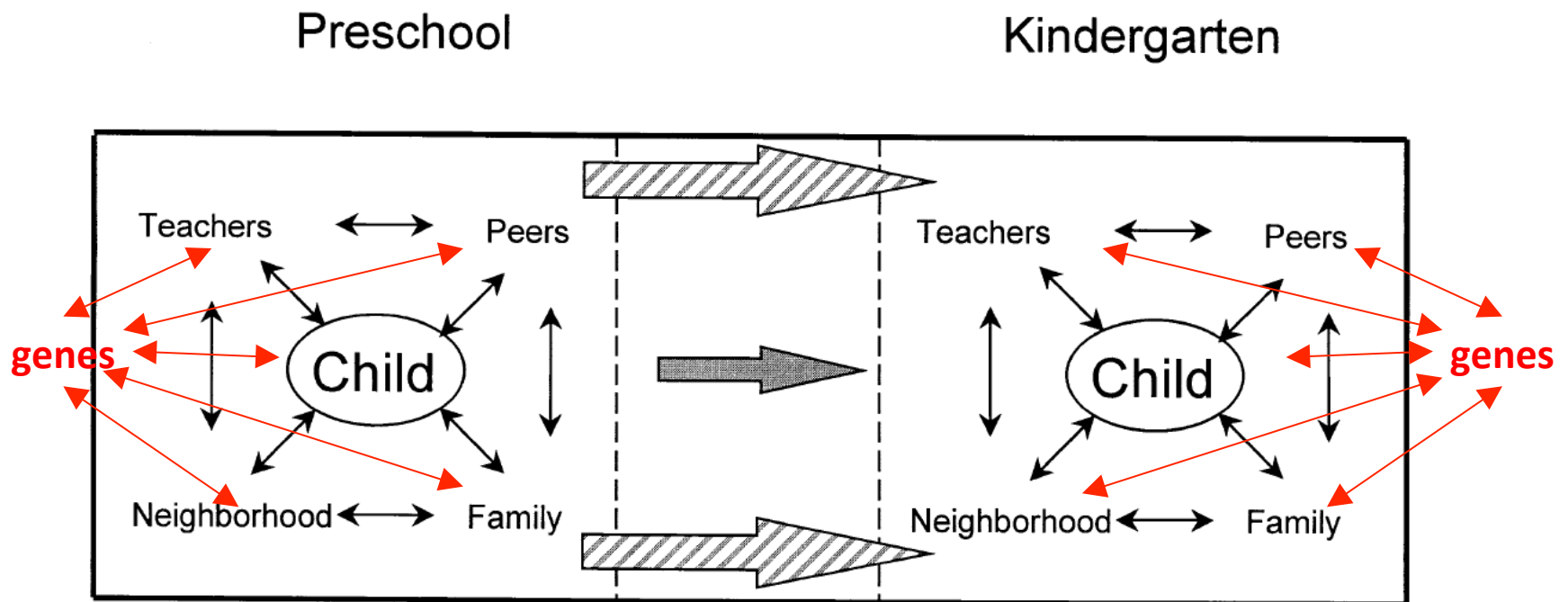
Rimm-Kaufman & Pianta (2000)

Model 4: The Ecological and Dynamic Model of Transition



The “New Look” of Behavioral Genetics: Gene-Environment Interplay

Model 4: The Ecological and Dynamic Model of Transition



Preschools and Genetic Variation

Does the preschool experience serve to enhance genetic variation?

Alternatively put, are there genetic differences in how children respond to the preschool experience?

Two Papers Employing Longitudinal Behavioral Genetic Methodology to Examine Heterogeneity in Preschool Effects

- 1. Gene-by-Preschool Interaction on the Development of Early Externalizing Problems (currently under review)**
- 2. Preschools Reduce Early Academic Achievement Gaps: A Longitudinal Twin Approach (in press, *Psychological Science*)**

Paper 1.

Gene-by-Preschool Interaction on the Development of Early Externalizing Problems

Center-Based Childcare Socioemotional Functioning (Externalizing)

Detrimental effects

- may interfere with attachment with mother
- may consist of overwhelming social pressures

vs.

Positive effects

- structured social interactions with teachers and peers may help to bridge the transition to kindergarten

Mixed Results in the Literature

- Childcare and higher rates of externalizing into middle school (Belsky et al., 2007)
- Salutary effects of childcare on children's externalizing after correcting for children's background risks (Borge, Rutter, Côté, & Tremblay, 2004)

Possible Sources of Heterogeneity in Preschool Effects on Externalizing

- Differences in Preschool Characteristics
 - high quality programs reduce risk for externalizing symptoms, whereas low quality programs exacerbate risk for externalizing symptoms (Votruba-Drzal et al., 2004)
- Differences in Timing (days/week, years)
- Differences in Child Characteristics
 - (including genetic differences)

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- **Differences in Child Characteristics**
(including genetic differences)

Early Childhood Longitudinal Study – Birth Cohort: 4 year, and 5 year waves

- Nationally representative sample of children born in the United States in 2001.
- 200 MZ Pairs *
- 400 DZ Pairs *
- 61% White, 16% African-American, 16% Hispanic, 3% Asian, 4% Mixed Race
- 25% lived below poverty line at study entry

*Sample sizes rounded to nearest 50, in accordance with ECLS-B security regulations.

Early Childhood Longitudinal Study – Birth Cohort: 4 year and 5 year waves

- Wave 4 took place in Fall 2005/Spring 2006
- Wave 5 took place in Fall 2006/Spring 2007
- Over 75% of assessments were completed in November or earlier

Preschool Enrollment

4 year wave

- Parents indicated whether each child was currently enrolled in Head Start, a day care center, a nursery school, a preschool, or a prekindergarten program on a regular basis
- 74% were enrolled in one of the above listed forms of center-based care
- 26% were not in any form of center-based care
- 6 pairs were excluded because only one of the two twins was enrolled in center-based care

Externalizing Behavior Problems

4 year and 5 year wave

Parent Reports on a 5 point scale

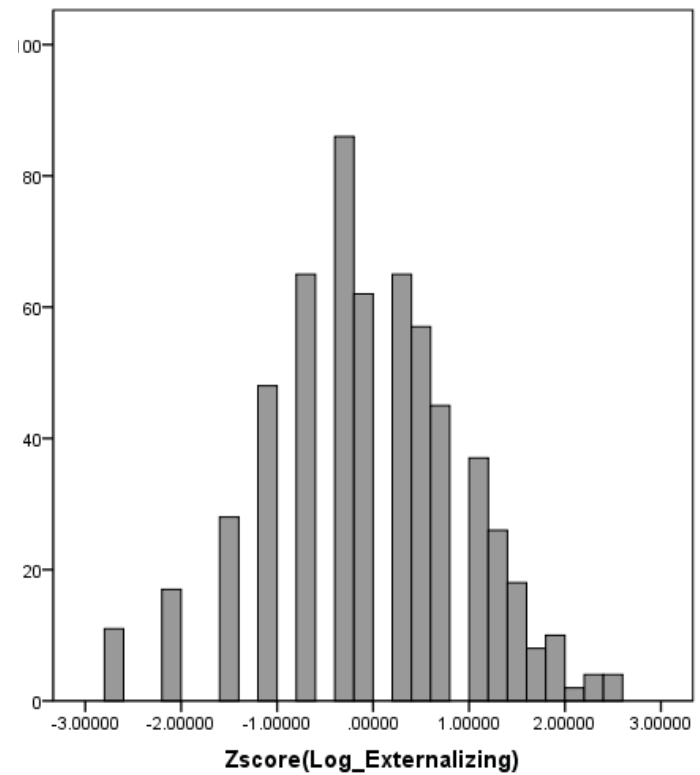
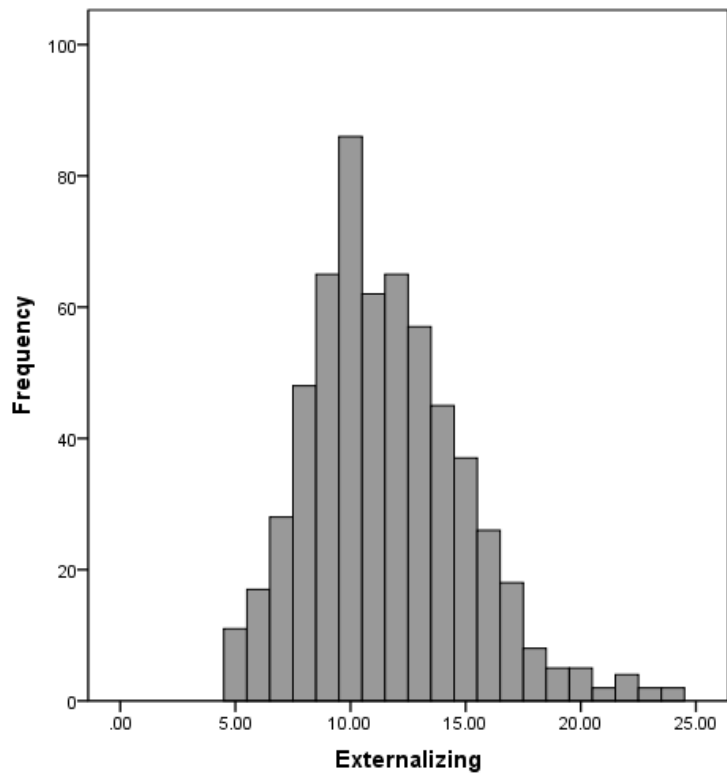
(never, rarely, sometimes, often, very often):

- 1) has temper outburst or tantrums
- 2) bothers and annoys other children
- 3) destroys things that belong to others
- 4) is physically aggressive (e.g. hits, kicks, or pushes)
- 5) gets angry

Alpha Reliability = .74 at 4 year wave, and .82 at 5 year wave

Log-Transformed & Z-Scored

(relative to M & SD at 4-year wave)



Covariates (For Sensitivity Analysis)

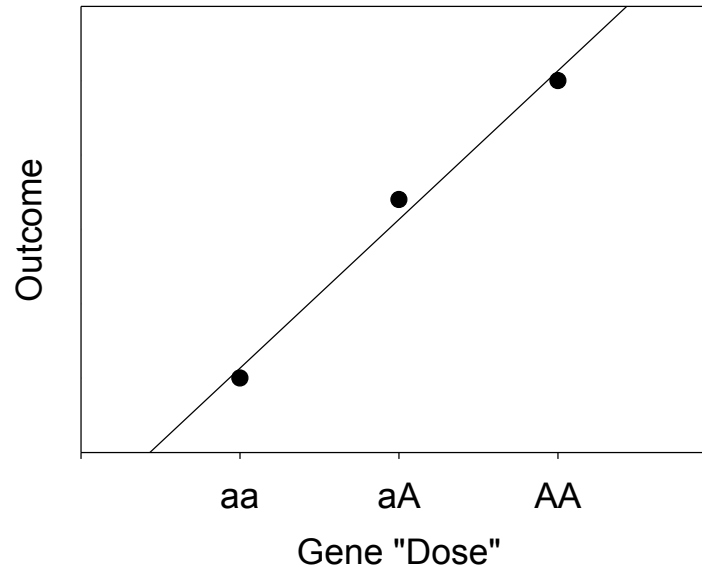
- Early Mental Ability (from 2 year wave):
Bayley Short Form Test of Mental Ability
(standardized to $M = 0$, $SD = 1$)
- Socioeconomic Status Composite ($M = .13$, $SD = .85$)
- Minority Status (0 = non-White; 1 = White)
- Age in Months at 4-year Assessment
(standardized to $M = 0$, $SD = 1$)

Quantitative Genetic Variance Decomposition

- (Additive) Genetic Variation (A)
- Shared (Common) Environmental Variation (C)
- Nonshared Environmental Variation (E)

Additive Genes (A) Defined

- Genes with dose-response relations



- A is the primary contributor to heritability (the proportion of population variation associated with genetic variation) in most psychological traits

Heritability (h^2) Operationalized

The percentage of population variation in an outcome that can be accounted for by genetic variation.

Shared Environment (C) Defined

- Environmental influences that occur at the family level
- Reflects influences of environments experienced by both siblings within the family that have the SAME effect on both of them
- Possible Examples:
 - Family Income
 - School Quality
 - Parental Affection (?)

Nonshared Environment (E) Defined

- Environments that are uniquely experienced by individual siblings, or environments that are experienced by both siblings but have different effects on them
- Possible Examples
 - Differential treatment by parents
 - Different classrooms at school
 - Chance experiences and encounters

Estimating A, C, and E: Identical and Fraternal Twins Reared Together

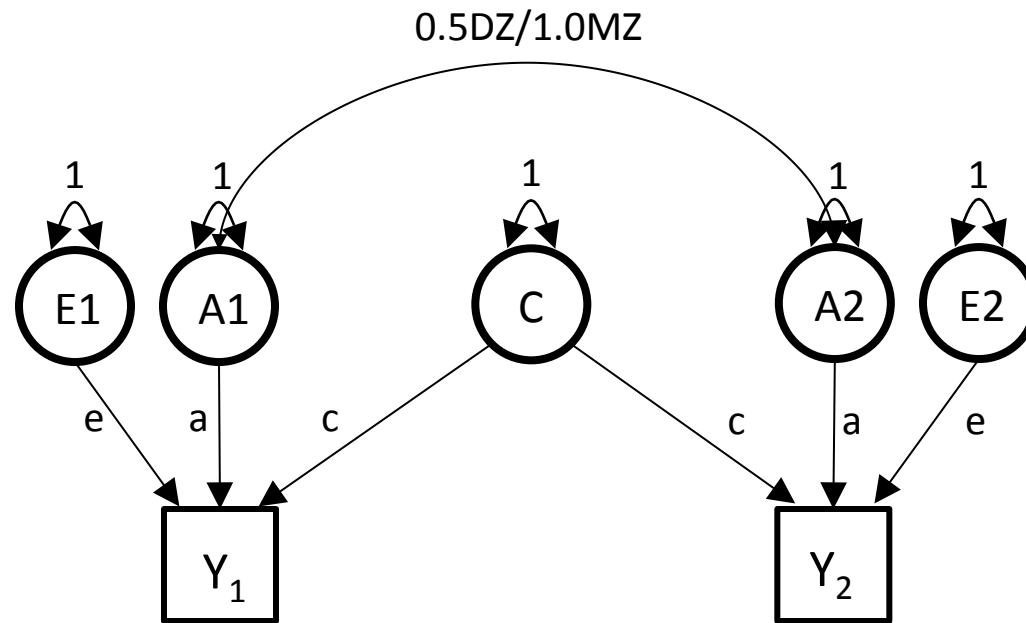
$$h^2 = 2(r_{MZ} - r_{DZ})$$

$$c^2 = r_{MZ} - h^2$$

$$e^2 = 1 - r_{MZ}$$

- **Question:** How much are genes involved in a trait?
- **Approach:** How much more similar are Identical (MZ) Twins than Fraternal (DZ) Twins on the trait?

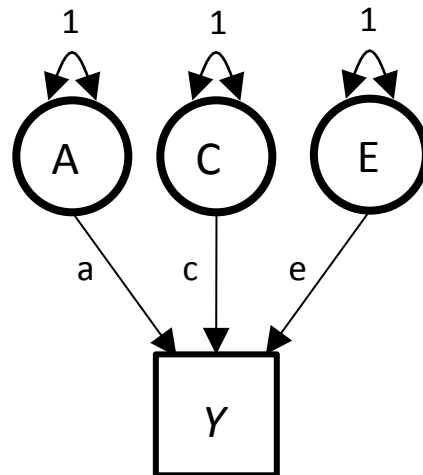
Structural Model for Identical and Fraternal Twins Reared Together



$$Y_{t,p} = \mu + a \cdot A_{t,p} + c \cdot C_p + e \cdot E_{t,p}$$

where $r_{AMZ} = 1.0$, $r_{ADZ} = 0.5$

Structural Model for Identical and Fraternal Twins Reared Together



Notes about ACE Models

- All about variation! These models are silent about human universals.
- A Includes both direct and “indirect” effects of genes
 - E.g. gene-environment correlation (rGE)
- Assumes A, C, and E are uncorrelated
 - A-C and A-E correlations are attributed to A
 - C-E correlations are attributed to E
 - Ways to estimate rGE include modeling an environment using the BG approach
- Has only recently been extended to include gene × environment interaction
 - Involves conditionalizing influences of A, C, and E on measured environments (e.g. SES, Preschool)

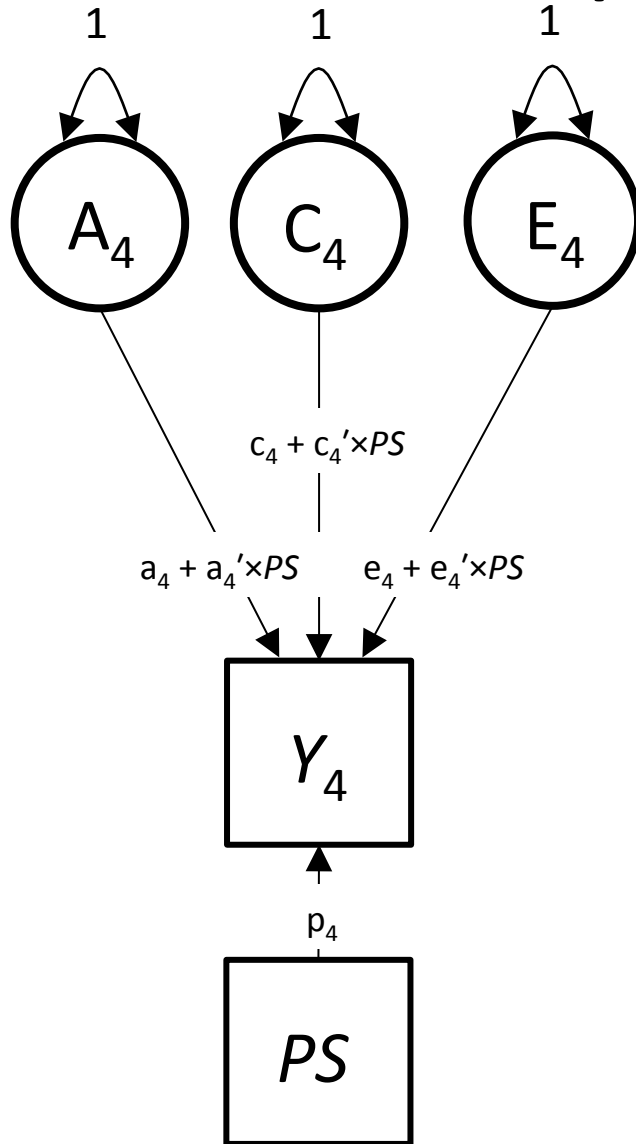
Additional Assumptions

- Twins are representative of the general population
 - Comparisons of Means and Variances of Traits in Twins and Singletons usually indicate only very small differences
- MZ twins aren't treated more similarly to one another than DZ twins just because they are MZ.
 - Studies of twins whose parents mistake MZ's for DZ's and vice versa indicate that true zygosity trumps believed zygosity in predicting twin similarity on psychological and health outcomes
- No Assortative Mating
 - Ignoring assortative mating, as is often done, results in an underestimation of genetic influences

Approach

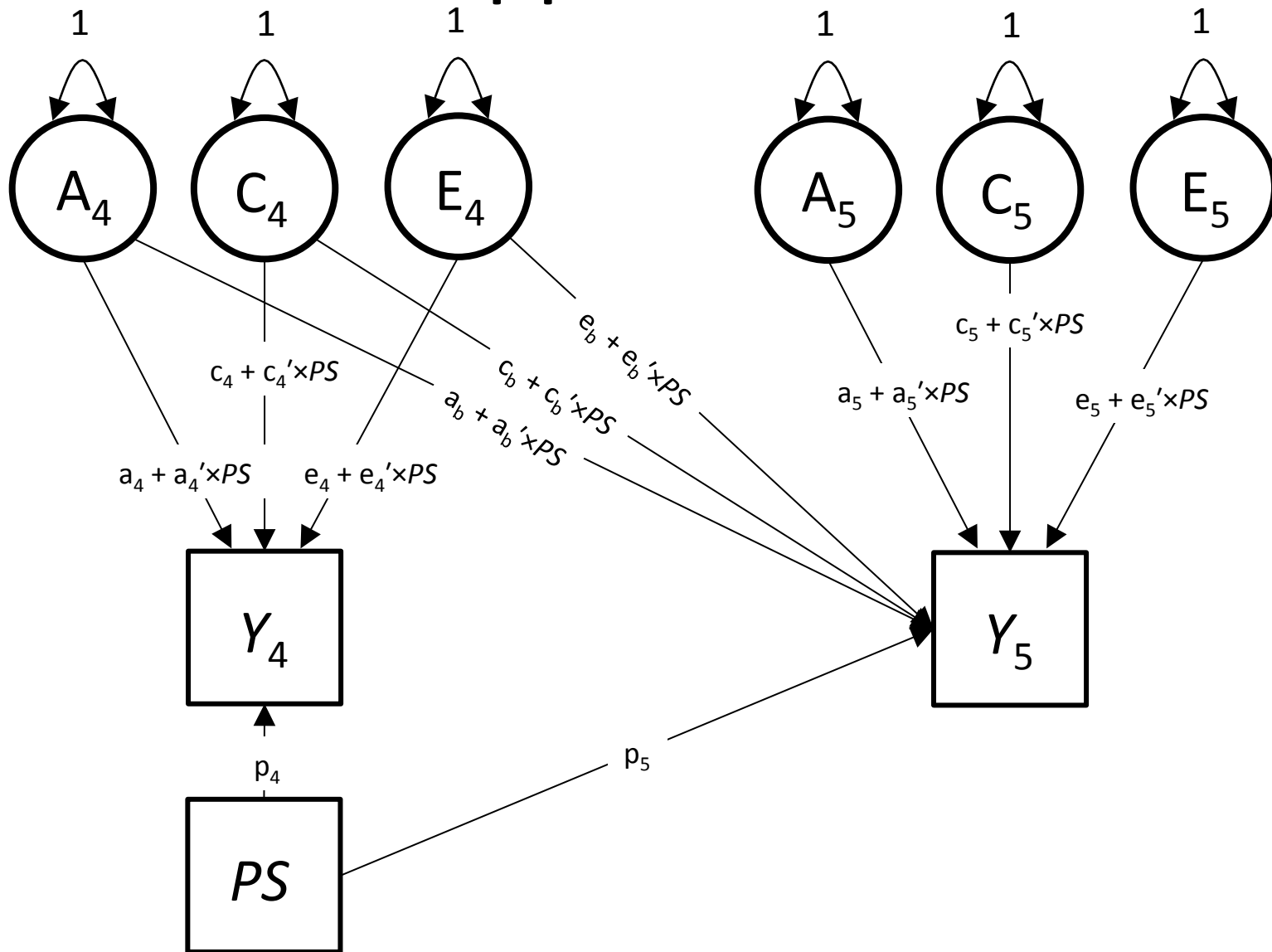
- Estimate population-average effects of A, C, and E on externalizing at 4 year and 5 year wave, along with effects of interactions between preschool enrollment (at age 4) and A, C, E
- Test whether gene-by-preschool interactions persist after controlling for key covariates (Early Mental Ability, SES, Minority Status, Age in Months)

Approach

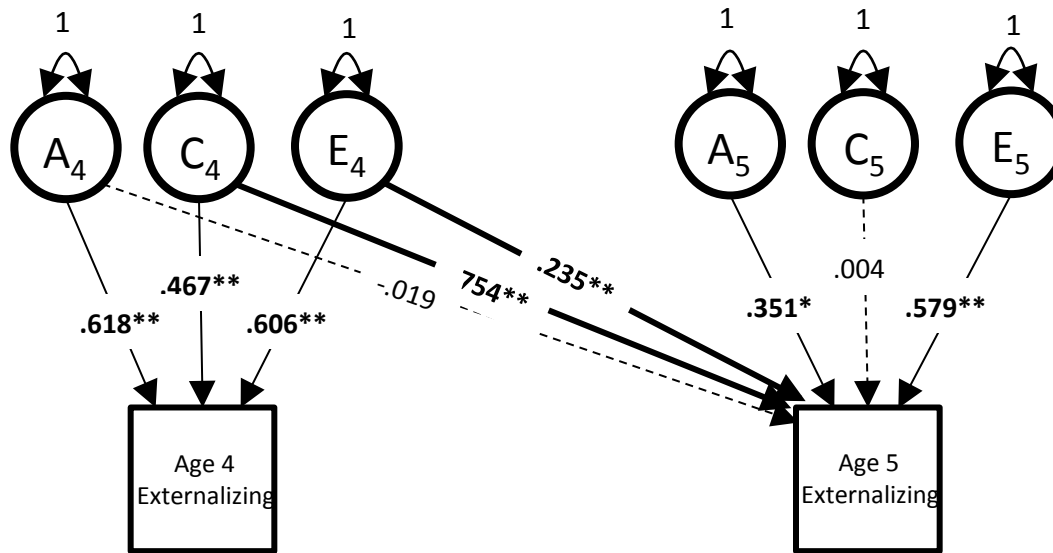


PS = -.5 for no Preschool at Age 4
PS = +.5 for Preschool Age 4

Approach



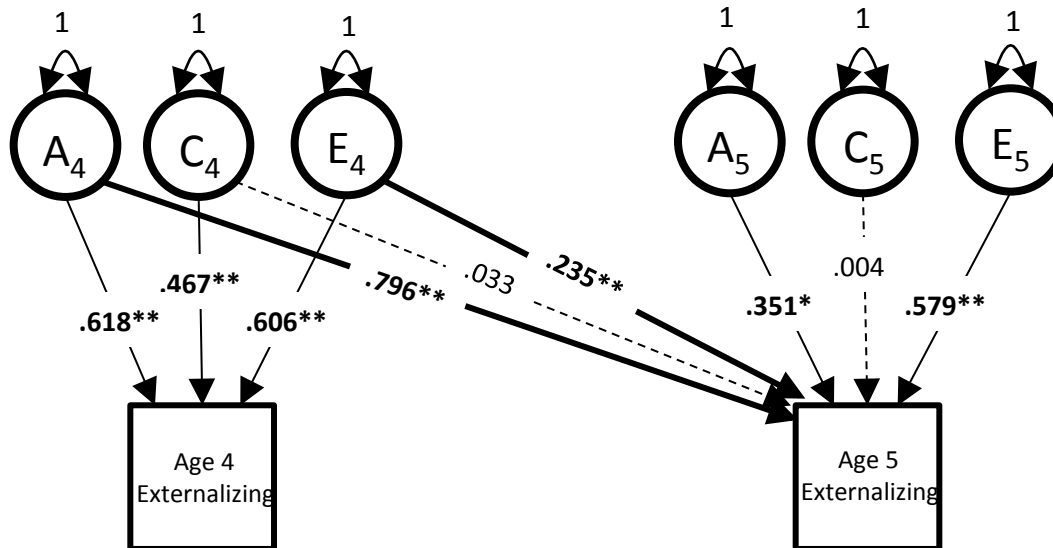
No Preschool
at Age 4



Mean Age 4 Externalizing = .024 (*ns*)
Main Effect of Preschool = -.036 (*ns*)

Mean Age 5 Externalizing = **-.122****
Main Effect of Preschool = **-.101 (*ns*)**

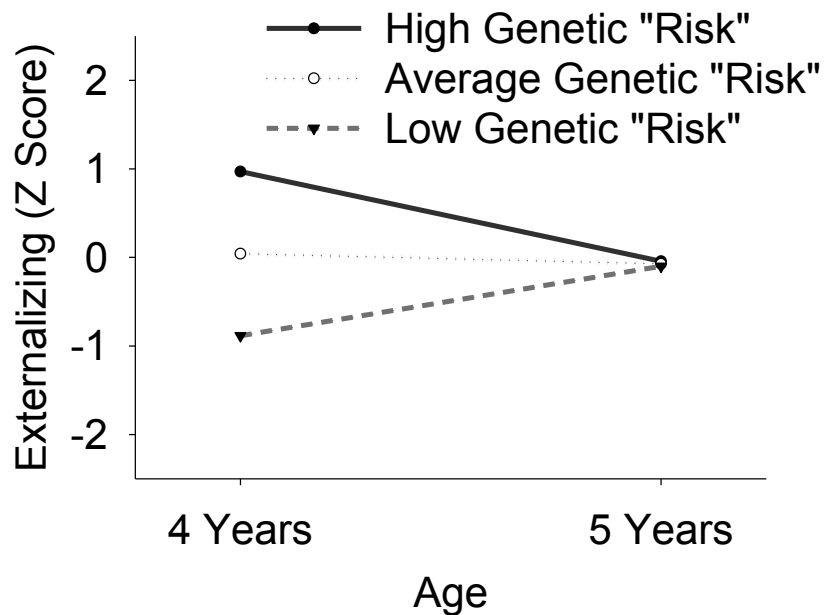
Preschool at
Age 4



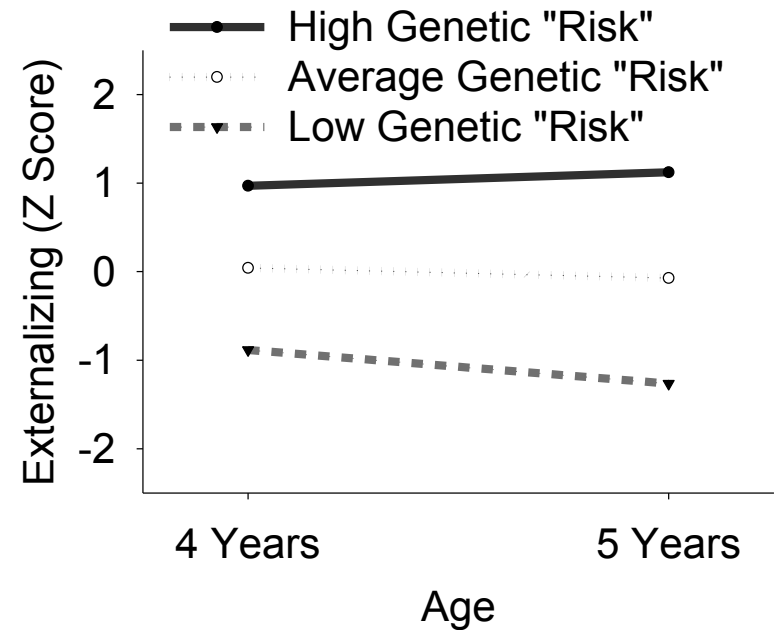
* $p < .05$
** $p < .01$

Differential Persistence of Genetic Effects by Context

No Preschool at Age 4

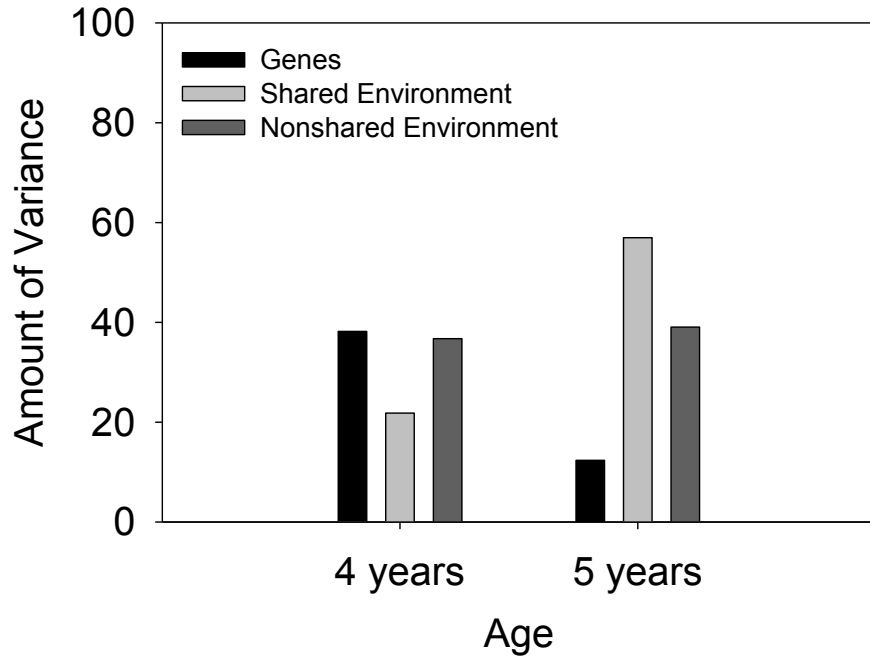


Preschool at Age 4

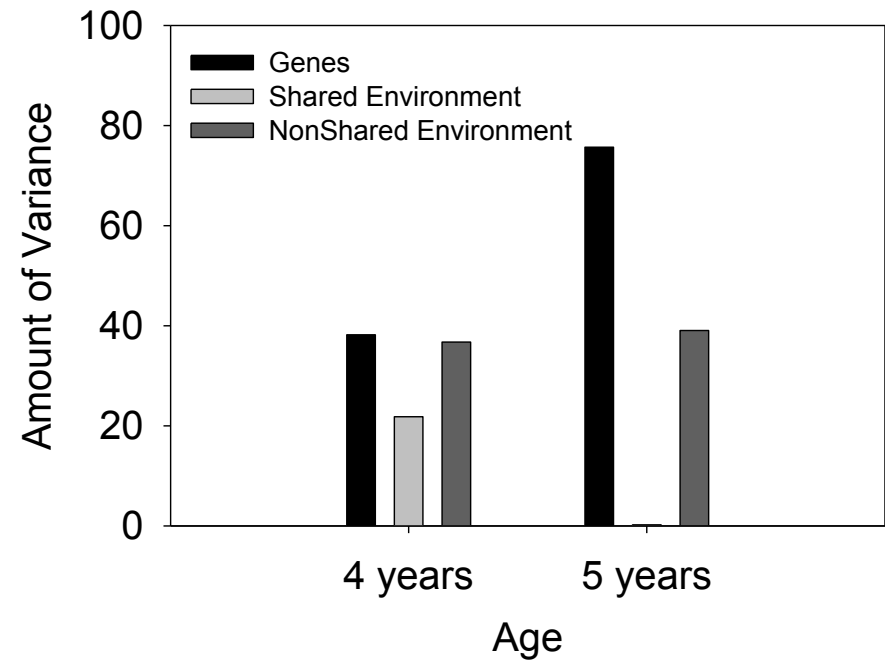


A, C, and E Estimates Separately by Preschool Enrollment Status

No Preschool At Age 4



Preschool at Age 4



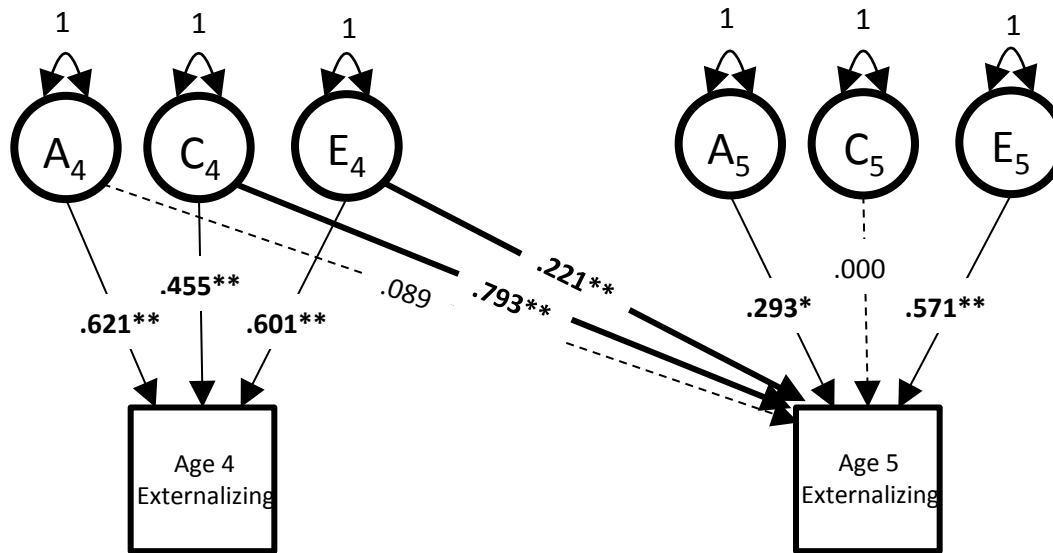
Sensitivity Analyses

Table 2. Multiple logistic regression predicting preschool enrollment at 4 year wave

Predictors	Estimate	SE
Early Mental Ability (2 year wave)	-0.017	0.102
Age in Months (4 year wave)	0.253**	0.090
SES (4 year wave)	0.555**	0.127
Minority Status (Nonwhite = 0, White = 1)	0.008	0.208

To avoid dependencies in this table, these results come from a model that included only one twin per pair. **p<.01.

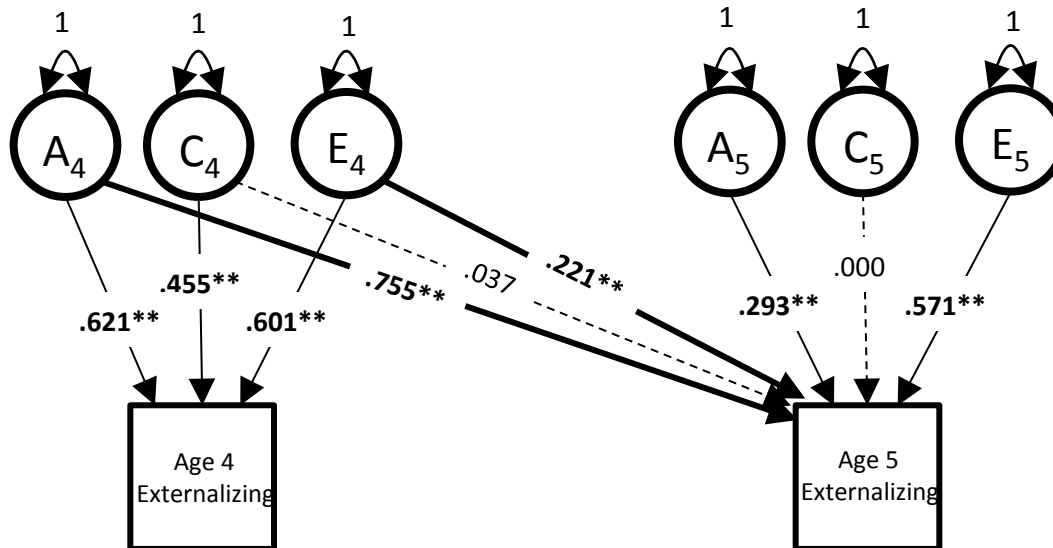
No Preschool
at Age 4



Mean Externalizing = .019(*ns*)
Main Effect of Preschool = .030 (*ns*)

Mean Externalizing = **-.114****
Main Effect of Preschool = **-.023 (*ns*)**

Preschool at
Age 4



* $p < .05$
** $p < .01$

Limitations & Future Directions

- Preschool was not randomly assigned
 - Key covariates did not reduce the gene-by-preschool interaction appreciably, but not all possible confounds were controlled
- Characteristics of preschools were not examined
 - Any form of center-based childcare was considered preschool
- Amount (days/week, # of years) of center-based care was not examined

Conclusions

- Evidence for a prospective *association* between preschool enrollment at age 4 and genetic influences on externalizing at age 5
- This gene-by-preschool interaction is robust to potential confounds associated with Early Mental Ability, SES, Minority Status, Age in Months

Paper 2.

Preschools Reduce Early Academic Achievement Gaps: A Longitudinal Twin Approach

Rationale for Positive Preschool Effects on Academic Skills

(Early Mathematics & Reading)

Structured lessons and activities specifically
designed to stimulate learning and teach
positive approaches towards learning

Rationale for Differential Effects by Home Environment

- “the best predictor of the size of [preschool] program effects may be the size of the gap between the program and home as learning environments... Thus, effects might be expected to be largest for the most disadvantaged.” -Barnett (1995; p. 43)

How Unequal Schools Can Serve as Equalizers

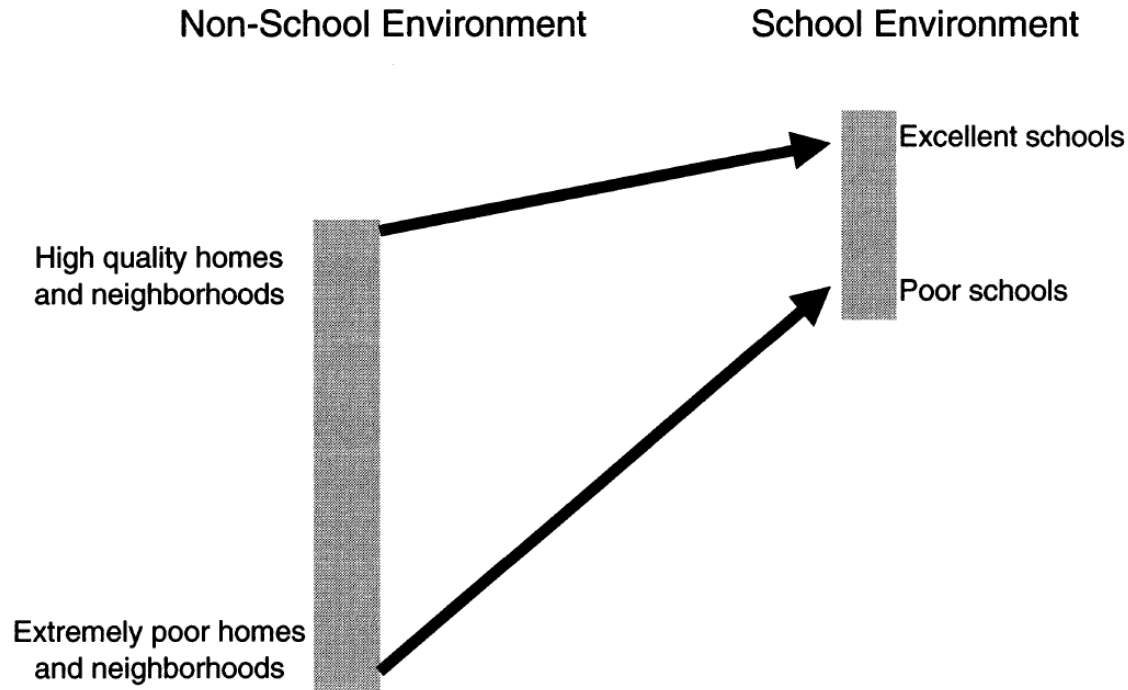


Figure 1. How Unequal Schools Can Serve as Equalizers

Note: Because non-school environments vary more than school environments, a child from a disadvantaged non-school environment can attend a disadvantaged school and yet still enjoy a greater school benefit than a child from an advantaged non-school environment who attends an advantaged school.

Early Childhood Longitudinal Study – Birth Cohort: 2 year, 4 year, and 5 year waves

- Twin Subsample
 - 200 MZ Pairs *
 - 400 DZ Pairs *

*Sample sizes rounded to nearest 50, in accordance with ECLS-B security regulations.

Cognition

- **Bayley Scale of Infant Mental Development Short Form – Research Edition (2 Years)**
 - quality of exploration of objects, early problem solving, the production of simple sound and gestures, and receptive and expressive communication with words
- **Early Reading Skills (4 & 5 Years)**
 - letter recognition, letter sounds, phonological awareness, matching words, and receptive vocabulary
- **Early Math Skills (4 & 5 Years)**
 - number sense, counting, operations, patterns, and spatial sense

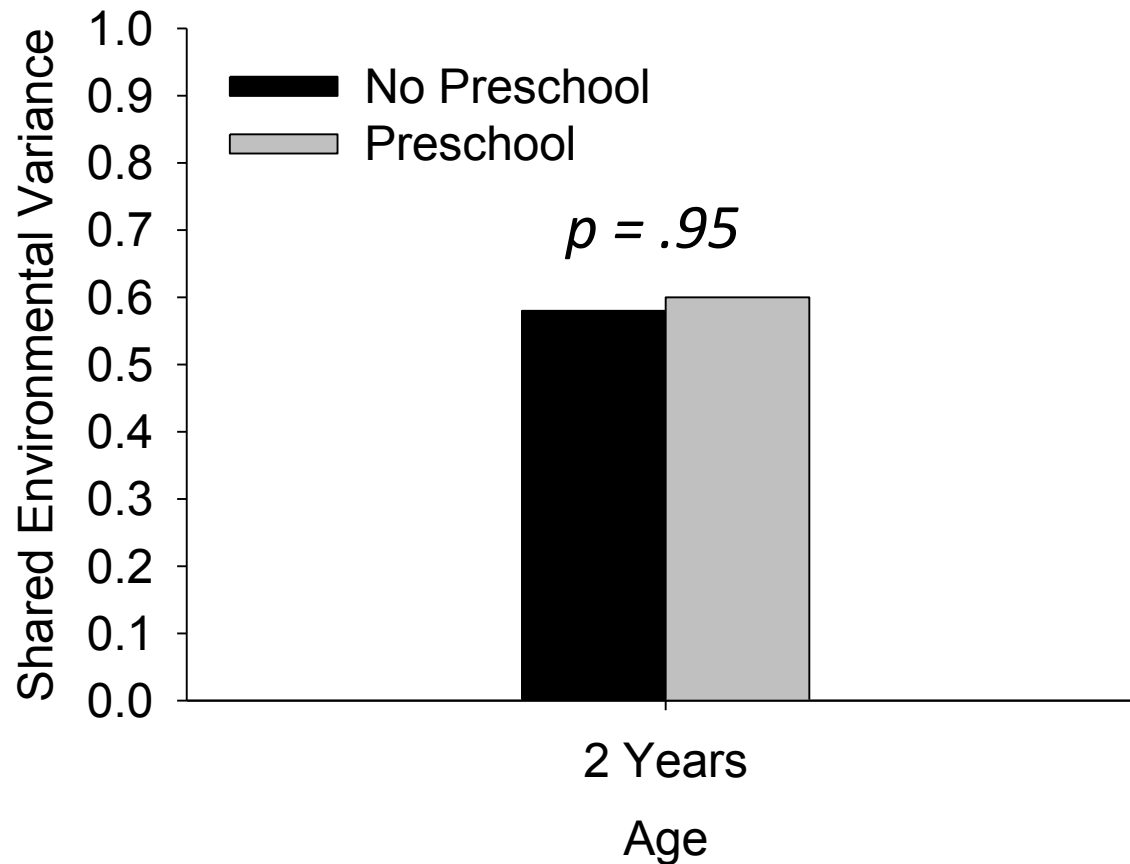
Measured Shared Environments

- Socioeconomic Status Composite
- Minority Status (0 = Non-White, 1 = White)
- Parental Stimulation of Cognitive Development
 - Rated from video recorded semi-structured parent-child interactions
 - the extent to which the parent demonstrates effortful, developmentally-appropriate teaching of the child to enhance cognitive, language, and perceptual development

Approach

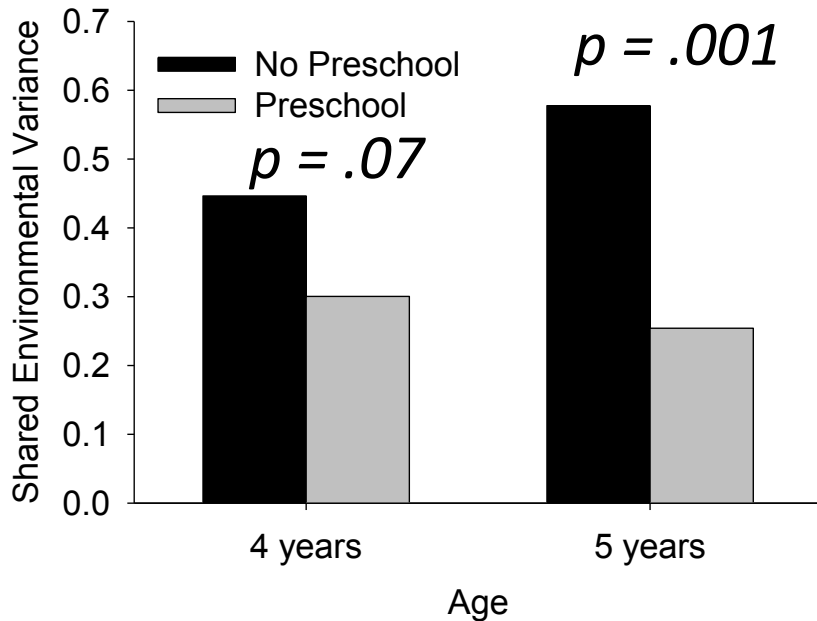
- Estimate population-average effects of A, C, and E on achievement, along with effects of interactions between preschool enrollment and A, C, E
- If preschools reduce achievement gaps, C should account for less variance in achievement amongst preschool enrollees compared to non-enrollees
- This effect should only occur prospectively

c^2 in 2 Year Bayley Scores as a Function of *Future* Preschool Status

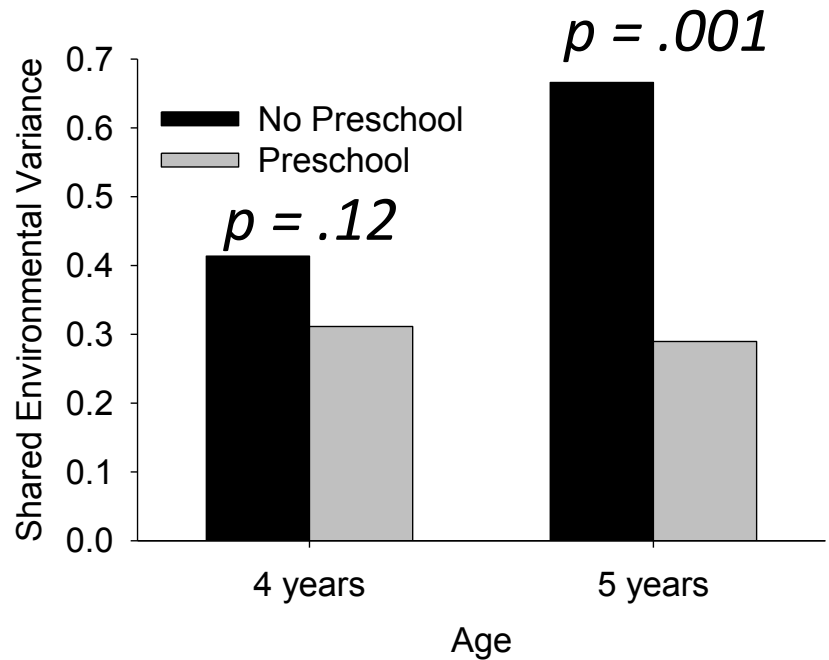


c^2 in Achievement Scores as a Functions of Preschool Enrollment

Mathematics

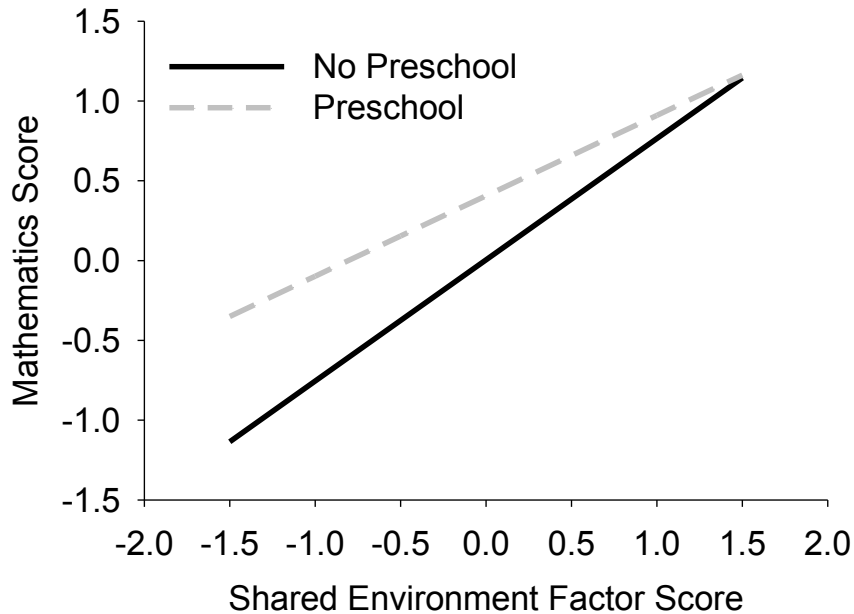


Reading

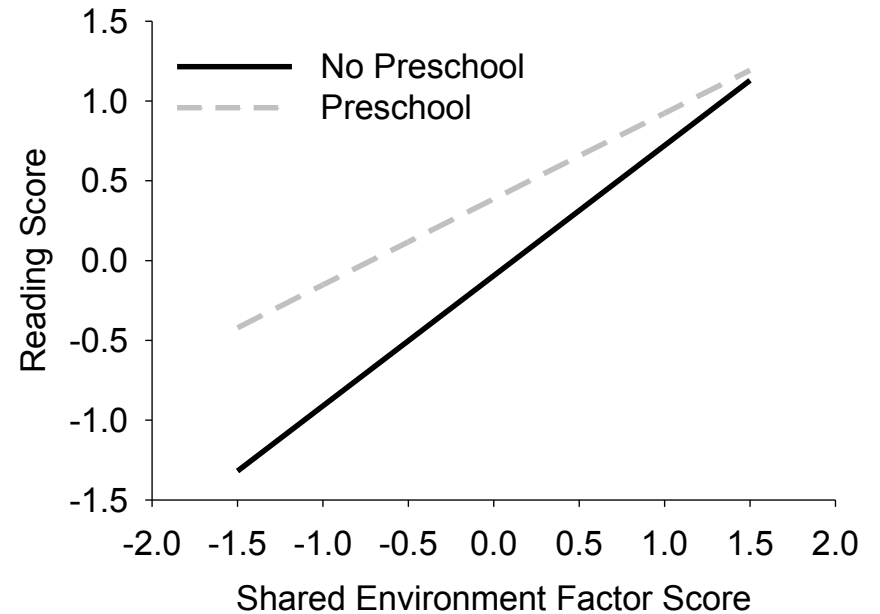


Achievement at 5 years

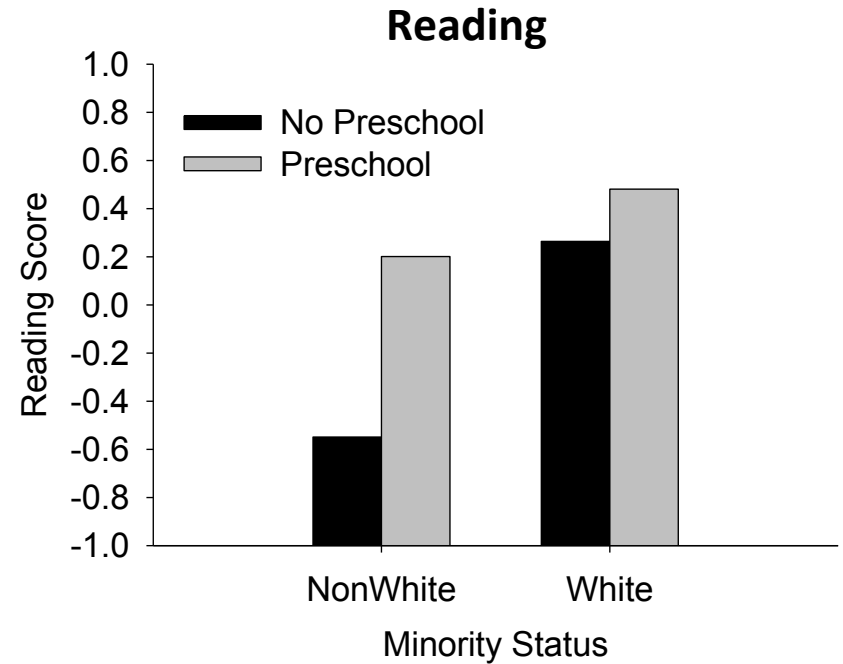
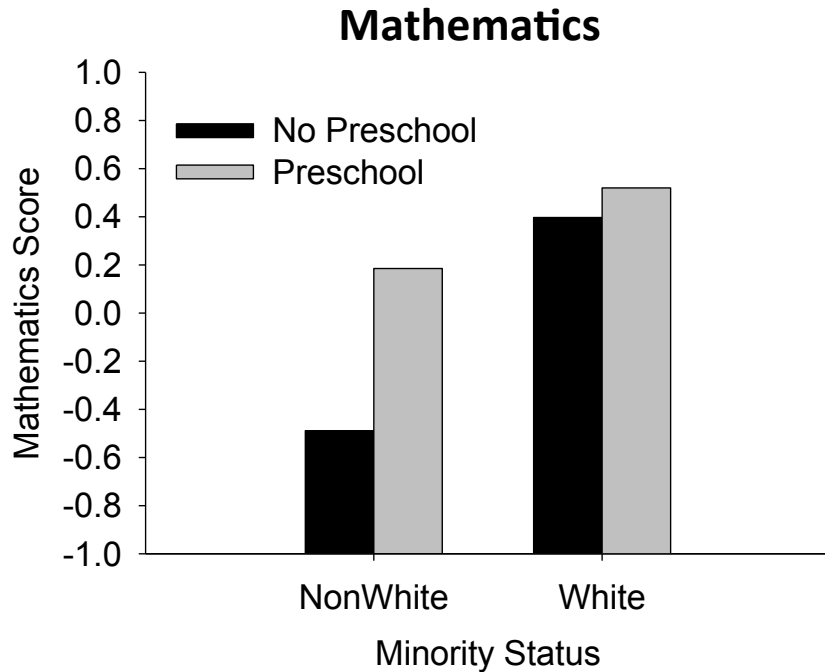
Mathematics



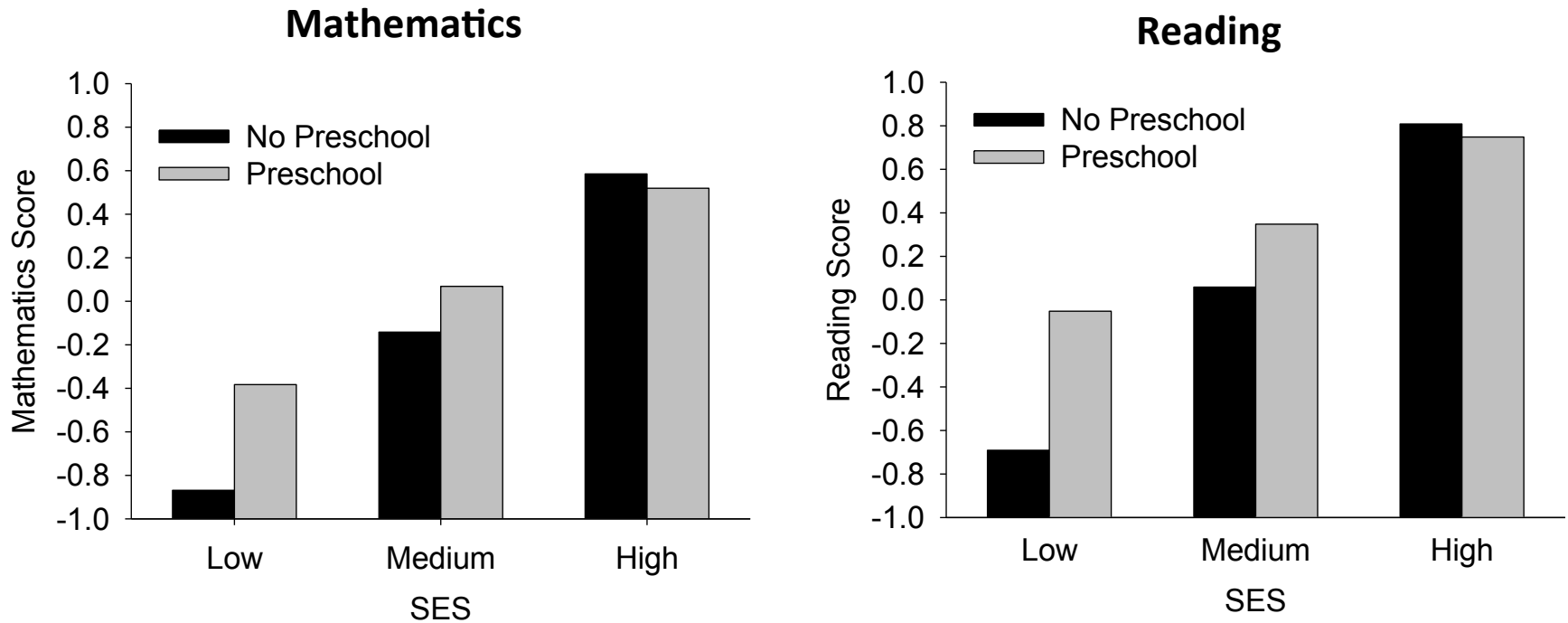
Reading



Accounting for the Preschool-by-Latent C interaction with **Measured** Shared Environments

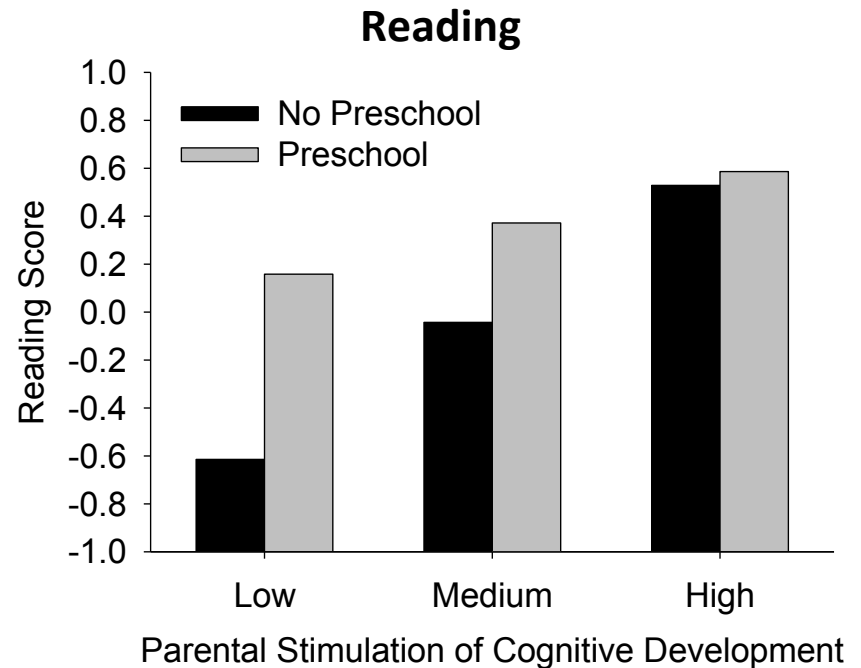
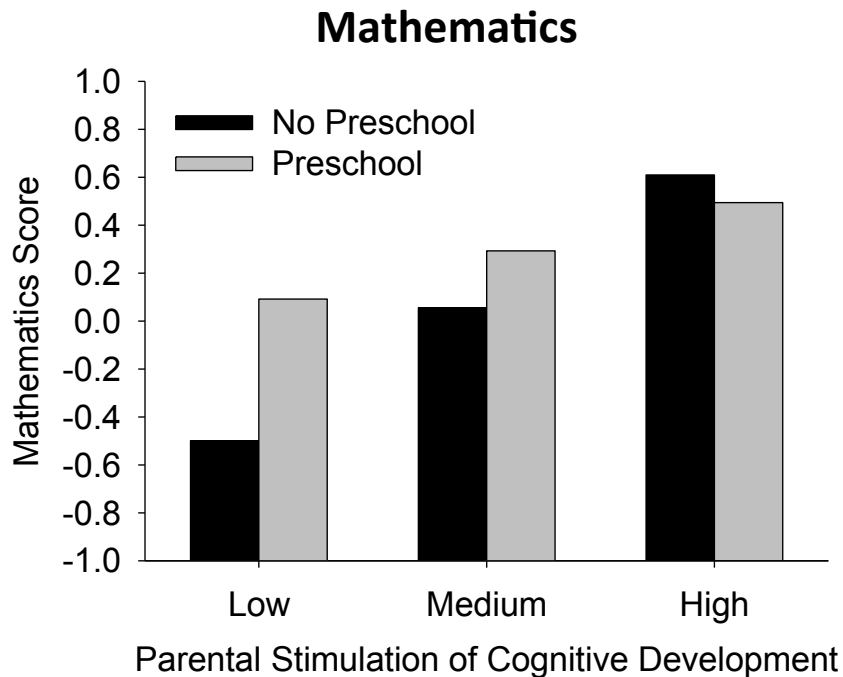


Accounting for the Preschool-by-Latent C interaction with **Measured** Shared Environments



(Low = 1.5 SD's below mean. Medium = mean. High = 1.5 SD's above mean)

Accounting for the Preschool-by-Latent C interaction with **Measured** Shared Environments



(Low = 1.5 SD's below mean. Medium = mean. High = 1.5 SD's above mean)

Conclusions: Preschools and Reduced Achievement Gaps

- Evidence for a *prospective* association between preschool enrollment at age 4 and between-family differences in achievement at age 5
- No interaction between future preschool enrollment and shared environmental influences in cognition at age 2
 - Evidence against selection
 - Nevertheless, causality is not definitive
- Preschool-by-Latent Environment interactions mediated by Preschool-by-Measured Environment interactions
 - Minority Status
 - Socioeconomic Status
 - Parental Stimulation of Cognitive Development

Thanks!