The Economics and Econometrics of Human Development
A Framework for Analyzing Human Development Over The Life Cycle

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Summer School on Socioeconomic Inequality Schedule
Summer 2012

- A framework for thinking about the dynamics of skill formation over the life cycle.

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2. They are not the sole determinants and possibilities for later effective interventions exist, but depends on the nature of the capability created.
3. More than smarts matter for success in life.

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    b. Alternative longitudinal study designs based on observational data
    c. No necessary primacy for social experiments, although they can play an important role in evaluating mean effects of interventions.

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7. To place the evaluation of specific policies to compensate for disadvantage on a common footing need to move beyond collections of "treatment effects" of policies, which are hard to interpret or use as the basis for policy when a variety of competing proposals are on the table.

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    3. Creative use of and supplementation of person registries

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4. Allows analysts and governments to compare and prioritize alternative policies over the life cycle.

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4. Capabilities are not set in stone. There is strong evidence of genetic components, but capabilities evolve and can be shaped in part by investments and environments.

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9. Today I present a dynamic state space framework that formalizes these ideas and is a guide for synthesizing evidence across diverse interventions for making policy and for understanding the mechanisms governing human development.

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  - $\theta_{H,t}$ is a vector of health stocks for mental and physical health at age t.

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  (d) **Constraints** reflecting access to credit markets, time constraints, and constraints arising from social interactions.

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- A_t represents other determinants of effort which might include some or all of the components of θ_t.

Capability Formation Process

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- θ_0 is the vector of initial endowments determined at birth or at conception.

- An important feature of the technology that explains many findings in the literature on skill formation is *complementarity of capabilities with investment:*

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- *Static complementarity* between period t capabilities and period t investment.
- The higher θ_t, the higher the productivity of investment I_t.

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- This in turn raises θ_s because the technology is increasing in θ_τ, for τ between t and s.
- This, in turn, raises $\dfrac{\partial f_s(\cdot)}{\partial I_s}$ because θ_s and I_s are complements, as a consequence of (4).

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- They enhance the productivity of later investments.

- Dynamic complementarity explains the evidence that early nurturing environments affect the ability of animals and humans to learn.
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- They enhance the productivity of later investments.
- Dynamic complementarity also explains why investment in low ability (low θ_t) adolescents and adults often has such low returns—because the stock of θ_t is low.

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- The technology is consistent with the body of evidence on critical and sensitive periods.
- Will discuss parental preferences, child-parent interactions, and constraints later.

Evidence on Inequality and Human Development

1. Multiple Capabilities Shape Human Achievement

- Cognitive traits (θ_C)

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  1. **crystallized** and **fluid intelligence**
  2. different age profiles for their development
- Socioemotional or noncognitive traits: personality traits and preference parameters (θ_N)
- Health θ_H (mental and physical health)
- Each trait evolves over time. Levels of each trait are positively (but not perfectly) correlated over time.

These capabilities or traits have direct **causal** effects on

wages (controlling for schooling),	schooling,
performance on achievement tests,	crime,
compliance with health protocols,	smoking,
adult health outcomes (mental and physical),	teenage pregnancy

and many other aspects of social and economic life.

Evidence on the Predictive Power of Cognitive and Socioemotional Traits

- The following figures show the effect of capabilities on diverse outcomes correcting for the effect of schooling on capabilities and the effect of capabilities on schooling.

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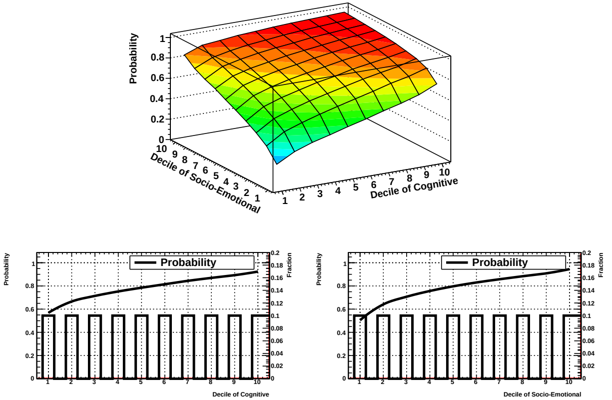
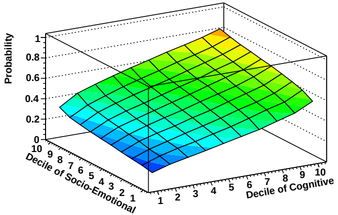
- The following figures show the effect of capabilities on diverse outcomes correcting for the effect of schooling on capabilities and the effect of capabilities on schooling.
- There is a causal effect of schooling on these capabilities.
- The empirical relationships I report next account for reverse causality — measured capabilities may be determined in part by schooling.

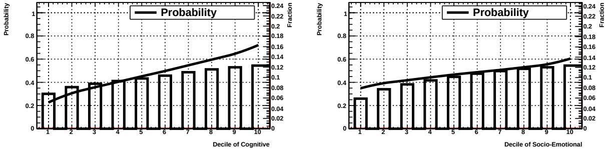
Figure 1: The Probability of Educational Decisions, by Endowment Levels, Dropping from Secondary School vs. Graduating



Source: Heckman, Humphries, Urzua, and Veramendi (2011).

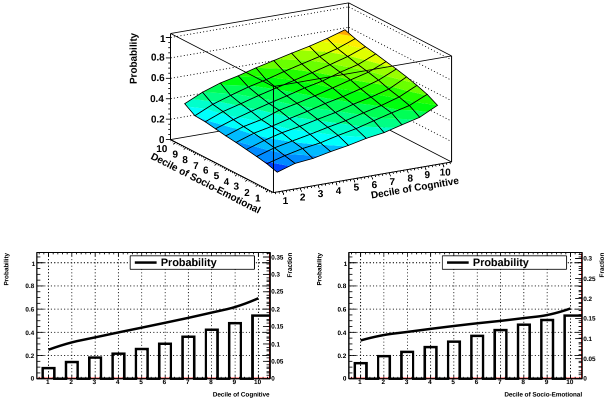
Figure 2: The Probability of Educational Decisions, by Endowment Levels, **HS Graduate** vs. College Enrollment





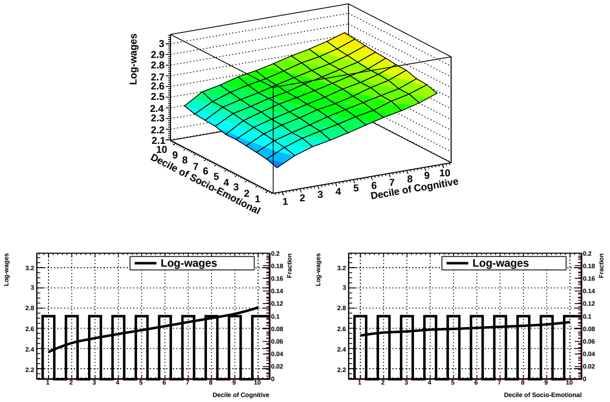
Source: Heckman, Humphries, Urzua, and Veramendi (2011).

Figure 3: The Probability of Educational Decisions, by Endowment Levels, **Some College** vs. **4-year college degree**



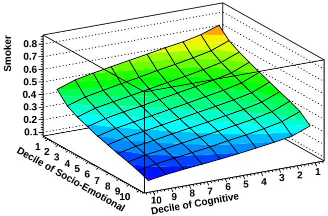
Source: Heckman, Humphries, Urzua, and Veramendi (2011).

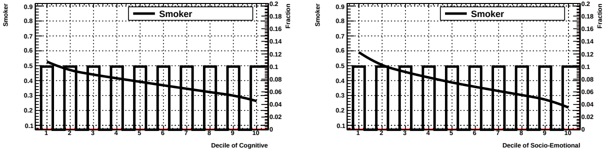
Figure 4: The Effect of Cognitive and Socio-emotional endowments, (log) Wages



Source: Heckman, Humphries, Urzua, and Veramendi (2011).

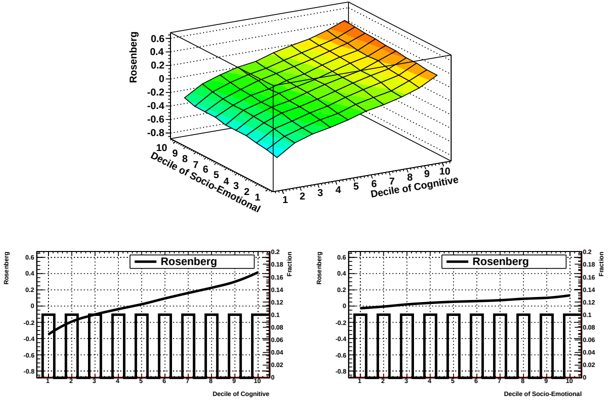
Figure 5: The Effect of Cognitive and Socio-emotional endowments, Daily Smoking





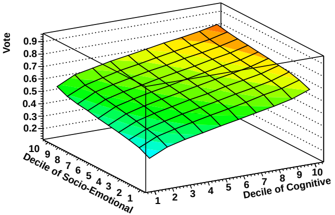
Source: Heckman, Humphries, Urzua, and Veramendi (2011).

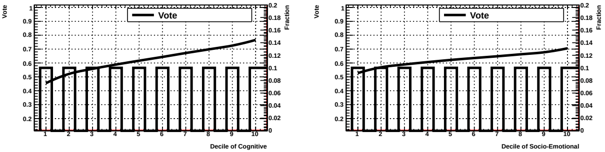
Figure 6: The Effect of Cognitive and Socio-emotional endowments, Self-Esteem



Source: Heckman, Humphries, Urzua, and Veramendi (2011).

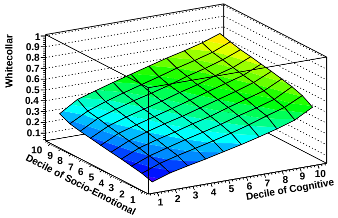
Figure 7: The Effect of Cognitive and Socio-emotional endowments, Participated in 2006 election

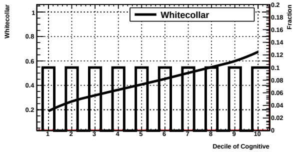


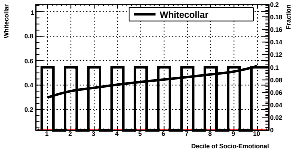


Source: Heckman, Humphries, Urzua, and Veramendi (2011).

Figure 8: The Effect of Cognitive and Socio-emotional endowments on Probability of White-collar occupation (age 30)

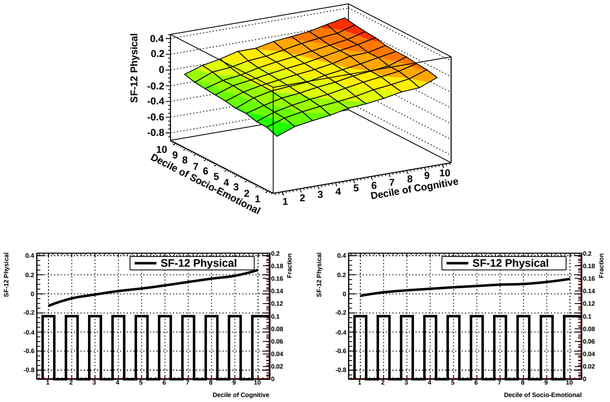






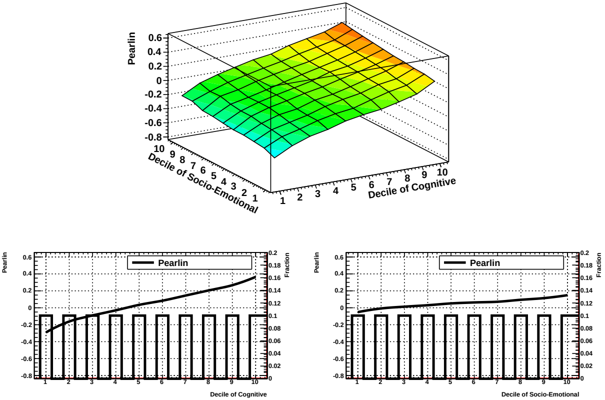
Source: Heckman, Humphries, Urzua, and Veramendi (2011).

Figure 9: The Effect of Cognitive and Socio-emotional endowments on Physical Health at age 40 (PCS-12)



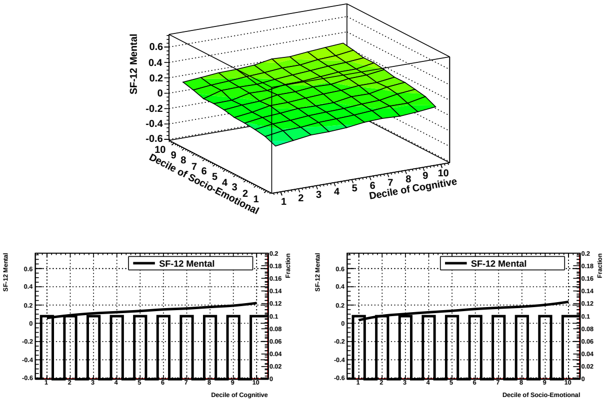
Source: Heckman, Humphries, Urzua, and Veramendi (2011).

Figure 10: The Effect of Cognitive and Socio-emotional endowments on Pearlin's "Personal Mastery Scale"



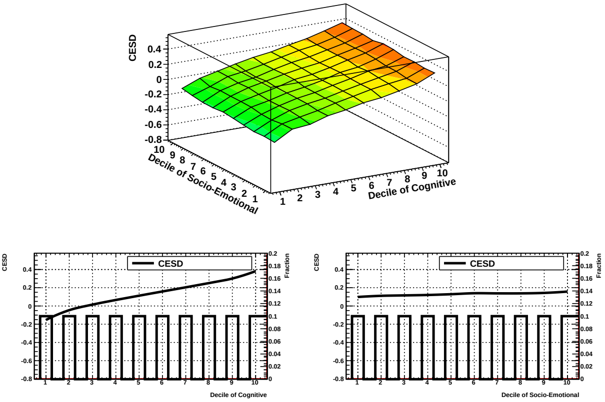
Source: Heckman, Humphries, Urzua, and Veramendi (2011).

Figure 11: The Effect of Cognitive and Socio-emotional endowments on Mental Health at age 40 (MCS-12)



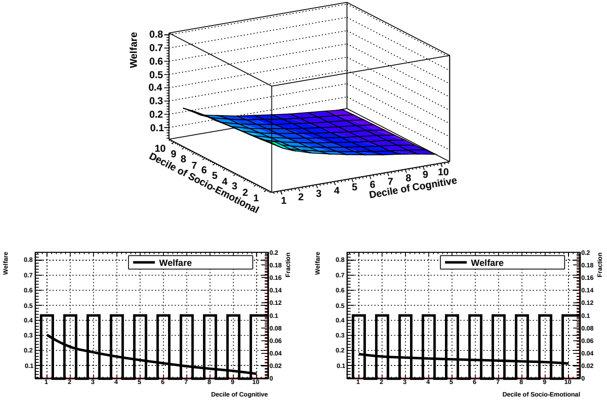
Source: Heckman, Humphries, Urzua, and Veramendi (2011).

Figure 12: The Effect of Cognitive and Socio-emotional endowments on Depression at age 40 (CES-D - Reverse Score)



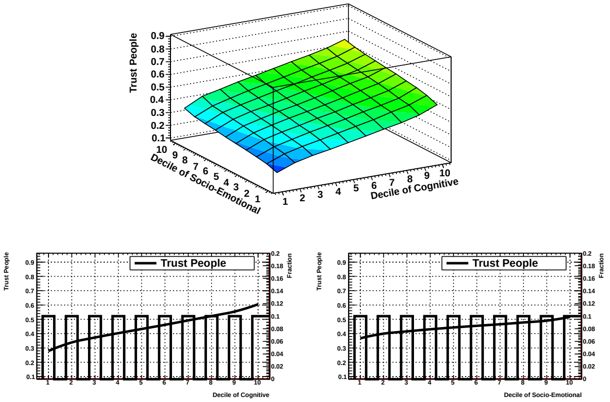
Source: Heckman, Humphries, Urzua, and Veramendi (2011).

Figure 13: The Effect of Cognitive and Socio-emotional endowments on Ever Participated in Welfare (1996-2006)



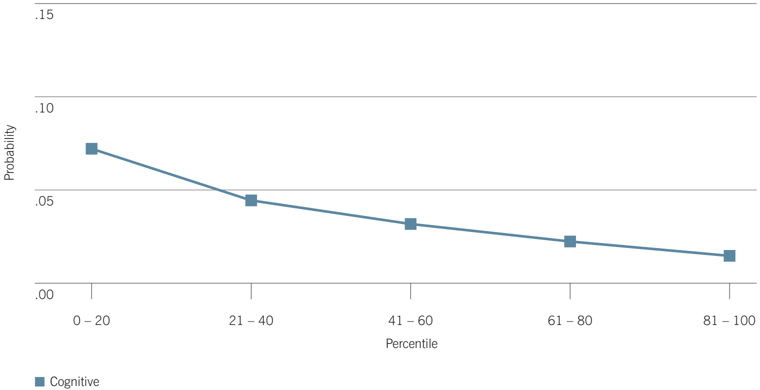
Source: Heckman, Humphries, Urzua, and Veramendi (2011).

Figure 14: The Effect of Cognitive and Socio-emotional endowments on Trusting People (2008)



Source: Heckman, Humphries, Urzua, and Veramendi (2011).

Ever been in jail by age 30, by ability (males)



Note: This figure plots the probability of a given behavior associated with moving up in one ability distribution for someone after integrating out the other distribution. For example, the lines with markers show the effect of increasing socioemotional ability after integrating the cognitive ability.

Source: Heckman, Stixrud, and Urzua (2006).

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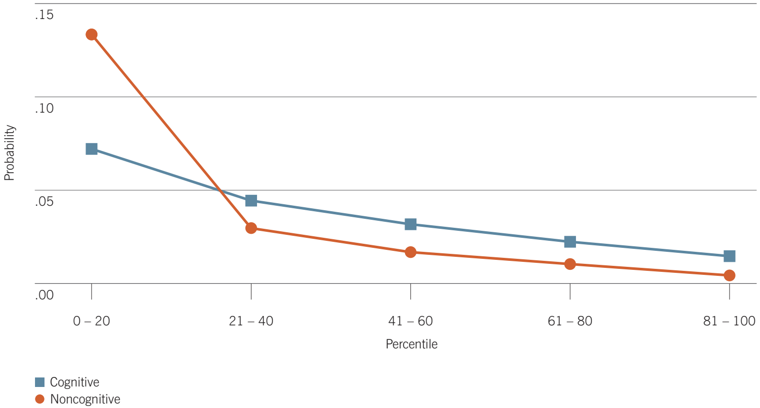

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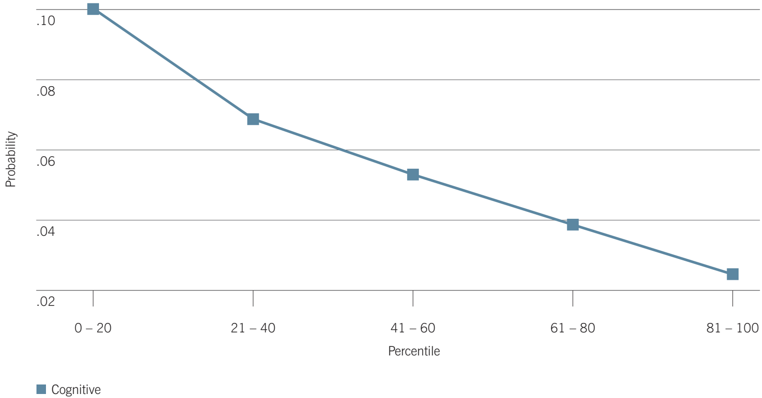
Probability of being teenage and single with children (females)



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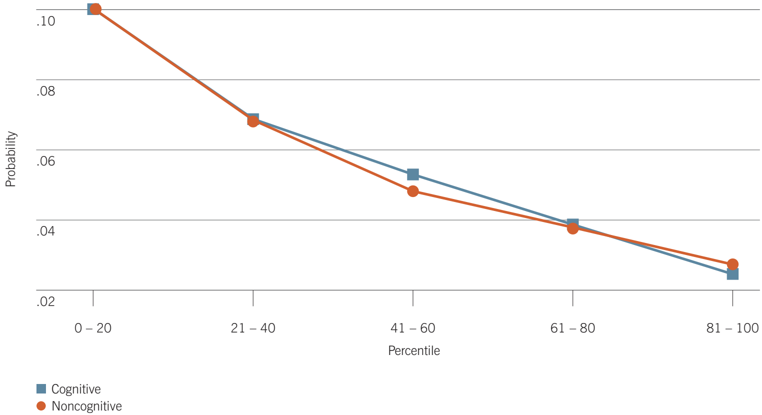

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- Emerging evidence that the effect of many (but not all) noncognitive (socioemotional) traits operates primarily though schooling. (Heckman, Humphries, Urzua, and Veramendi, 2011)

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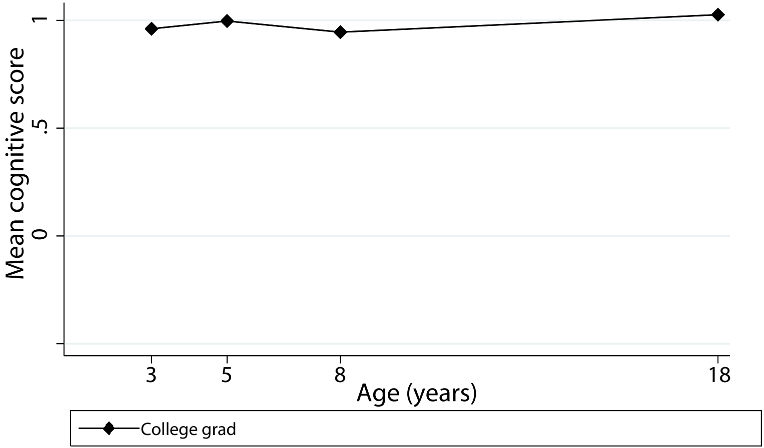
- Fixing schooling, and controlling for its endogeneity, effects of both cognitive and noncognitive traits on outcomes are diminished, often entirely eliminated.

2. For both cognitive and personality traits, ability gaps across socioeconomic groups open up at early ages and persist before children enter school.

For health traits, gaps tend to widen with age.

Trend in mean cognitive score by maternal education



Each score standardized within observed sample. Using all observations and assuming data missing at random. Source: Brooks-Gunn et al. (2006).

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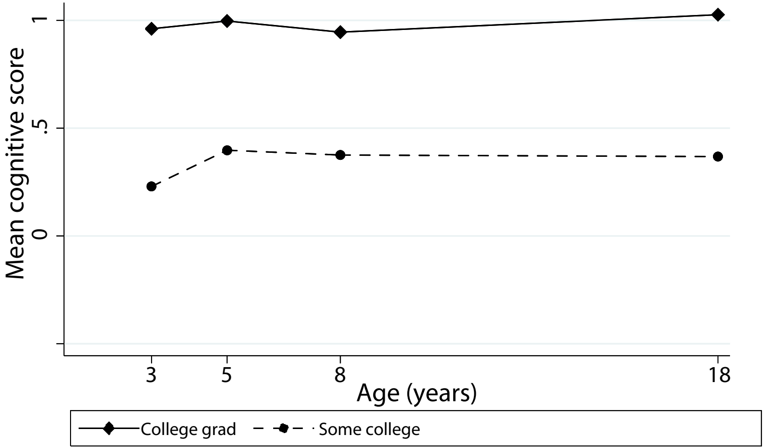

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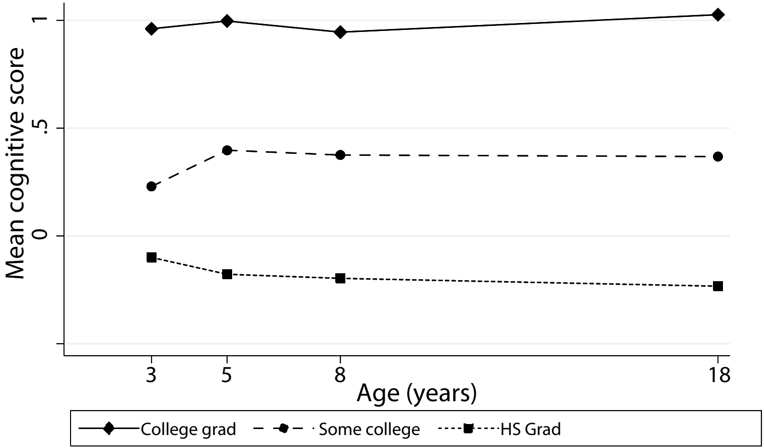

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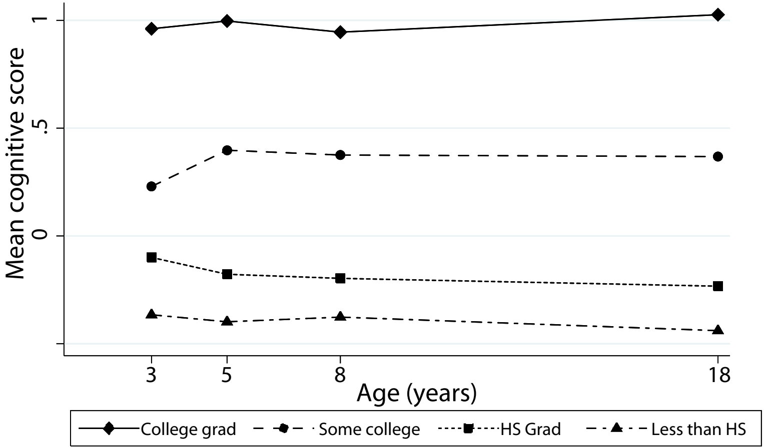

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- Controlling for early family environments using conventional statistical methods substantially narrows the gaps.

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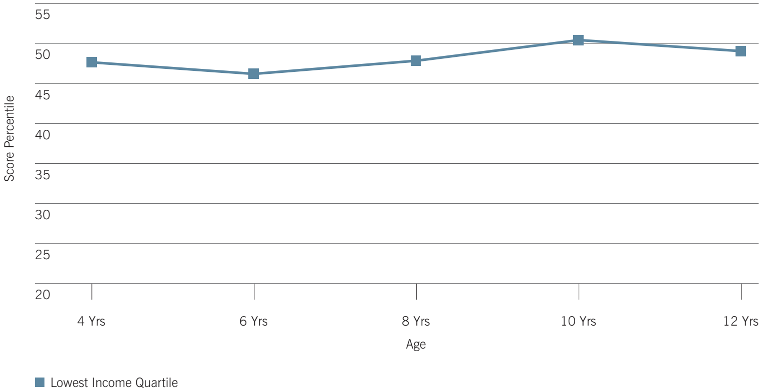
- There are comparable phenomena in the evolution of gaps in behavioral problems.

Average percentile rank on anti-social behavior score, by income quartile



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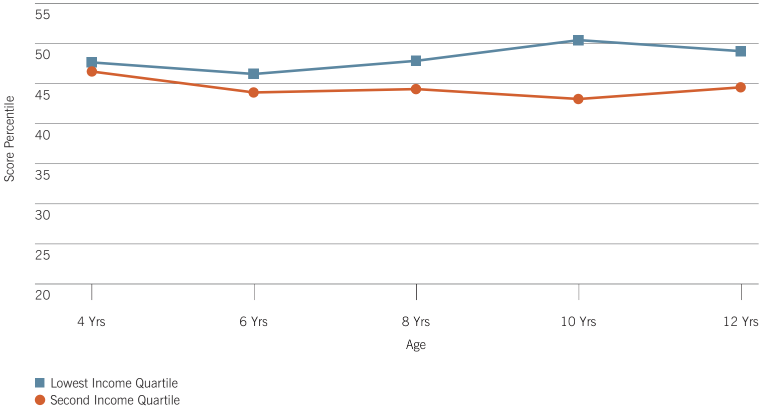

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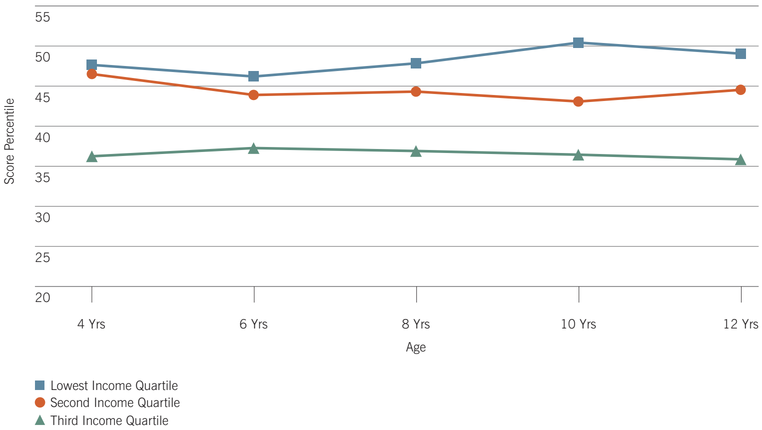

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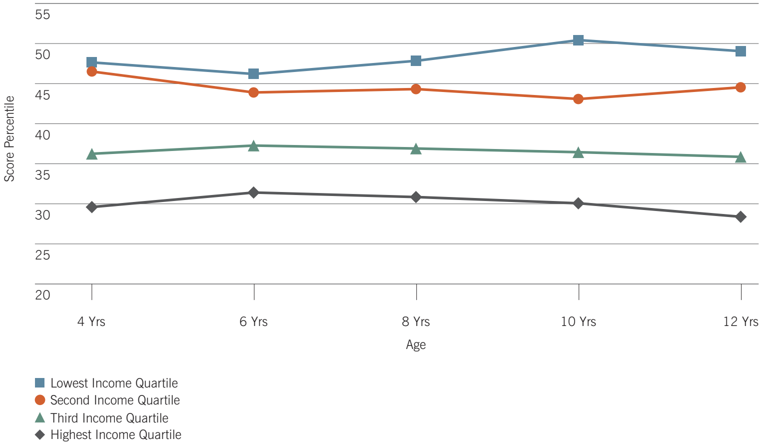
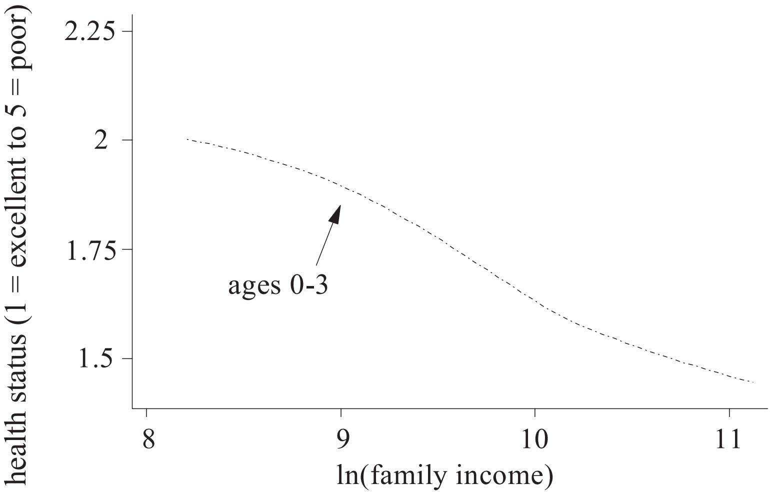


Gaps also emerge in health. They *diverge* with age.

Health and income for children and adults, U.S. National Health Interview Survey 1986-1995.*



* From Case, A., Lubotsky, D. & Paxson, C. (2002), American Economic Review, Vol. 92, 1308-1334.

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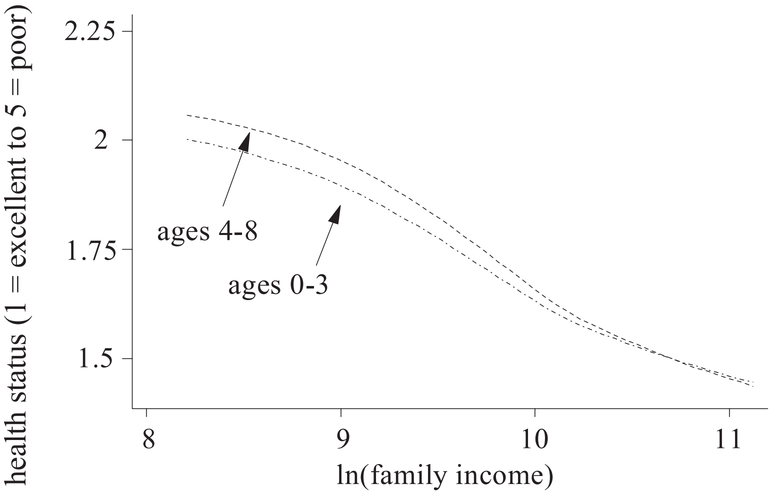

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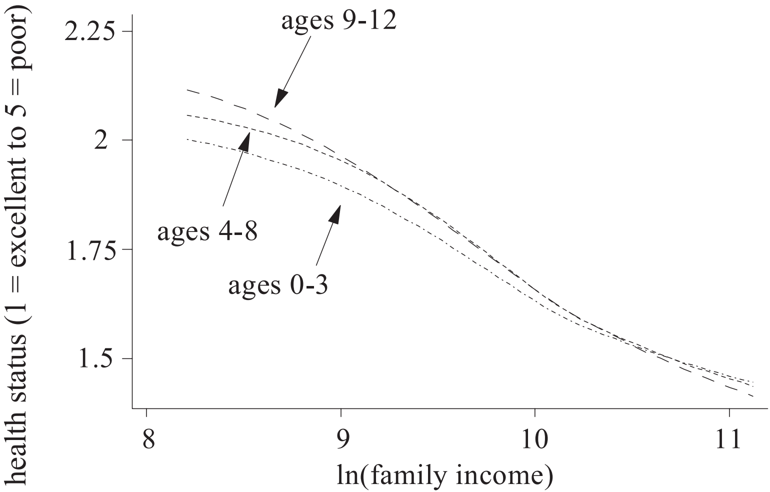

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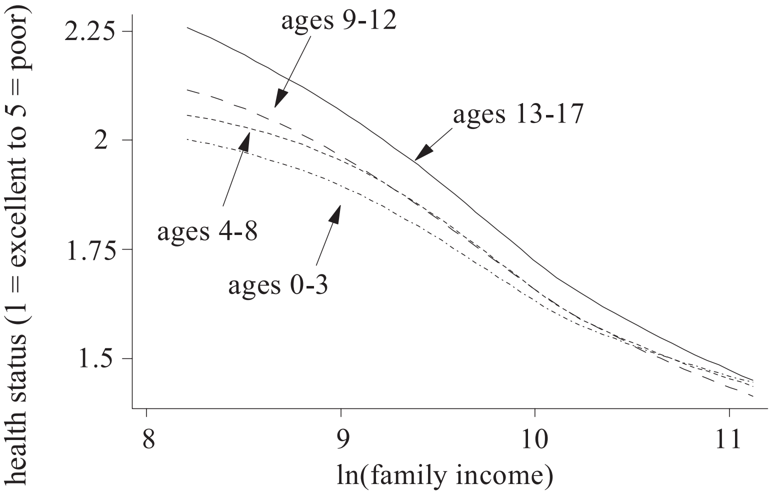

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- Evidence for neighborhood effects and social interactions is less clear cut and is still being investigated.
- Some claim that peers are more important than parents.

3. Gaps in capabilities by age across different socioeconomic groups have counterparts in gaps in family investments and environments.

- Investment in children varies substantially by family type.

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- Investment in children varies substantially by family type.
- Differences are persistent over the age of the child.

Family Environments

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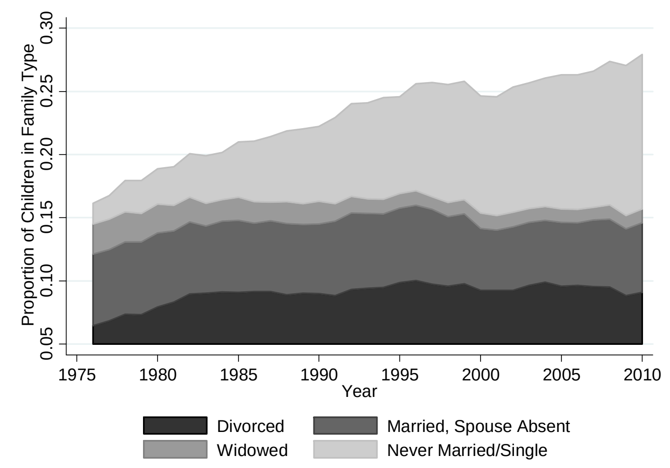
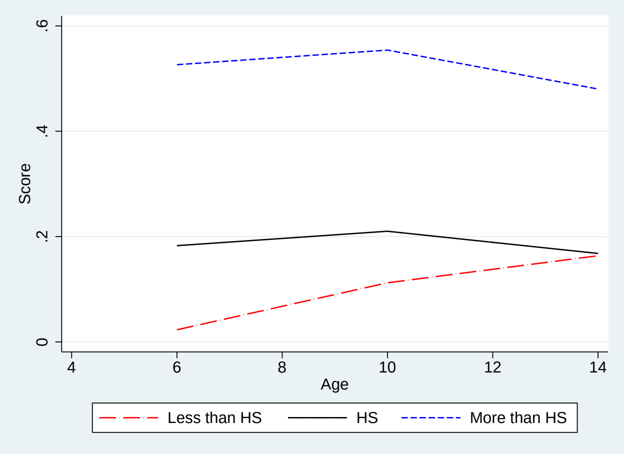
- Likely fosters persistence of inequality across generations.
- Fewer Danes seem to be in this category.
- Perhaps for this reason, intergenerational family influence much stronger in the U.S. than in Denmark.

Children Under 18 Living in Single Parent Households by Marital Status of Parent



Source: March CPS 1976-2010 ; Note: Parents are defined as the head of the household. Children are defined as individuals under 18, living in the household, and the child of the head of household. Children who have been married or are not living with their parents are excluded from the calculation. Separated parents are included in "Married, Spouse Absent" Category.

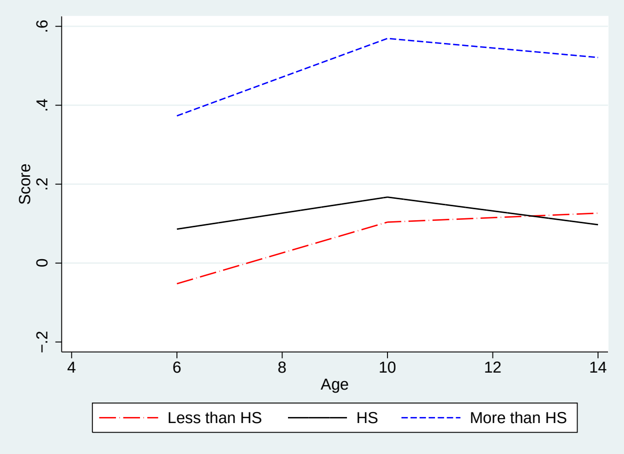
Figure 15: Parental Investment over Childhood among Whites by Mother's Education: Material Resources



Data: A balanced panel from Children of National Longitudinal Survey of Youth 1979.

Source: Moon (2012).

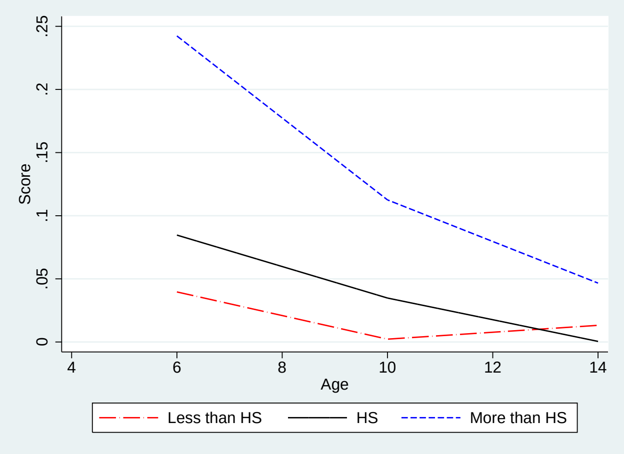
Figure 16: Parental Investment over Childhood among Whites by Mother's Education: Cognitive Stimulation



Data: A balanced panel from Children of National Longitudinal Survey of Youth 1979.

Source: Moon (2012).

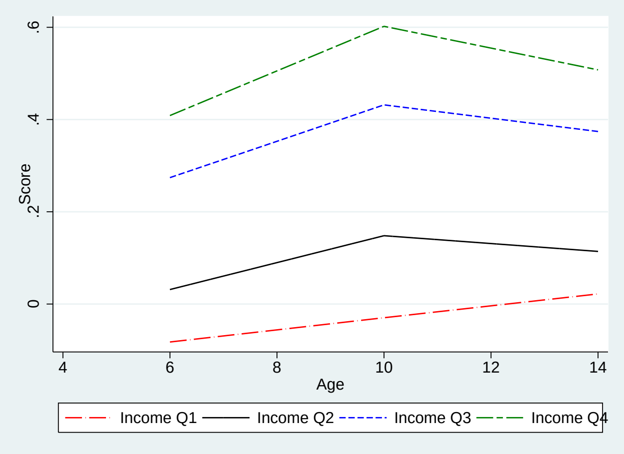
Figure 17: Parental Investment over Childhood among Whites by Mother's Education: Emotional Support



Data: A balanced panel from Children of National Longitudinal Survey of Youth 1979.

Source: Moon (2012).

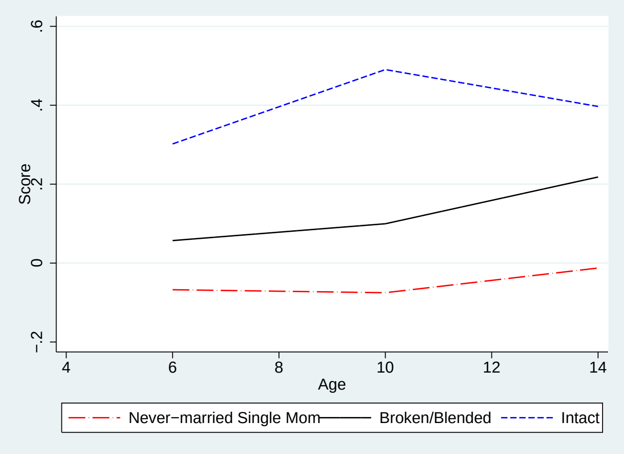
Figure 18: Parental Investment over Childhood among Whites by Family Income Quartile: Cognitive Stimulation



Data: A balanced panel from Children of National Longitudinal Survey of Youth 1979.

Source: Moon (2012).

Figure 19: Parental Investment over Childhood among Whites by Family Type: Cognitive Stimulation



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Early Life Conditions Matter

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- See Knudsen et al. (2006)

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- Early life conditions are reinforced by (or attenuated by) later-life interventions.

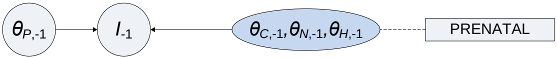
A Life Cycle Framework for Organizing Studies and Integrating Evidence

$\theta_t = (\theta_C, \theta_N, \theta_H)$ capacities at t

$\theta_{P,t}$: parental traits at t

I_t: investment at t

$\theta_{t+1} = f_t(\theta_t, I_t, \theta_{P,t})$: **Technology of Skill Formation**



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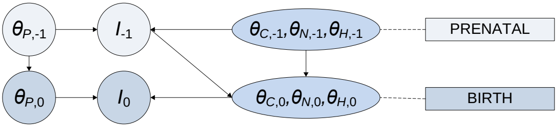

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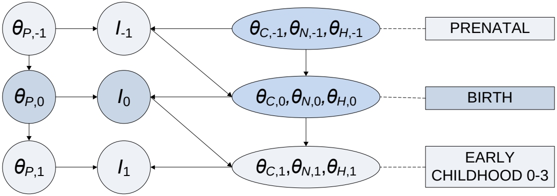

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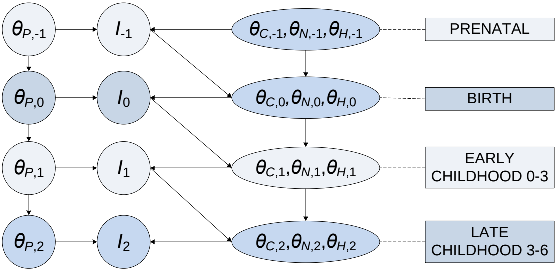

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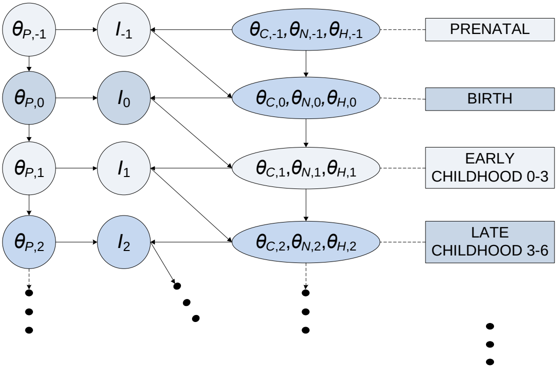

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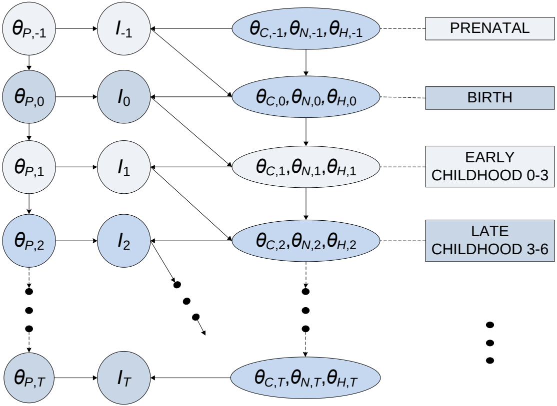

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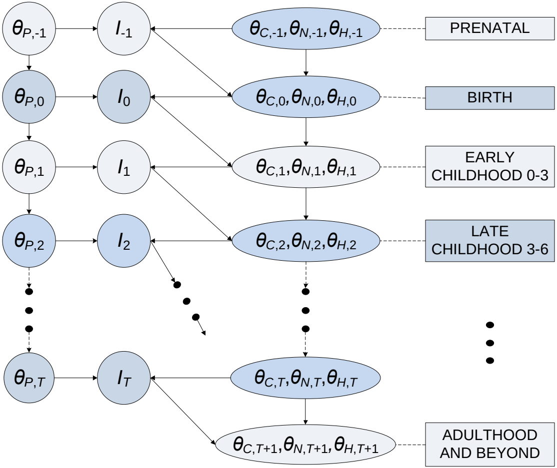

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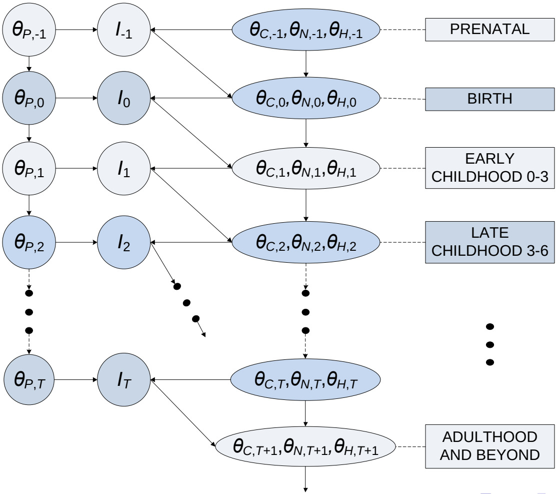

- Few early-life studies control for later-later conditions.

5. Genes, Biological Embedding of Experience and Gene-Environment Interactions

- An emerging literature on embedding of experience in the biology of organisms.

- Evidence of environmental effects on gene expression.

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- Traditional linear models that are widely used and attempt to separate genes and environments fail to capture this interaction.

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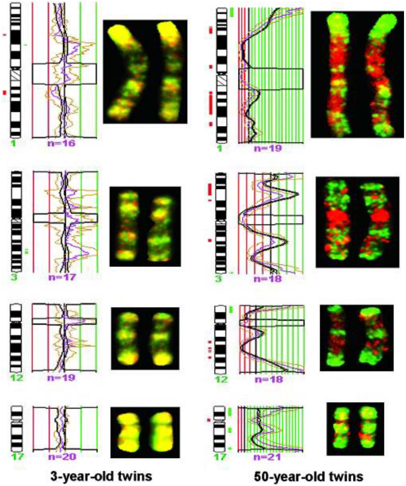
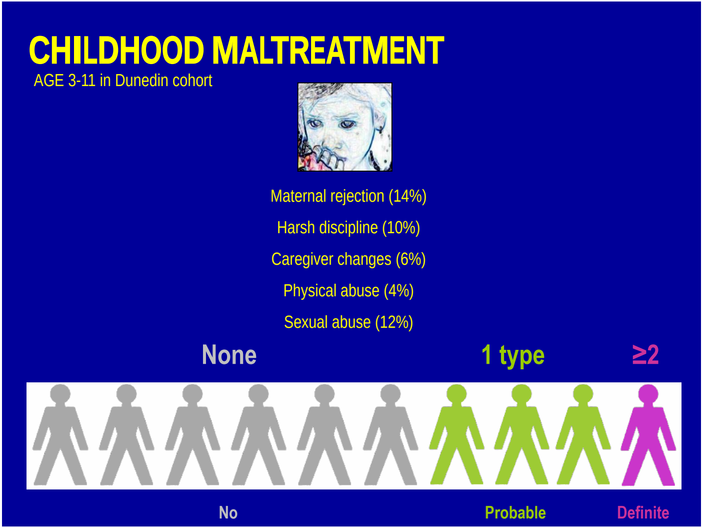
- Estimated "genetic" effects have a strong environmental component.

DNA methylation and histone acetylation patterns in young and old twins

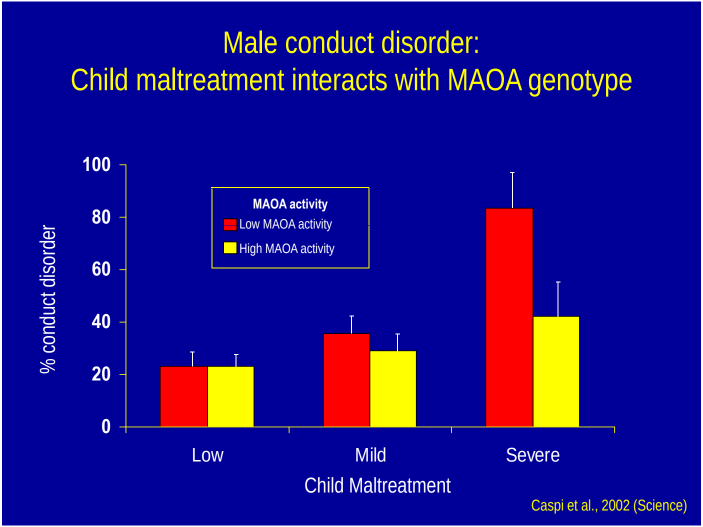


Source: Fraga, Ballestar et al. (2005)

Examples of How Genes are Triggered by Environments



Source: Moffitt, "Gene-Environment Interaction in Problematic and Successful Aging," NIA Meeting Feb 12, 2008.



Caspi, McClay et al. (2002).

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- But what is the quantitative importance of this and related phenomena?

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- In a companion paper we also show that the adverse effects of early rearing conditions are *not compensated* by a normal social environment later in life.

The Rhesus Monkeys Experiment

- At birth, monkeys are randomized into 1 of 3 rearing conditions:

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  - PR are placed in groups of 4, and spend 24 hrs a day together in cages;
  - SPR spend 22 hrs a day alone in a cage with a Surrogate mother (hot water bottle hanging in the cage); for 2 hrs a day they play with a peer group of 3 other monkeys.

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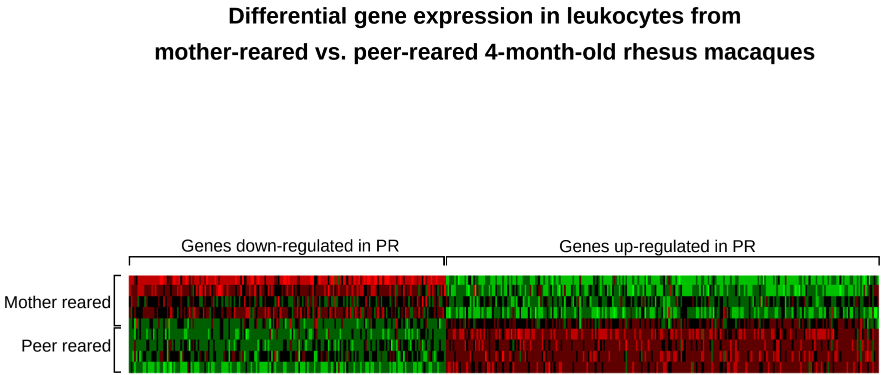
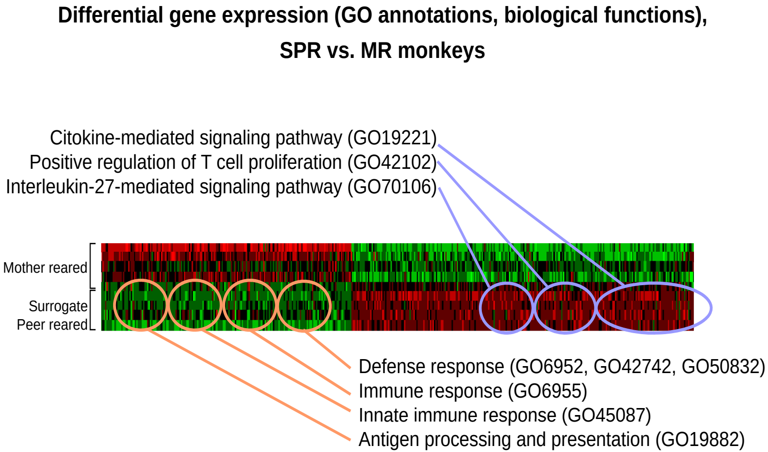
- We analyze the genome-wide transcriptional profile of circulating immune cells in 4-month old infant rhesus macaques.



Source: Cole, Conti, Heckman, and Suomi (2011).

Early Life Experiences Change The Way Genes Express Themselves

Up- and Down-Regulated Genes in Rhesus Monkeys

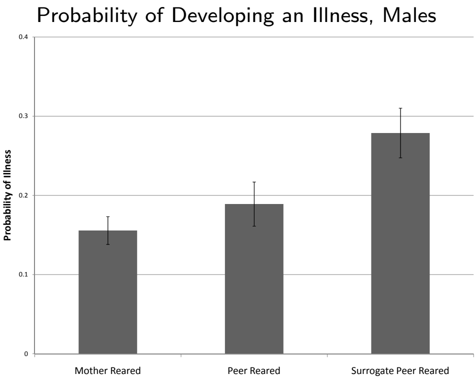


Source: Cole, Conti, Heckman and Suomi.

What Are the Late Life Effects of Early Adverse Rearing Conditions?

- What is the quantitative significance of these epigenetic effects?

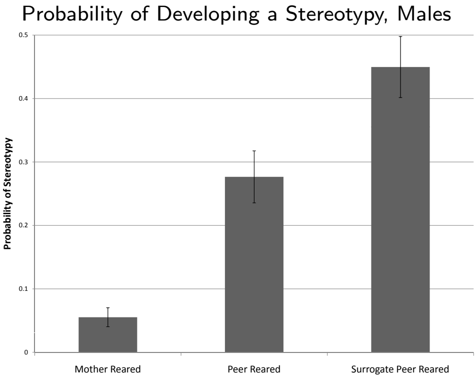
Early Life And Later Physical Health in Rhesus Monkeys



Source: Conti, Hansman, Heckman and Suomi.

- Males show greater susceptibility to early separation: role of cortisol and 5-HIAA.

Early Life And Later Mental Health



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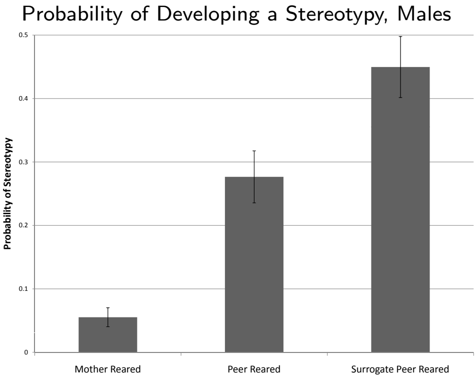

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- We find the same longlasting effect for females.
- **We find no evidence that the detrimental effects of early rearing conditions are compensated by a normal environment later in life.**

6. But Early Life Conditions Are Not the Full Story: Resilience, Recovery, and Repair

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- The central economic question is what is the cost of remediation?
- How important are experiences and investments at various stages of the life cycle?

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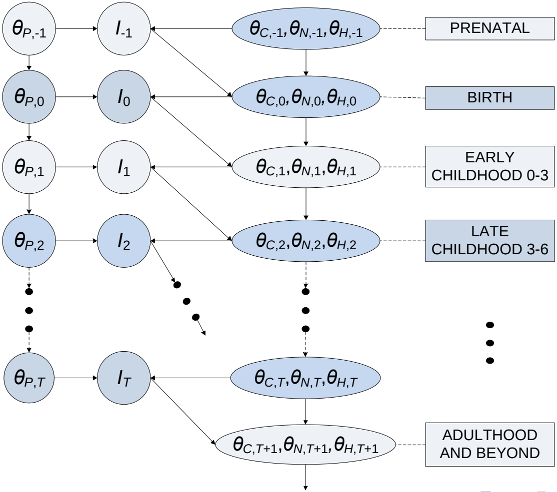

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- Family income in the adolescent years plays only a minor role in explaining schooling.
- Family income in early years shows more effect on adult outcomes than family income in the adolescent years.

8. Enriched Early Environments Compensate In Part For the Risks Arising from Disadvantaged Environments

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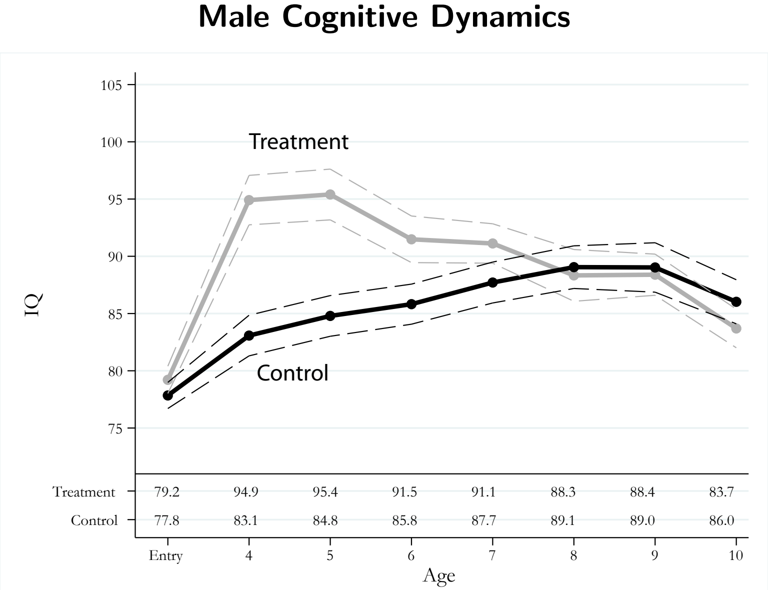
- Early childhood program that primarily targeted social and emotional skills.

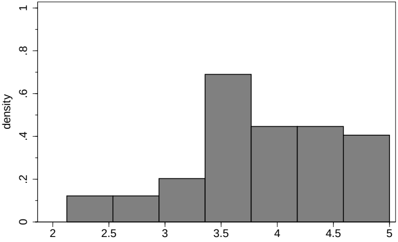
Cognitive Evolution Through Time, Perry Males



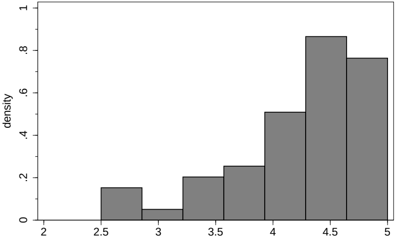
	Entry	4	5	6	7	8	9	10
Treatment	79.2	94.9	95.4	91.5	91.1	88.3	88.4	83.7
Control	77.8	83.1	84.8	85.8	87.7	89.1	89.0	86.0

- Yet the Perry Program has a statistically significant annual rate of return of around 7–10% per annum—for both boys and girls—above the post World War II stock market returns to equity in U.S. labor market estimated to be 5.8%.

Figure 20: Personal Behavior Index by Treatment Group

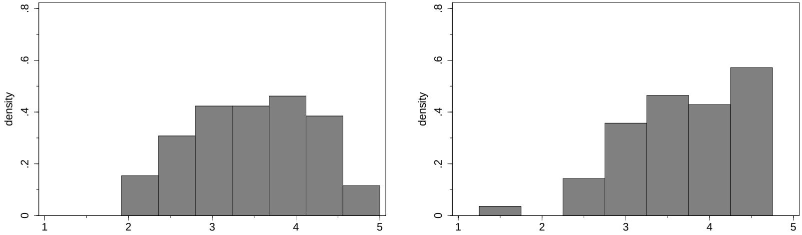


(a) Control



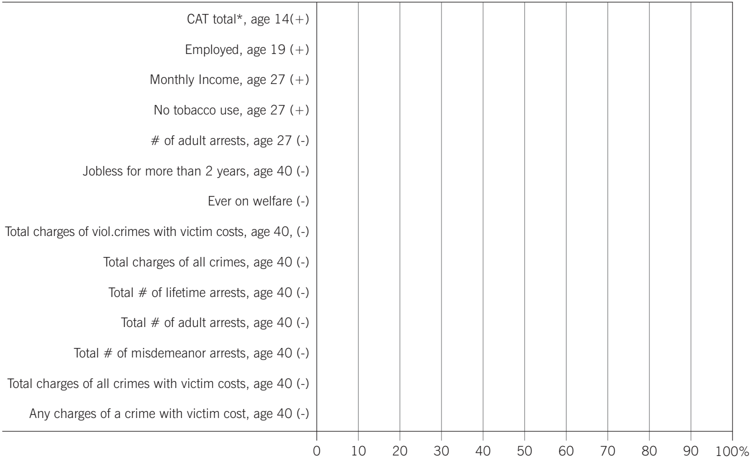
(b) Treatment

Figure 21: Socio-Emotional Index by Treatment Group



(a) Control (b) Treatment

Decomposition of Treatment Effects, Males



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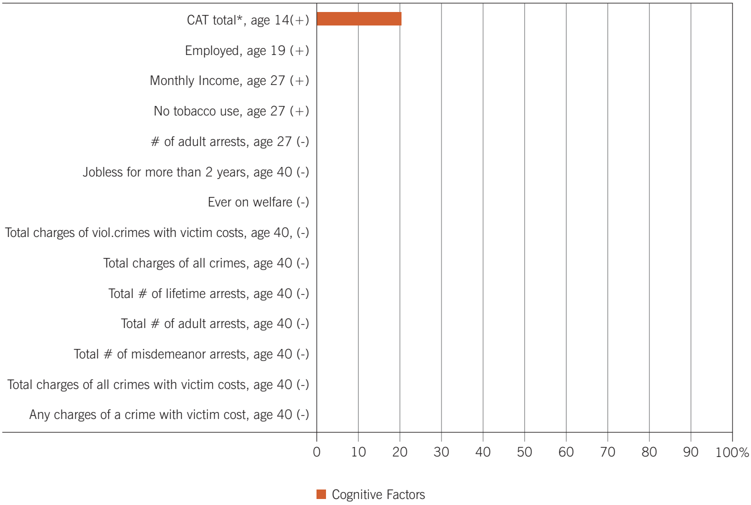

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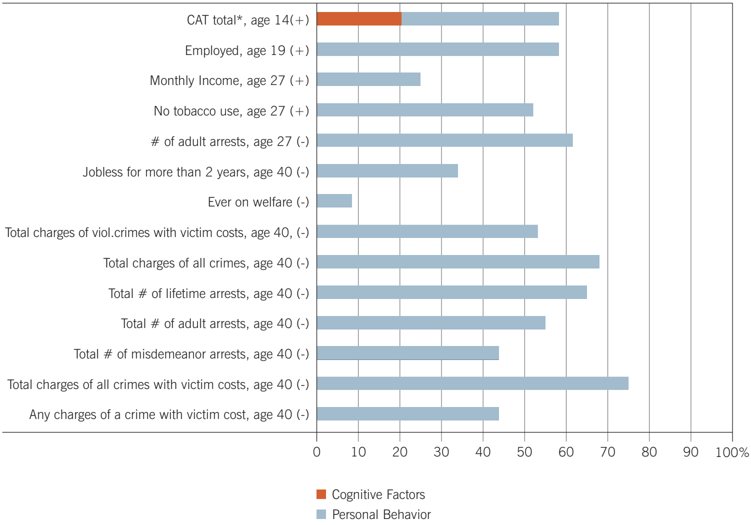

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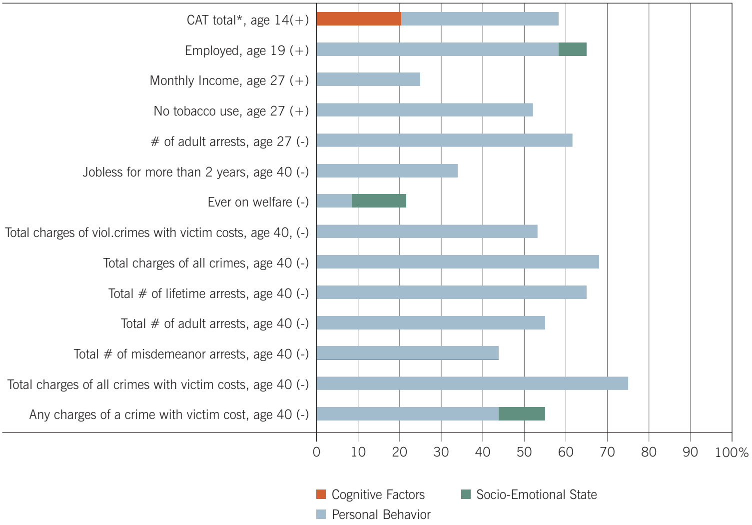

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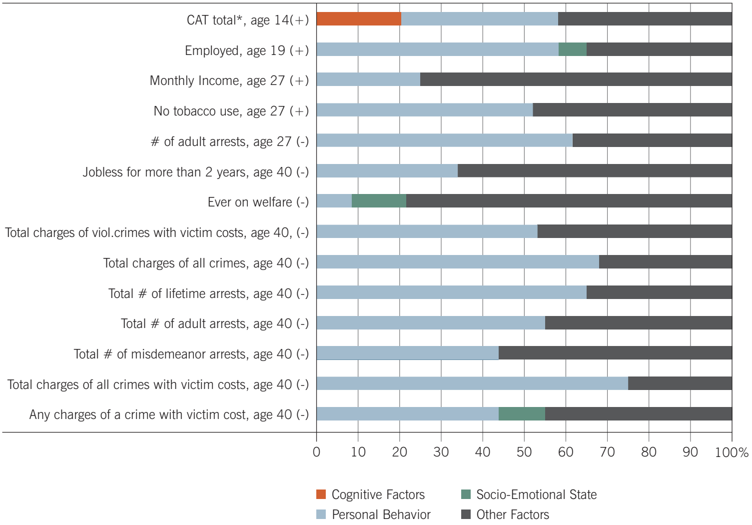

Schooling in Adolescent Years Also Promotes Capabilities That Matter

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- Study a random sample of people at different schooling **at the date of the interview** all of whom complete the same final schooling.

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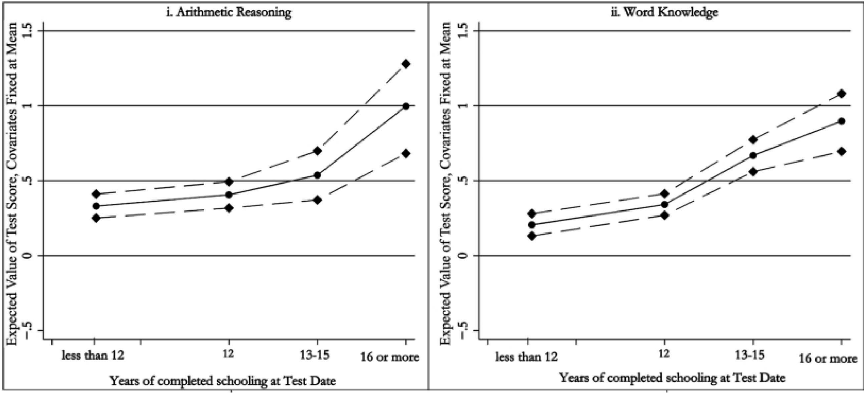
- One can also use observational data.
- Exploit panel design. (Heckman, Stixrud, and Urzua, 2006)
- Study a random sample of people at different schooling **at the date of the interview** all of whom complete the same final schooling.
- The variation in schooling at the date of the interview on measures of capabilities **conditioning on final schooling attained (as a measure of control for selection)** can be interpreted as the causal effect of schooling.

Figure 22: Causal Effect of Schooling on ASVAB Measures of Cognition



Notes: Effect of schooling on components of the ASVAB. The first four components are averaged to create male's with average ability. We standardize the test scores to have within-sample mean zero, variance one. The model is estimated using the NLSY79 sample. Solid lines depict average test scores, and dashed lines, confidence intervals.
Source: Heckman, Stixrud and Urzua [2006, Figure 4].

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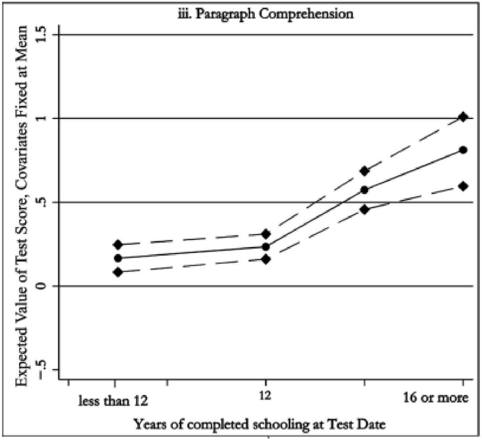

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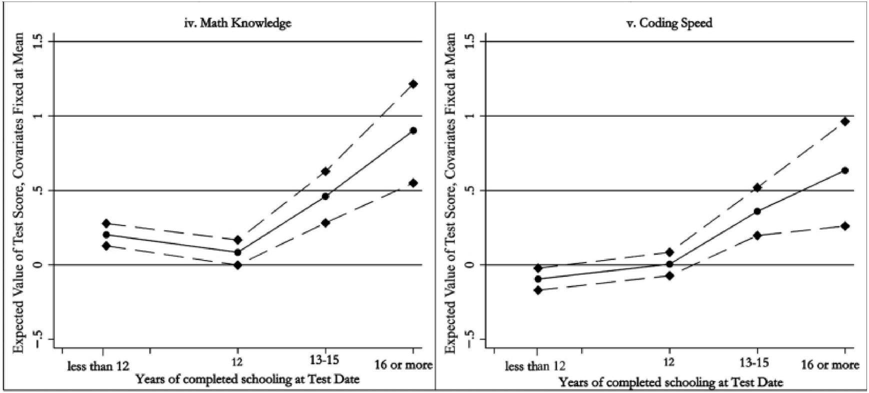

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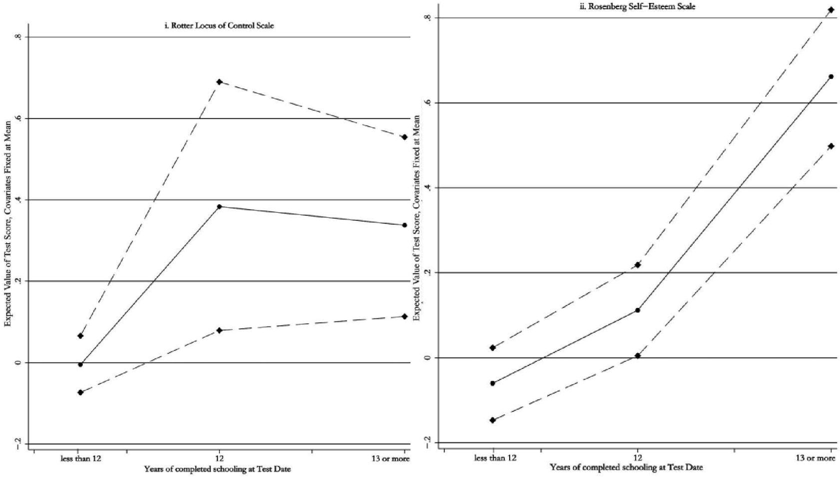
Figure 23: Causal Effect of Schooling on Two Measures of Personality



Source: Heckman, Stixrud and Urzua [2006, Figure 5].

9. Later Remediation is Costly and Often Ineffective

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- Confuses the discussion by not controlling for ability in evaluating rates of return

10. Key Policy Issues

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- How costly is delay in addressing early disadvantage? How critical are the early years and for what traits?
- What is the optimal timing for intervention in different capacities?
- To address these problems, a clearly articulated empirical framework is useful.

A Framework For Integrating the Evidence and Guiding Policy

Becker and Tomes (1986):

- An early paper that *loosely* guides recent research

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- A one period-one skill model of childhood with ability transmitted solely genetically.

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3. Recognizes the modern literature on the biology and psychology of skill formation and the literature on critical and sensitive periods in development

4. Multiple capabilities (cognitive, noncognitive, and biological capabilities)

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5. Child preference formation and emergence of decision making (transition from child to adult)
6. Interactions between child and parents in shaping investment (principle-agent problems)
7. Recognizes the importance of within generation (within lifecycle) budget constraints

Review and apply the framework sketched at the start of this lecture.

Modeling Human Capability Formation

- An agent at age t is characterized by a vector of capabilities

$$\theta_t = (\theta_{C,t}, \theta_{N,t}, \theta_{H,t}),$$

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- $\theta_{H,t}$ is a vector of health stocks for mental and physical health at age t.

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  (a) outcome functions that show how capabilities, effort and incentives affect outcomes;
  (b) dynamic technologies for producing capabilities;
  (c) parental (and social) preferences; and
  (d) constraints reflecting access to financial markets, as well as genetic endowments.

Formal models of child outcomes and investment in children

- The *outcome from activity k at age t* is Y_t^k, where

$$Y_t^k = \psi_k \left(\theta_{C,t}, \theta_{N,t}, \theta_{H,t}, e_{k,t} \right), \quad k \in \{1, \ldots, K\} \tag{5}$$

where $e_{k,t}$ is effort devoted to activity k at time t where the effort supply function depends on rewards and endowments:

$$e_{k,t} = \delta_k \left(R_t^k, A_t \right) \tag{6}$$

where R_t^k is the reward per unit effort in activity k and A_t represents other determinants of effort which might include some or all of the components of θ_t.

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- Captures needs to standardize measures for incentives and context.

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Capability Formation Process

- The capability formation process is governed by a multistage technology.

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- Each stage corresponds to a period in the life cycle of a child.

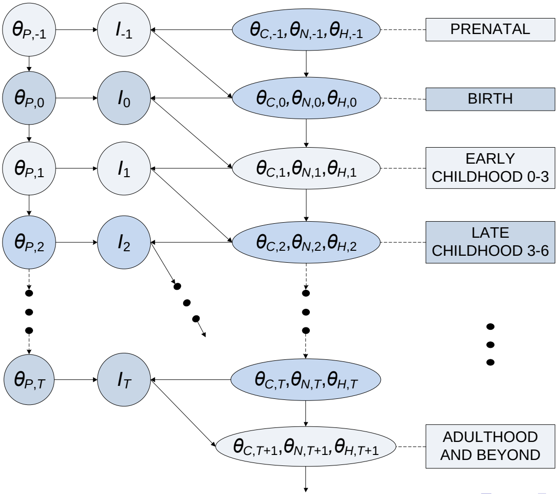
A Life Cycle Framework for Organizing Studies and Integrating Evidence

$\theta_t = (\theta_C, \theta_N, \theta_H)$ capacities at t

$\theta_{P,t}$: parental traits at t

I_t: investment at t

$\theta_{t+1} = f_t(\theta_t, I_t, \theta_{P,t})$: **Technology of Skill Formation**



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- The **technology of production of skill** when the child is t years-old:

$$\theta_{t+1} = f_t(\theta_t, I_t, \underset{\substack{\uparrow \\ \text{parental environmental variables} \\ \text{affect productivity of investment}}}{\theta_{P,t}}), \qquad t = 1, \ldots, T. \tag{7}$$

- *Dynamic complementarity* arises when

$$\frac{\partial^2 f_t\left(\theta_t, I_t, \theta_{P,t}\right)}{\partial\theta_t \partial I_t'} > 0.$$

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- Two distinct ideas:
  1. Higher stocks of capabilities at age t promote the productivity of investment at that age;
  2. Investment today raises the stock of skills in future periods and raises the productivity of future investment.

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- This includes own and cross effects. (*Cross complementarity of capabilities*)

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- This technology also captures the critical and sensitive periods in humans and animals.

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   t^* is the critical period for that investment.
   2. If
   $$\frac{\partial f_t}{\partial I_t}(\cdot) > \frac{\partial f_{t'}}{\partial I_{t'}}(\cdot) \qquad t \neq t'$$
   then t is a sensitive period, where "$\cdot$" is a common point of evaluation.

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$$\theta_{t+1} = f_t(\theta_t, I_t, \theta_{P,t}) = f_t(\theta_{P,0}, \theta_0), \quad \forall t \geq 0$$

(initial conditions fully determinative, no investment, no feedback, Nagin-Tremblay).

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  - More general models feature adaptive responses of parents and environments to current states facing agents.

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- To account for the full life cycle of skill formation not just focus on one stage.
- To move beyond correlations between early life and later life events — to understand the mechanisms of capability formation.

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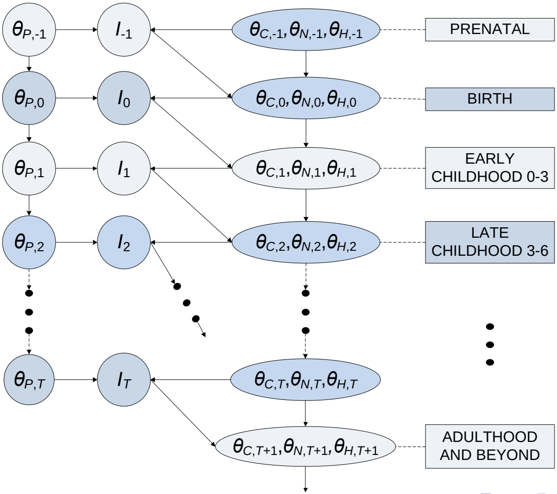

Stylized Model of Parental Investment

Cunha and Heckman (2007, 2009)

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Cunha and Heckman (2007, 2009)

- One child families
- Multiple periods as adults and as children
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$$\theta_3 = M_2(\underbrace{I_2, \quad I_1}_{\substack{\text{investments} \\ \text{(determined} \\ \text{by parents)}}}, \quad \underbrace{\theta_0}_{\substack{\text{initial} \\ \text{conditions} \\ \text{of child}}})$$

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  - (A) Perfect substitutes

$$\theta_3 = M_2\left(\gamma I_1 + (1-\gamma) I_2, \theta_0\right)$$
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- It is essential to invest early to get satisfactory adult outcomes.
- But it is also essential to invest late to harvest the fruits of the early investment.

- More General Case

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- Technology explains why returns to education are in adolescent years for disadvantaged (low I_1)

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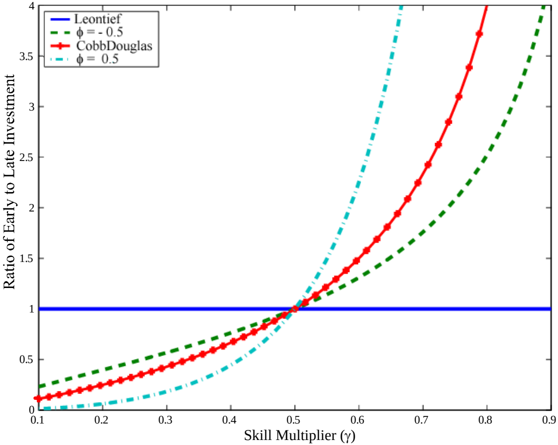
The Ratio of Early to Late Investment in Human Capital As a Function of the Skill Multiplier for Different Values of Complementarity



(Assumes $r = 0$)

Source: Cunha et al. (2007, 2009).

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  3. Can be undone (over a range) by parental substitution of their own consumption over time.

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  a. Self-productivity becomes stronger as children become older, for both cognitive and noncognitive skill formation (i.e., $\frac{\partial \theta_{t+1}}{\partial \theta_t} \uparrow t$).
  b. Complementarity between cognitive skills and investment becomes stronger as children become older. The elasticity of substitution for cognition is *smaller* in second stage production.

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d. Complementarity between noncognitive skills and investments becomes slightly *weaker* as children become older.

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- This econometric evidence is consistent with a broad array of evidence from intervention studies on life cycle profile of rates of return.

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- These estimates suggest that the measures of cognitive and noncognitive capabilities are powerful, but not exclusive, determinants of educational attainment and that other factors, besides the measures of family investment that we use, are at work in explaining variation in educational attainment.

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- 50-60% of the variance in lifetime income determined by factors present at the time college-going decisions are being made (Cunha et al., 2005; Hoffman, 2010; Yaron et al., 2010)

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- Evidence that they are effective (rate of return is 7–10%), and a primary channel of influence is through noncognitive skills — personality
  (Heckman, Malofeeva, et al., 2008; revised 2011).

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  b. Identify different technologies (public and private) that produce θ_t.

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- Family chooses a technology to minimize the cost of achieving a given level of capabilities.

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- Can determine the capabilities that each technology produces

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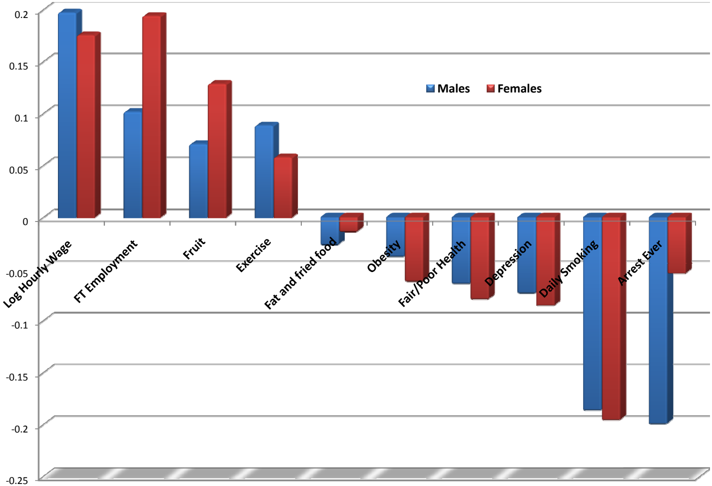
- Kruger (2011)

Evidence from Studies Applying This Framework

Conti, Heckman, and Urzua (2012)

- UK Data

Disparities by Education



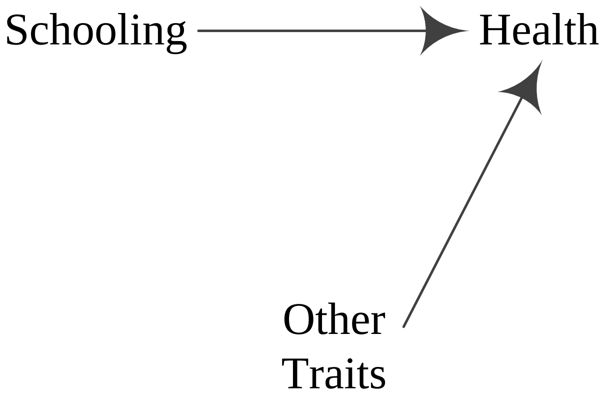
Note: U.K. Data: Authors' calculations using BCS70. The graph shows the raw differentials in the outcomes between individuals with post-compulsory and compulsory level of education. Source: Conti, Heckman and Urzua (2012).

Inferring Causation

Schooling $\longrightarrow$ Health

Other
Traits

Inferring Causation



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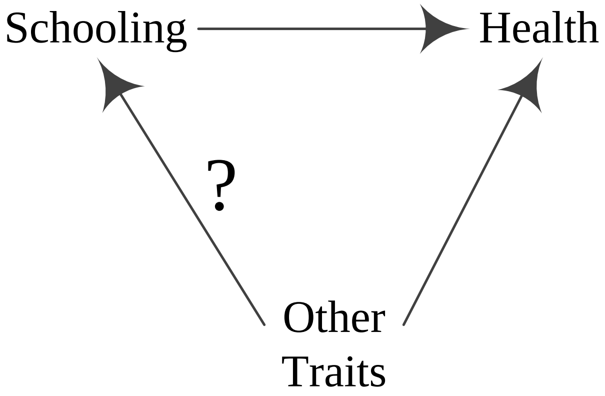

Search for causality: Two strategies

(a) Instruments Z

Z

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Other
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Random assignment is an instrument

Search for causality: Two strategies

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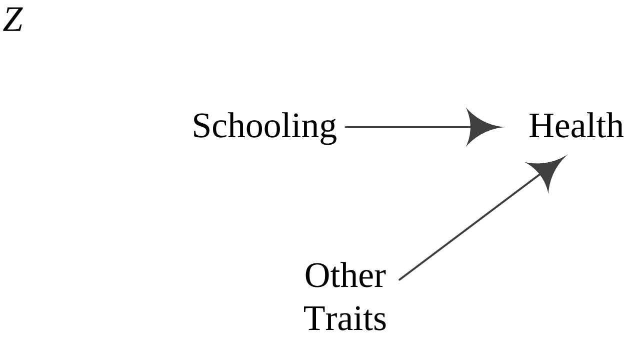

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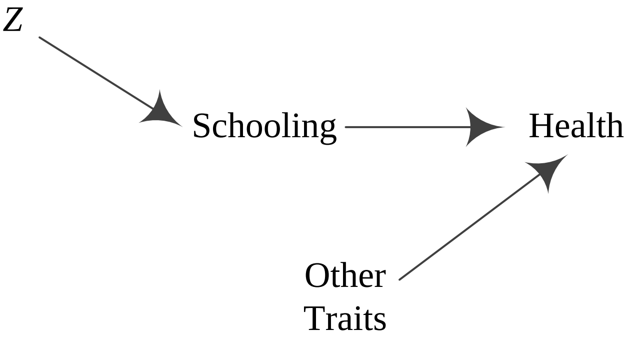

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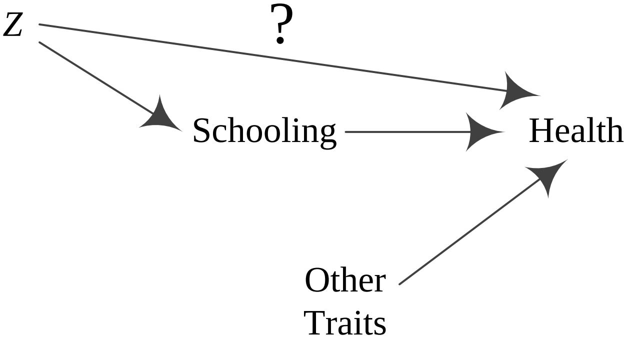

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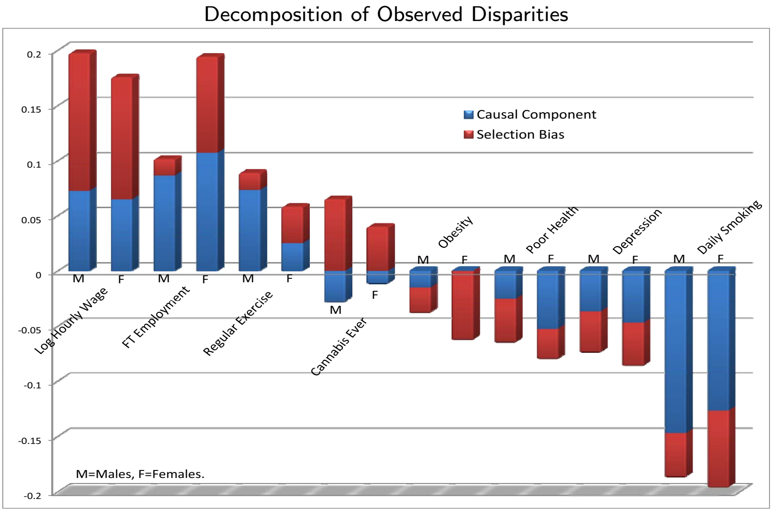
   iii. Allows for matching on mismeasured variables (Heckman, Schennach, and Williams, 2011).

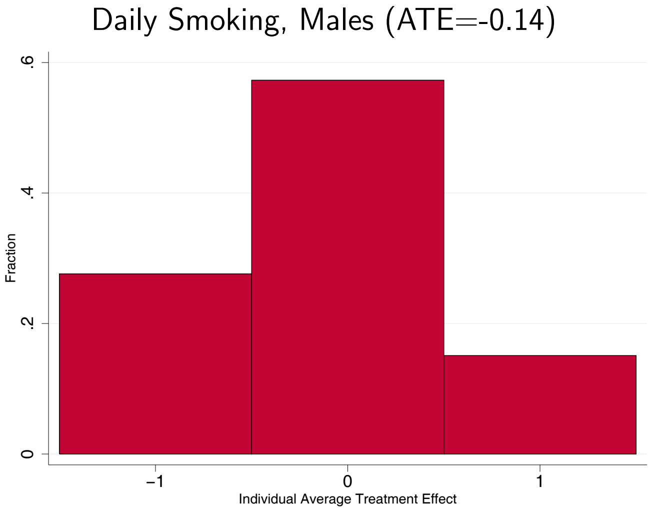
The Causal Effect of Education



Distributional Treatment Effects: Does everybody benefit?

- We also identify **the joint distribution** of the treatment effects.

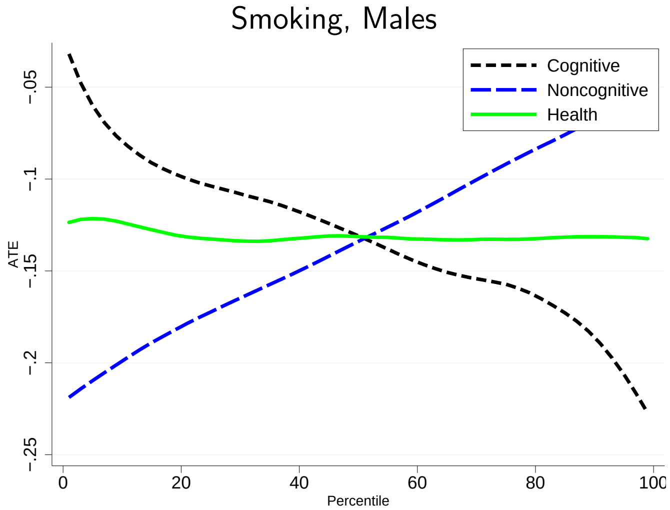
Distribution of Average Treatment Effects



- Behind the ATE, there are gains and losses for different individuals.

Who benefits?

Treatment Effect Heterogeneity



- Education compensates for low early noncognitive endowments and reinforces high early cognitive endowments.

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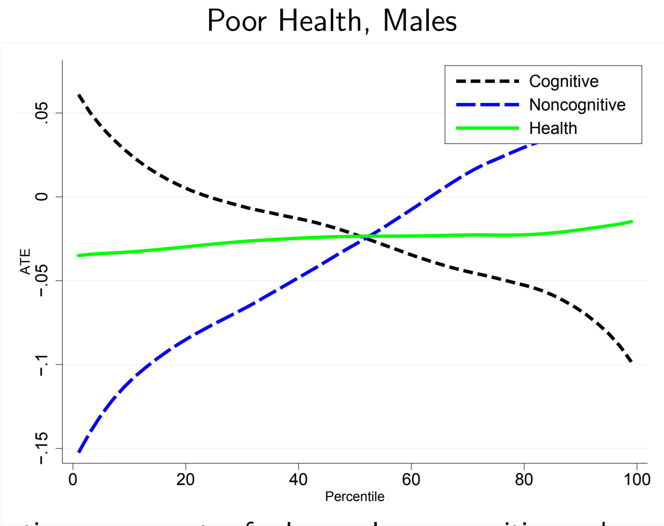
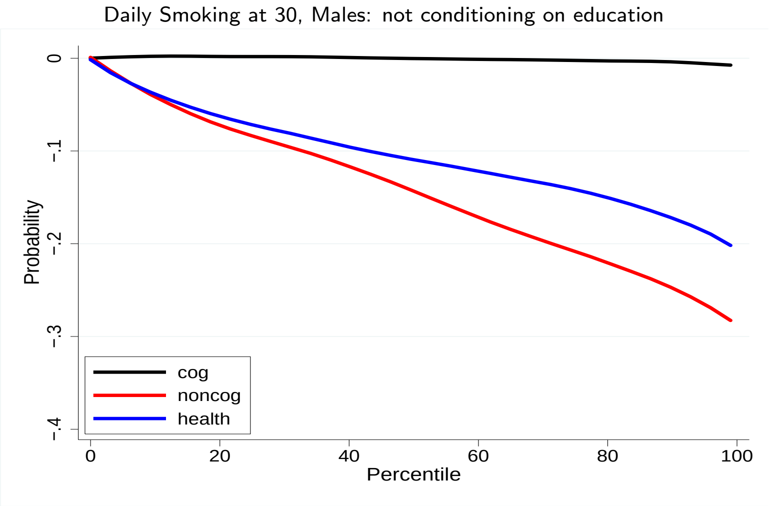


- Education compensates for low early noncognitive endowments and reinforces high early cognitive endowments.

The Role of Factors up to Age 10

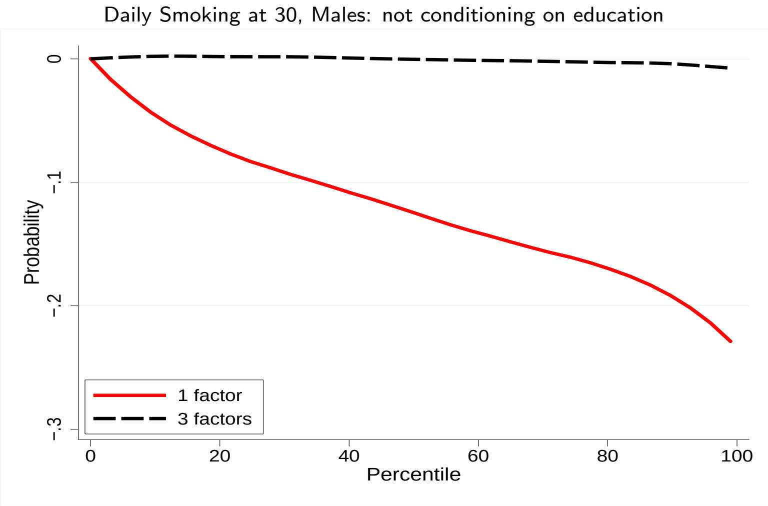
- Cognitive ability has a significant effect on health and health behaviors if self-regulation is not included in the model.

The Role of Factors up to Age 10



- Both self-regulation and physical health are equally important determinants of smoking.

The Role of Factors up to Age 10



- But not accounting for them *overestimates* the importance of cognition.

Data: The National Longitudinal Survey of Youth (NLSY79) (Heckman, Humphries, Urzua, and Veramendi, 2011)

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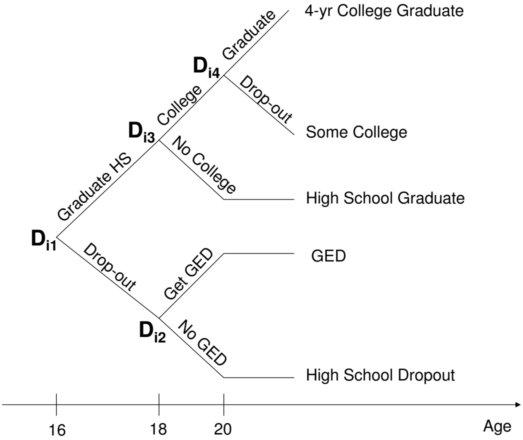
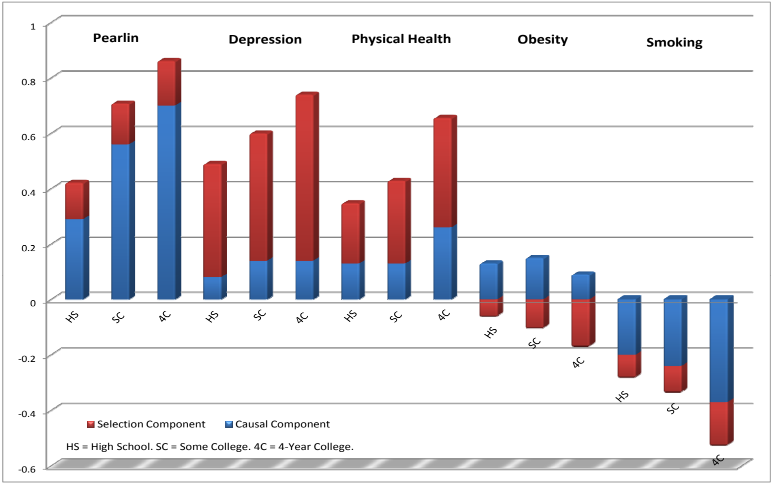
  2. θ_N: 9^{th} grade GPA in reading social studies, science and math, as well as early measured behaviors.

Figure 24: Sequential model for schooling decisions.



Decomposition of Mean Differences

Pairwise comparisons of a terminal education level to being a dropout



Heckman, Humphries, Urzua, and Veramendi (2011).

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12. Technology of capability formation is a vehicle for doing so.

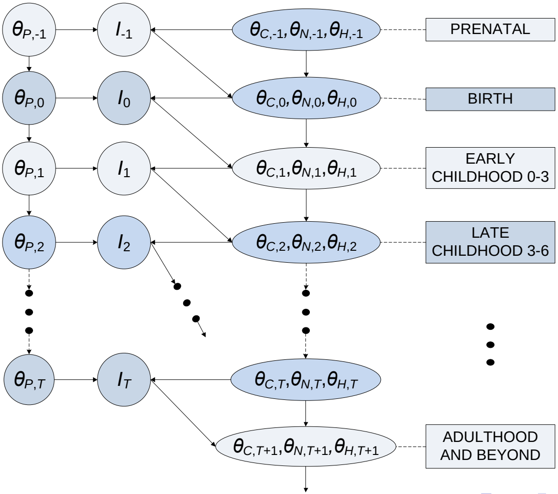
A Life Cycle Framework for Organizing Studies and Integrating Evidence

$\theta_t = (\theta_C, \theta_N, \theta_H)$ capacities at t

$\theta_{P,t}$: parental traits at t

I_t: investment at t

$\theta_{t+1} = f_t(\theta_t, I_t, \theta_{P,t})$: **Technology of Skill Formation**



Appendix

Example From Cunha et al. (2007, 2009)

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- The first T years, the individual is a child of an adult parent.
- From age $T+1$ to $2T$ the individual lives as an adult and is the parent of a child.
- The individual dies at the end of the period in which he is $2T$ years-old, just before his child's child is born.

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- The output of the investment process is a skill vector.

Preferences and the Optimal Life-Cycle Profile of Investments

- Assume $T = 2$; stationary environment. (Two periods of childhood)

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- w: wage rate
- r: interest rate
- At the beginning of adulthood, the parents draw the initial level of skill of the child, θ_1, from $J(\theta_1)$, which they can influence through investment.

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- On reaching adulthood, parents receive bequest b.
- State variables for the parent: parental skills, h, the parental financial resources, b, and the initial skill level of the child, θ_1.
- c_1 and c_2 denote the consumption of the household in the first and second period of the life cycle of the child.
- The budget constraint is:

$$c_1 + I_1 + \frac{c_2 + I_2}{(1+r)} + \frac{b'}{(1+r)^2} = wh + \frac{wh}{(1+r)} + b. \quad (9)$$

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- δ: measure of parental altruism toward the child.
- $\eta(\cdot)$ is the one period utility function.
- Problem of the parent:

$$V\left(h,b,\theta_1\right) = \max\left\{\eta\left(c_1\right) + \beta\eta\left(c_2\right) + \beta^2\delta E\left[V\left(h',b',\theta_1'\right)\right]\right\}. \tag{10}$$

An Informative Special Case

- Assume θ_1, I_1, I_2 are scalars.

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- If late investments are zero, $I_2 = 0$, it does not pay to invest early.

Dual Face of Complementarity

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- Complementarity has a dual face.
- It is essential to invest early to get satisfactory adult outcomes.
- But it is also essential to invest late to harvest the fruits of the early investment.

- More general technology:

$$h' = m_2\left(h, \theta_1, \left[\gamma\left(I_1\right)^{\phi} + (1-\gamma)\left(I_2\right)^{\phi}\right]^{\frac{1}{\phi}}\right), \tag{14}$$

for $\phi \leq 1$ and $0 \leq \gamma \leq 1$.

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- Thus I_1 directly increases θ_2 which in turn affects the productivity of I_2 in forming h'.
- γ captures the net effect of I_1 on h' through both self-productivity and direct complementarity.

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- The other face of CES complementarity is that when ϕ is small, high early investments should be followed with high late investments if the early investments are to be harvested.
- In the extreme case when $\phi \to -\infty$, (14) converges to (13).

- This technology explains why returns to education are low in the adolescent years **for disadvantaged** (low h, low I_1, low θ_2) adolescents but are high in the early years.

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- In the one-period model of childhood, inputs at any stage of childhood are perfect substitutes.
- Application of the one period model supports the widely held but empirically unsupported intuition that diminishing returns make investment in less advantaged adolescents *more* productive.

Optimal Investment Strategies for $\phi = 1$ (perfect substitutes)

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- Productivity of early investment: γ; late investment $(1 - \gamma)$.
- Invest early if $\gamma > (1 - \gamma)(1 + r)$

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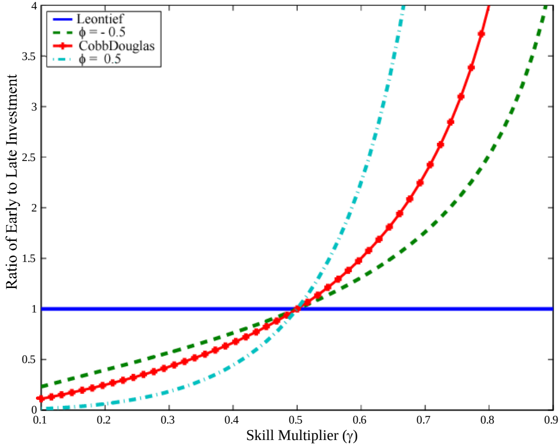
- $-\infty < \phi < 1$:

$$\frac{I_1}{I_2} = \left[\frac{\gamma}{(1-\gamma)(1+r)}\right]^{\frac{1}{1-\phi}}. \tag{15}$$

The Ratio of Early to Late Investment in Human Capital As a Function of the Skill Multiplier for Different Values of Complementarity



(Assumes $r = 0$)

Source: Cunha et al. (2007, 2009).

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- (But not other features of the model.)
- This generalizes Becker-Tomes (1980) and shows the fundamental role of parental influence.
- From the point of view of the child, this is a market failure due to the accident of birth.

Constraints on Borrowing Across Generations

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- Suppose parents cannot borrow against child's future earnings. (Becker-Tomes, 1986)
- A second credit constraint: the parental bequests must be non-negative and parents only have access to of a risk-free bond, and not to contingent claims.
- The problem of the parent is to maximize (10) subject to (9), the technology (14), and the liquidity constraint:

$$b' \geq 0. \tag{16}$$

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- Under this formulation of market incompleteness, underinvestment in skills starts at early ages and continues throughout the life cycle of the child.
- **Lower investment in both periods** *does not* **affect** *ratio* **of investments** (I_1/I_2)**.**

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- Children who come from constrained families with lower b will have lower early *and* late investments.
- Interventions that occur at early stages would exhibit high returns, especially if they are followed up with resources to supplement late investments.

Parents Themselves Face Lifetime Liquidity Constraints

- Cunha and Heckman (2007).

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- Assume that parents' productivity grows exogenously at rate α.

- s: parental savings.

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- Parents face a sequence of constraints at each stage of the life cycle of the child:

$$c_1 + I_1 + \frac{s}{(1+r)} = wh + b \tag{17}$$

$$c_2 + I_2 + \frac{b'}{(1+r)} = w(1+\alpha)h + s, \tag{18}$$

$s \geq 0$ and $b' \geq 0$.

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- Some parents may be willing to do this, especially when α is high.
- In the case when $s \geq 0$ and $b' \geq 0$ bind, and investments are not perfect substitutes, early income matters.

- Suppose $\eta(c) = \left(c^{\lambda} - 1\right)/\lambda$:

$$\frac{I_1}{I_2} = \left[\frac{\gamma}{(1-\gamma)(1+r)}\right]^{\frac{1}{1-\phi}} \underbrace{\left[\frac{(wh + b - I_1)}{\beta\left((1+\alpha)wh - I_2\right)}\right]^{\frac{1-\lambda}{1-\phi}}}_{\leq 1}.$$

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- $(1-\lambda)/(1-\phi) \in [0.8\bar{3}, 1.\bar{3}]$. Family resource influence on investment.

- This analysis of credit constrained families joined with a low value of ϕ interprets the fact that the timing of family income in the early stages of childhood apparently affects the level of ability and achievement of the children, although there is still some controversy about the empirical importance of this effect.

Estimating and Interpreting the Estimates of the Technology of Skill Formation

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  f. Output as measured by test scores is meaningless.

Findings from Nonlinear Model (Cunha et al., 2010)

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    a. Self-productivity becomes stronger as children become older, for both cognitive and noncognitive skill formation (i.e., $\frac{\partial\theta_{t+1}}{\partial\theta_t} \uparrow t$).
    b. Complementarity between cognitive skills and investment becomes stronger as children become older. The elasticity of substitution for cognition is *smaller* in second stage production.

- ($\sigma_C \doteq 0.3$) It is more difficult to compensate for the effects of adverse environments on cognitive endowments at later ages than it is at earlier ages. This pattern of the estimates helps to explain the evidence on ineffective cognitive remediation strategies for disadvantaged adolescents.

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d. Complementarity between noncognitive skills and investments becomes slightly *weaker* as children become older.

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- Noncognitive traits promote the accumulation of cognitive traits (but not vice versa).
- This econometric evidence is consistent with a broad array of evidence from interventions studies on life cycle profile of rates of return.

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Some Implications for Policy

- Targeted strategies

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- Arises because compensation for adversity in noncognitive skills is somewhat less costly in the second period, and because of discounting of costs and concavity of the technology, it is efficient to invest relatively more in noncognitive traits in the second period.

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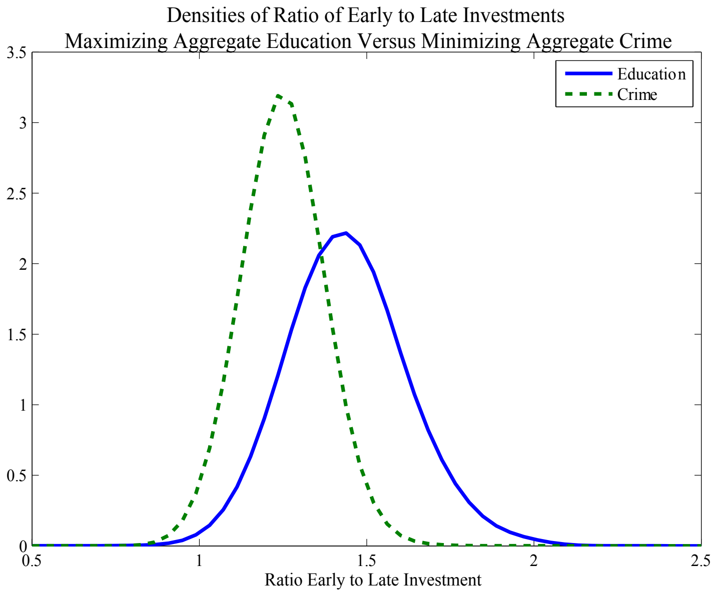
- The opposite is true for cognitive skills.


Densities of Ratio of Early to Late Investments
Maximizing Aggregate Education Versus Minimizing Aggregate Crime
Education
Crime
3.5
3
2.5
2
1.5
1
0.5
0
0.5
1
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Ratio Early to Late Investment

Estimating the Technology of Skill Formation

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- Use state space methods

$$\theta_{t+1} = f_t(\theta_t, I_t, \theta_{P,t})$$
$$M^{\theta_t} = \mu_t^{\theta_t}(\theta_t, \epsilon_t^{\theta_t})$$
$$M^{I_t} = \mu_t^{I_t}(I_t, \epsilon^{I_t})$$
$$M^{\theta_{P,t}} = \mu^{\theta_{P,t}}(\theta_{P,t}, \epsilon_t^{\theta_{P,t}})$$

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- Not accounting for measurement error produces downward-biased estimates of self-productivity effects and perverse estimates of investment effects.

Table 1: Share of Residual Variance in Measurements of Cognitive Skills Due to the Variance of Cognitive Factor (Signal) and Due to the Variance of Measurement Error (Noise)

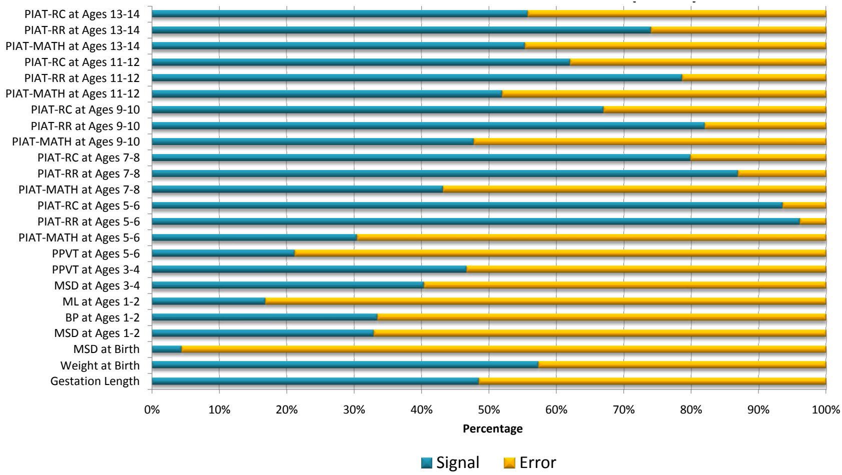
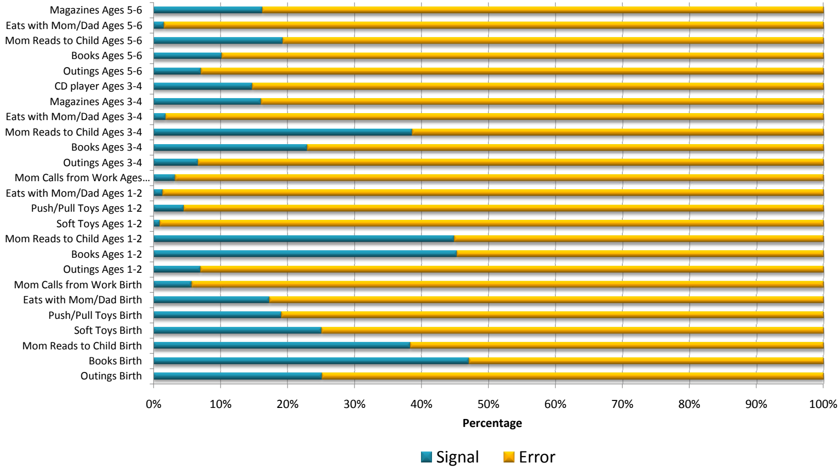


Table 2: Share of Residual Variance in Measurements of Investments Due to the Variance of Investment Factor (Signal) and Due to the Variance of Measurement Error (Noise)



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- How costly is it to wait to address early disadvantage?

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- Stage 2 corresponds to age 5 through 14.

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  (a) Self-productivity becomes stronger as children become older, for both cognitive and socioemotional capability formation.
  (b) It is more difficult to compensate for the effects of adverse environments on cognitive endowments at later ages than it is at earlier ages. This helps to explain the evidence on ineffective cognitive remediation strategies for disadvantaged adolescents.
  (c) It is **equally easy** to substitute at both stages for socioemotional skills over the life cycle.

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- Measured parental investments account for 15% of the variation in educational attainment.
- This has implications for policy forming capabilities.

The Implications of the Estimates for Policy

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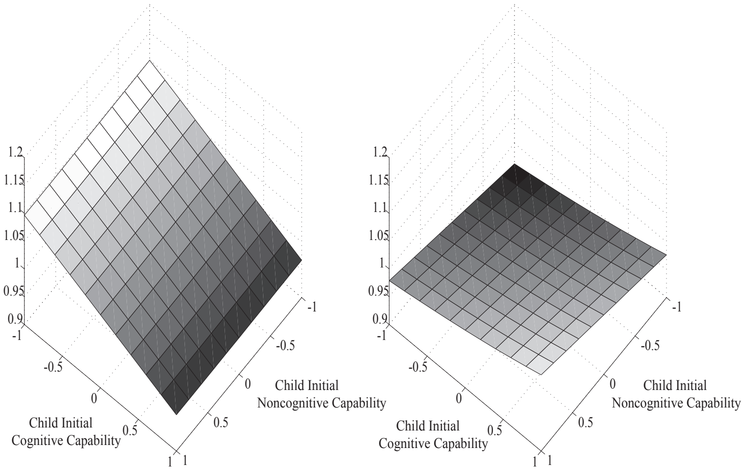
- Consider a policy for a social planner to optimize the stock of education in society.
- No consideration of social fairness or equality — just efficiency.
- Yet the optimal policy invests the most in the disadvantaged.

Figure 25: Optimal Early (Left) and Late (Right) Investments by Child Initial Conditions of Cognitive and Socioemotional Capabilities Maximizing Aggregate Education



- For the most disadvantaged, the optimal policy is to invest a lot in the early years.

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- It is optimal to invest more in the second period of the lives of advantaged children than in disadvantaged children.
- A similar profile emerges for investments to reduce aggregate crime.

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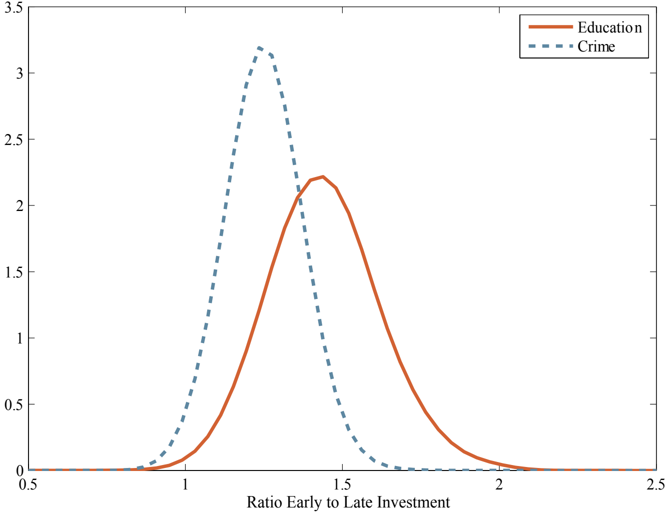
- Crime is more intensive in socioemotional skill than educational attainment, which depends much more strongly on cognitive skills.
- Because compensation for adversity in socioemotional skills is less costly in the second period than in the first period, while the opposite is true for cognitive skills, it is optimal to weight first and second period investments in the directions indicated in the figure.

Figure 26: Densities of Ratio of Early to Late Investments Maximizing Aggregate Education versus Minimizing Aggregate Crime



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- Targeted strategies are likely to be effective especially for different targets that weight cognitive and socioemotional traits differently.

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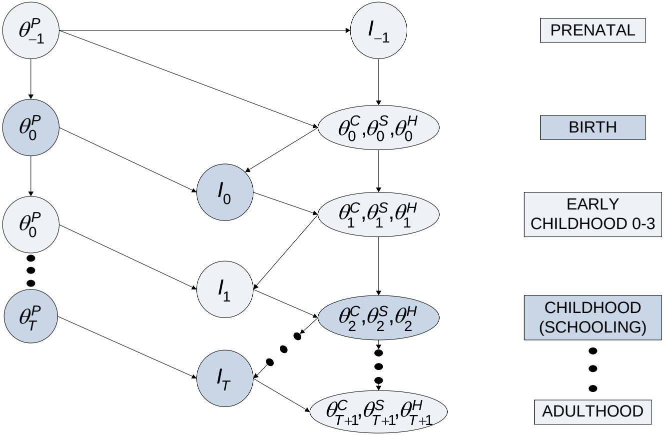
- Estimating the effect of early life conditions on later life outcomes without accounting for all intermediate stages can be very misleading.

A Life Cycle Framework for Organizing Studies and Integrating Evidence: $T+1$ Periods of Life Cycle

$$\theta_t = (\theta_t^C, \theta_t^S, \theta_t^H) \text{ capacities at } t$$

$$I_t\text{: investment at } t$$

$$\theta_{t+1} = f_t(\theta_t, I_t, \theta_t^P)$$



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  b. We examine the effect of education at a variety of educational levels, and we estimate dynamic sequential models.
  c. We estimate distributions of treatment effects (what % benefit and lose) and the heterogeneity in response to treatment for people with different endowments.

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- These papers offer a consistent picture of the importance of education relative to the importance of factors in place before adolescence begins.

Generalized Roy Model

A Framework of Analysis of Counterfactuals

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- Two potential outcomes for each person i:

$$\left(\underbrace{Y_{0i}}_{\substack{\text{no} \\ \text{schooling}}} , \underbrace{Y_{1i}}_{\text{schooling}} \right)$$

- The potential outcome equation for the treated state is:

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$$Y_{1i} = \mu_1(\underbrace{X_i}_{\text{observed}}, \underbrace{U_{1i}}_{\text{unobserved}})$$

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- The potential outcome for the untreated state is:

$$Y_{0i} = \mu_0(\underbrace{X_i}_{\text{observed}} , \underbrace{U_{0i}}_{\text{unobserved}})$$

Treatment Choice

- $D_i = 1$ denotes receipt of education (the treatment), $D_i = 0$ compulsory education for person i.

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- Neyman (1923)–Cox (1958)–Quandt (1958)–Rubin (1974) model.
- Key idea introduced into literature in economics is the notion of a selection function (choices made by patients, parents, doctors, etc.).

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- We confront the selection problem.
- Some of the traits that generate both schooling and health are not observed, and we cannot condition on them.
- Knowledge of selection function reveals information about the choices of agents and their preferences.

Disparities by Education

- In general, due to uncontrolled unobserved factors

$$\underbrace{E(Y_1 \mid D = 1)}_{\substack{\text{mean schooled}\\ \text{outcome}}} - \underbrace{E(Y_0 \mid D = 0)}_{\substack{\text{mean unschooled}\\ \text{outcome}}} \neq \underbrace{E(Y_1 - Y_0)}_{\substack{\text{mean causal effect}\\ \text{of schooling}}}$$

- We use a variety of empirical strategies

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  2. Proxies for the unobserved traits correcting for proxy measurement error (state space methods)

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- Extends factor analysis to non-normal, non-parametric settings.

Data: The British Cohort Study (BCS70)

- Cohort of all individuals born in one week of April 1970 in the United Kingdom.

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  3. θ_H: 4 measures (height, head circumference)

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- What are the effects on health of other levels of education?

Evidence from U.S.

- Does education also have a strong impact on health?

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- Are pre-education factors also relevant in explaining the education-health gradient?

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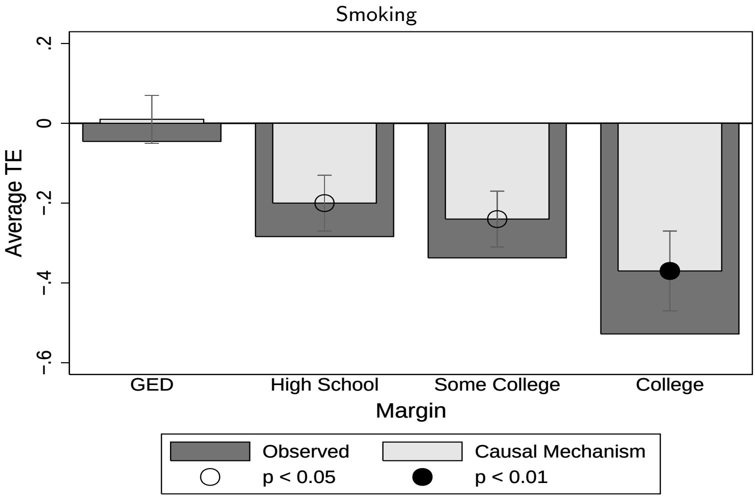
- Are pre-education factors also relevant in explaining the education-health gradient?
- Sequential model of educational choice.

Heckman, Humphries, Urzua, and Veramendi (2011) [HHUV]: "The Effects of Schooling on Labor Market and Health Outcomes"

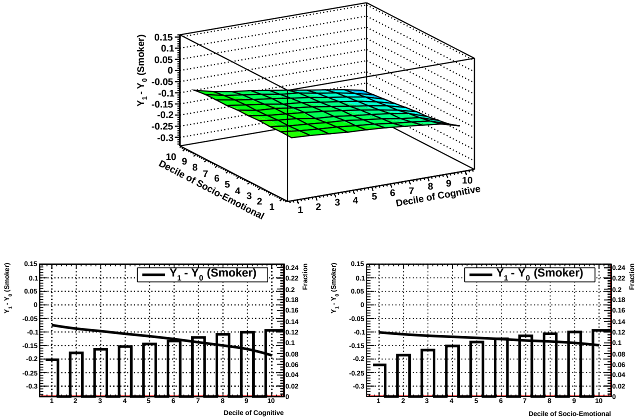
Effects of Education



- Like for U.K., the % of the observed disparities in daily smoking due to education is comparable across educational levels (70%).

Treatment Effect Heterogeneity

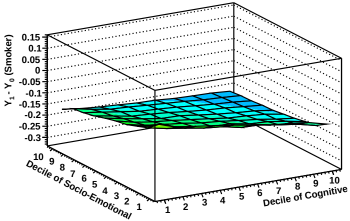
HS Graduate vs. College Enrollment

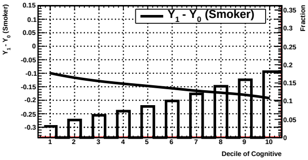


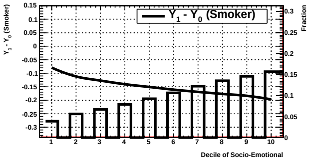
- Education is a complement of both adolescent cognitive and socio-emotional endowments in U.S.

Treatment Effect Heterogeneity

Some College vs. 4-year college degree







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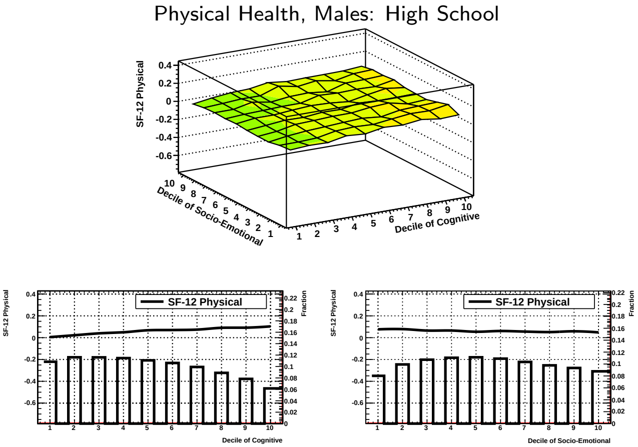
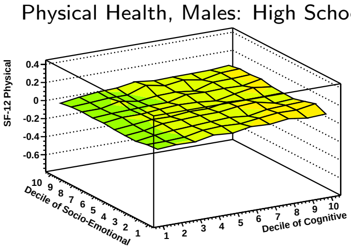
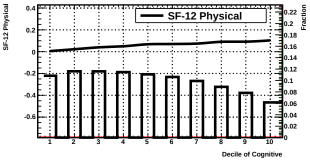
Cognitive and Socioemotional Factors

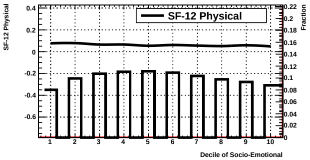


- Not so conditional on education.

Cognitive and Socioemotional Factors

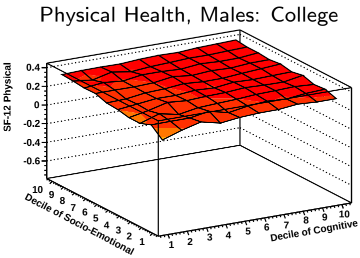


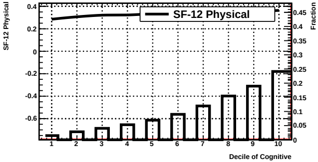


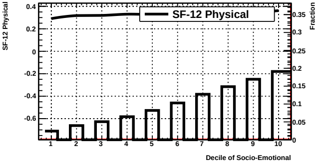


- Not so conditional on education.
- Primary mechanism is through education.

Cognitive and Socioemotional Factors







- ...but not conditional on education.

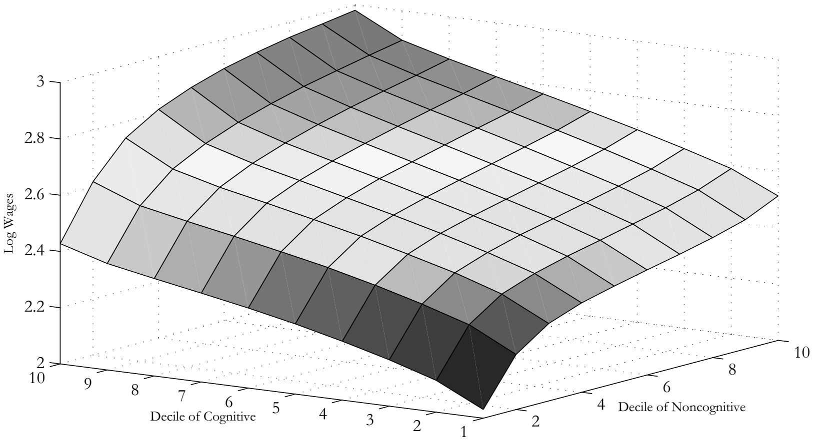
Table 3: Intergenerational Income elasticities and correlations from Jäntti et al. (2006)

Country	Elasticity (β)	Correlation (ρ)
Men		
Denmark	0.071	0.089
	[0.064, 0.079]	[0.079, 0.099]
Finland	0.173	0.157
	[0.135, 0.211]	[0.128, 0.186]
Norway	0.155	0.138
	[0.137, 0.174]	[0.123, 0.152]
Sweden	0.258	0.141
	[0.234, 0.281]	[0.129, 0.152]
UK	0.306	0.198
	[0.242, 0.370]	[0.156, 0.240]
US	0.517	0.357
	[0.444, 0.590]	[0.306, 0.409]

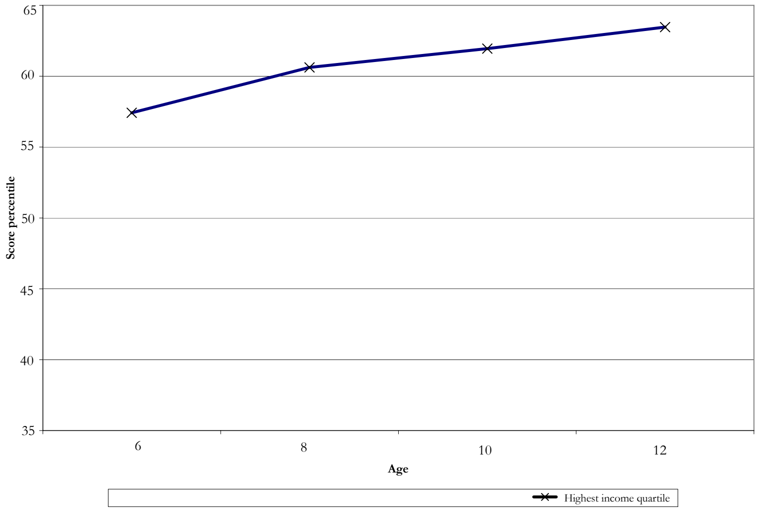
Numbers in brackets below the point estimates show the bias corrected 95% bootstrap confidence interval.

Source: This reproduces much of Table 2 from Jäntti et al. (2006).

Fact 1: Cognitive and Noncognitive Skills Matter
Log Wages at Age 30: Heckman, Stixrud, and Urzua (2006)



Fact 2a: Average percentile rank on PIAT-Math score, by income quartile



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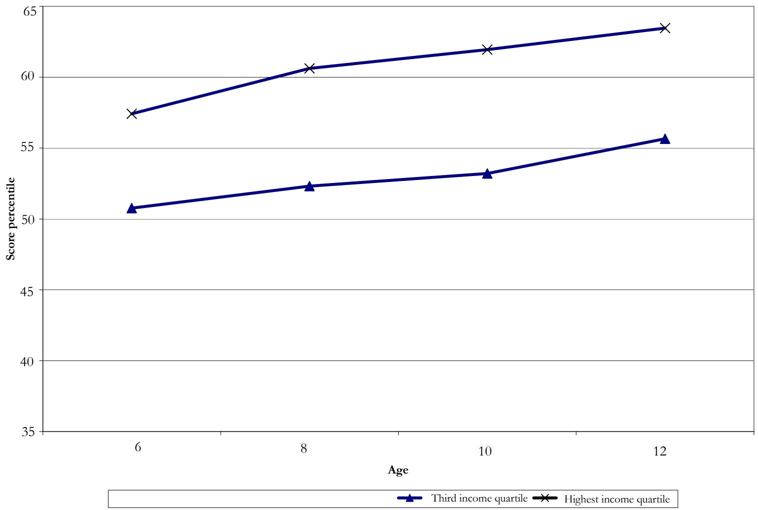

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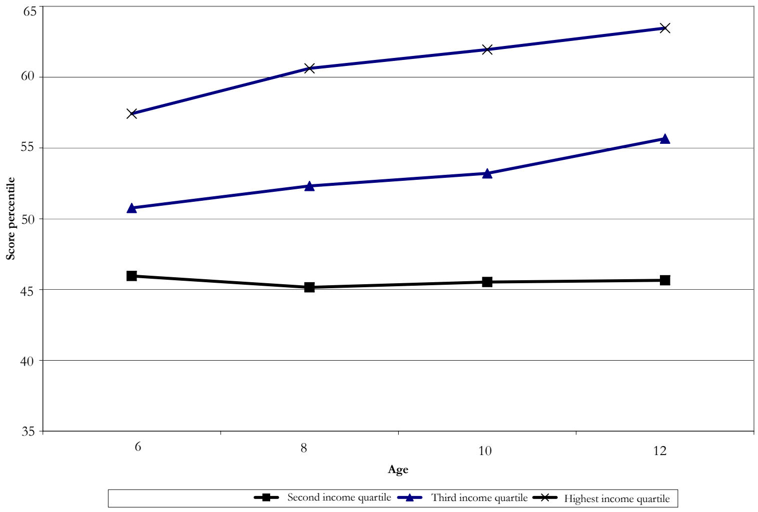

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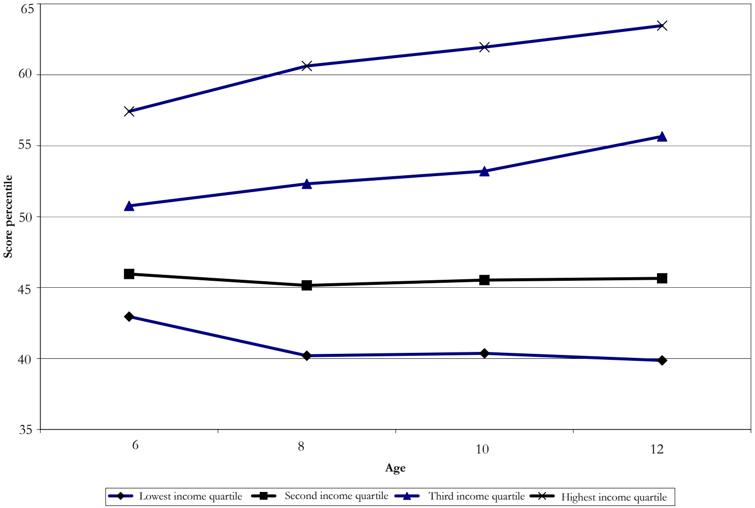
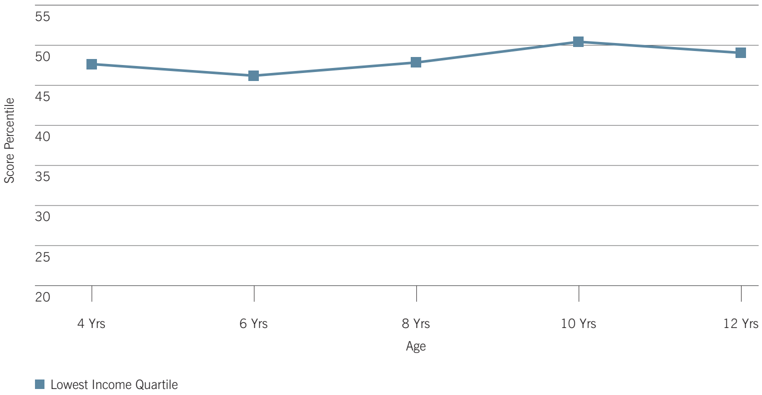


Fact 2b: Average percentile rank on anti-social behavior score, by income quartile



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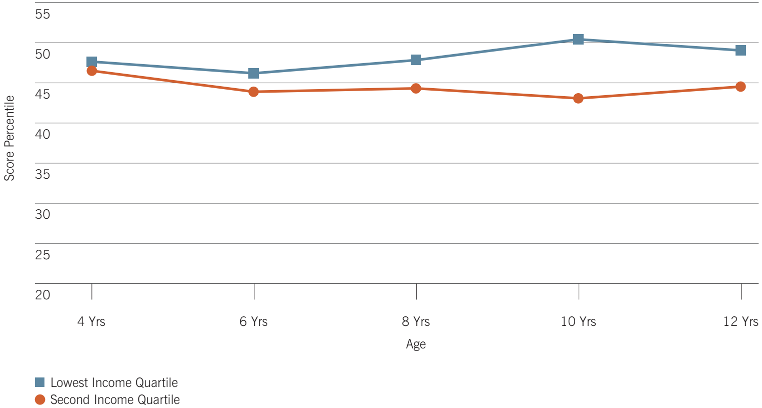

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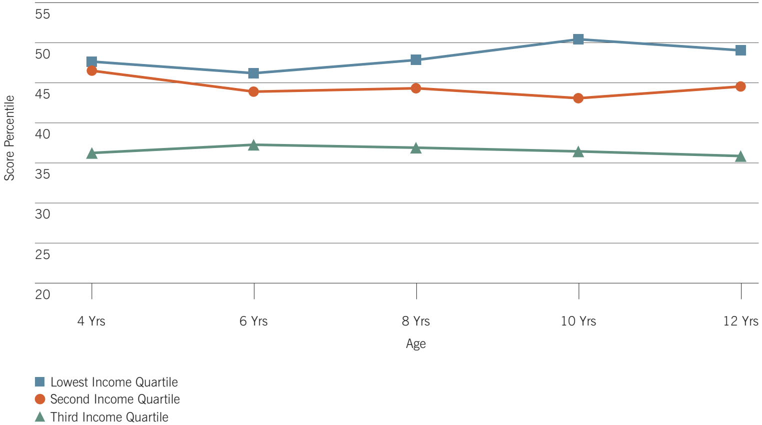

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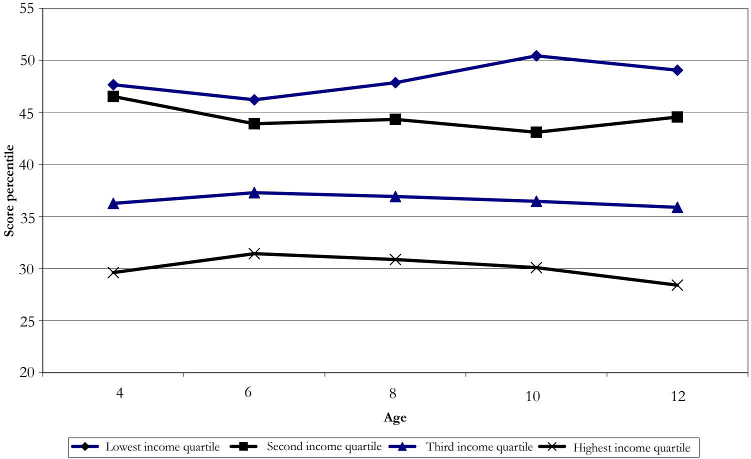

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    5. We anchor test scores on adult outcomes of interest.
    6. The data on inputs and outputs are characterized by considerable measurement error, and our models are nonlinear.
    7. Investments are chosen by parents who have more information than econometricians. Need to address and solve the problem of endogeneity in nonlinear systems.

Findings Based on Estimates of the Technologies:

Main policy conclusions from our analysis:

- Public investment directed toward the early years should be targeted to children from disadvantaged backgrounds.

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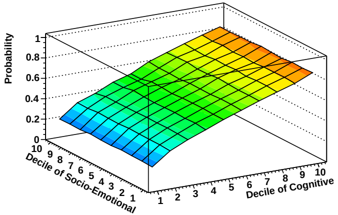
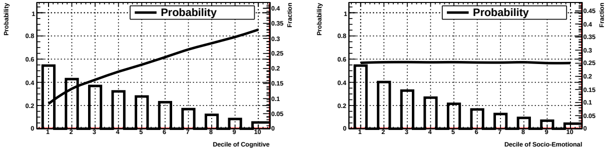
Main policy conclusions from our analysis:

- Public investment directed toward the early years should be targeted to children from disadvantaged backgrounds.
- Investment should be tailored to the particular circumstances of disadvantage.
- The optimal ratio of early to late investment depends on the outcome of interest.
- If remediation does not occur at early stages of childhood, then remediation at later stages should focus primarily on fostering noncognitive skills.

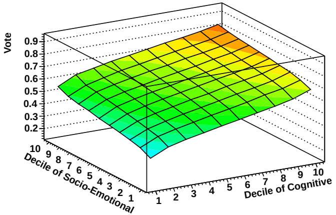
Figure 27: The Probability of Educational Decisions, by Endowment Levels, **HS Dropout** vs. Getting a GED

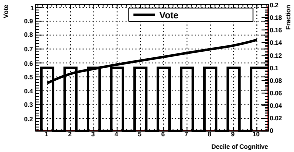


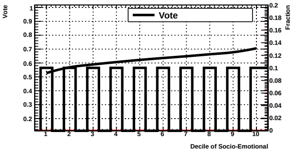


Source: Heckman, Humphries, Urzua, and Veramendi (2011).

Figure 28: The Effect of Cognitive and Socio-emotional endowments on Participation in 2006 Election, All

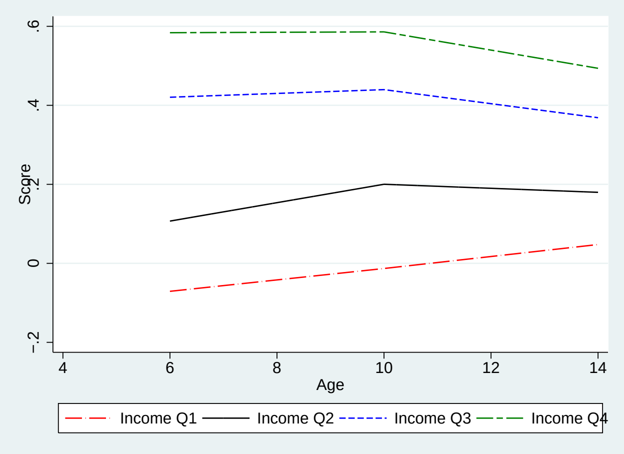






Source: Heckman, Humphries, Urzua, and Veramendi (2011).

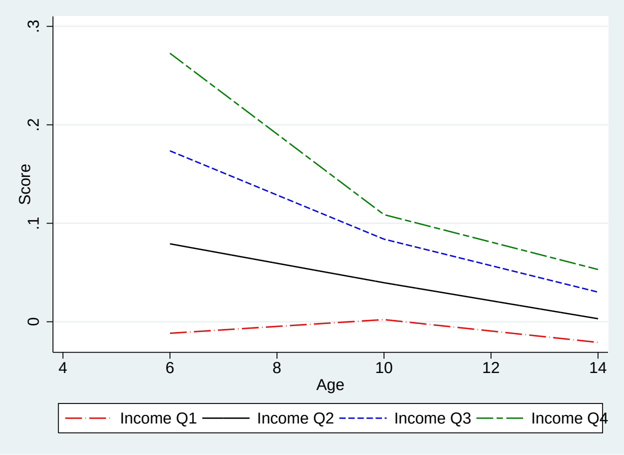
Figure 29: Parental Investment over Childhood among Whites by Family Income Quartile: Material Resource



Data: A balanced panel from Children of National Longitudinal Survey of Youth 1979.

Source: Moon (2012).

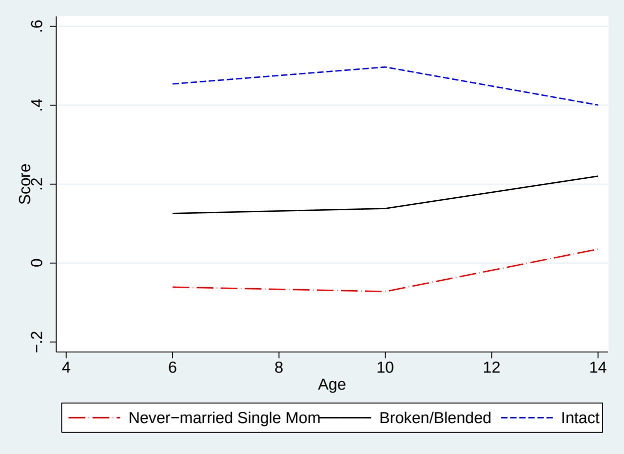
Figure 30: Parental Investment over Childhood among Whites by Family Income Quartile: Emotional Support



Data: A balanced panel from Children of National Longitudinal Survey of Youth 1979.

Source: Moon (2012).

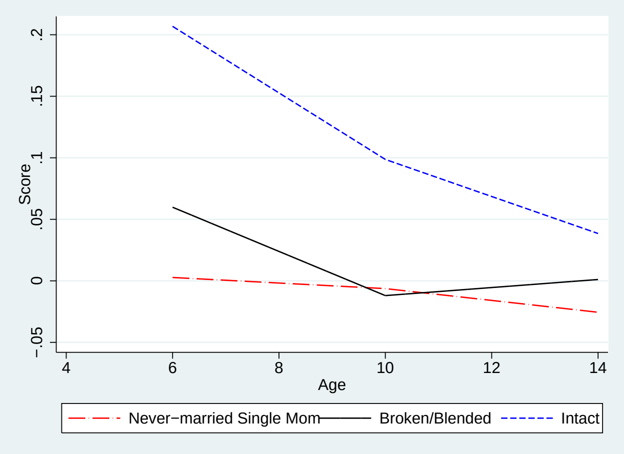
Figure 31: Parental Investment over Childhood among Whites by Family Type: Material Resource



Data: A balanced panel from Children of National Longitudinal Survey of Youth 1979.

Source: Moon (2012).

Figure 32: Parental Investment over Childhood among Whites by Family Type: Emotional Support



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High/Scope Perry Preschool Program

- The Perry preschool program enriched the lives of low income black children with initial IQs below 85 at age 3.

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  - program stops after two years
  - the program taught planning and persistence as well as social adjustment
  - "Plan, Do, Review": Plan a project, do it, review it collectively

- Evaluated by the method of random assignment.

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- Strong effects are found for both boys and girls, although different effects are found at different ages for different outcomes.

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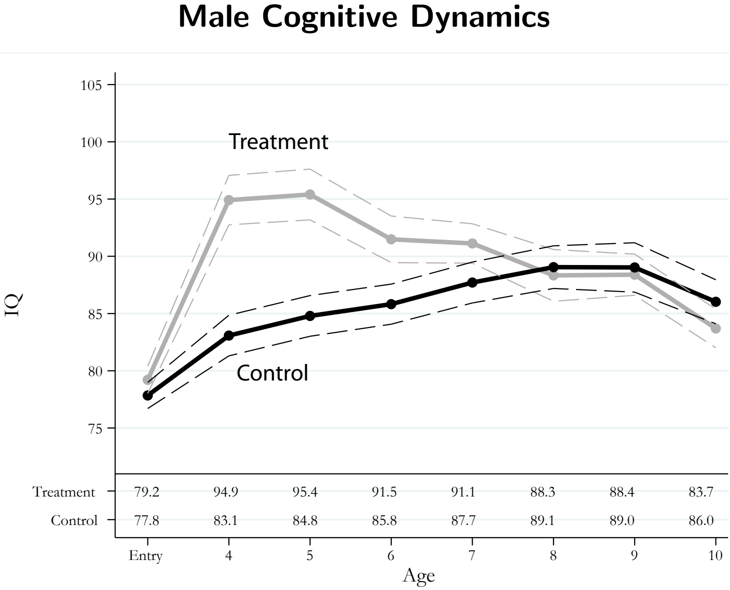
- Strong effects are found for both boys and girls, although different effects are found at different ages for different outcomes.
- Did not lead to sustained gains in IQ for males, and only slight effect for females.

Cognitive Evolution Through Time, Perry Males



	Entry	4	5	6	7	8	9	10
Treatment	79.2	94.9	95.4	91.5	91.1	88.3	88.4	83.7
Control	77.8	83.1	84.8	85.8	87.7	89.1	89.0	86.0

- Yet the Perry Program has a statistically significant annual rate of return of around 7–10% per annum—for both boys and girls—above the post World War II stock market returns to equity in U.S. labor market estimated to be 5.8%.

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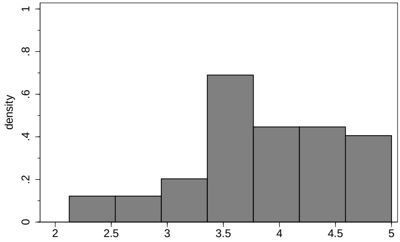
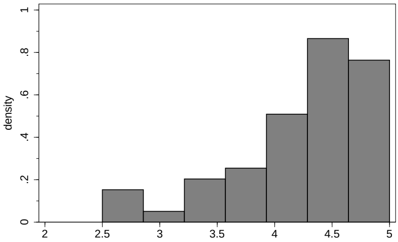
- Socioemotional factors and cognitive factors both explain performance on achievement tests (Duckworth, 2006; Borghans et al., 2008; Borghans et al., 2009).

Figure 33: Personal Behavior Index by Treatment Group



(a) Control



(b) Treatment

- Treatment shifts the distribution upwards (1=bad;...;5=good).

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- Statistically significant treatment effect is observed: $p = 0.002$.

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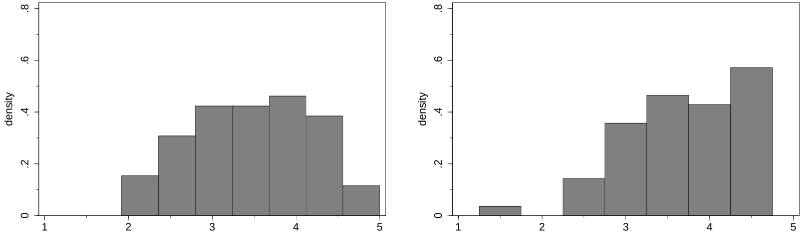
- Statistically significant treatment effect is observed: $p = 0.002$.
- The Personal Behavior Index is an unweighted average of four items: "absences and truancies", "lying or cheating", "steals" and "swears or uses obscene words".

Figure 34: Socio-Emotional Index by Treatment Group



(a) Control (b) Treatment

- Treatment shifts the mean upwards (1=bad;...;5=good).

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- Treatment effect one-sided p-values is 0.096 (borderline statistically significant).

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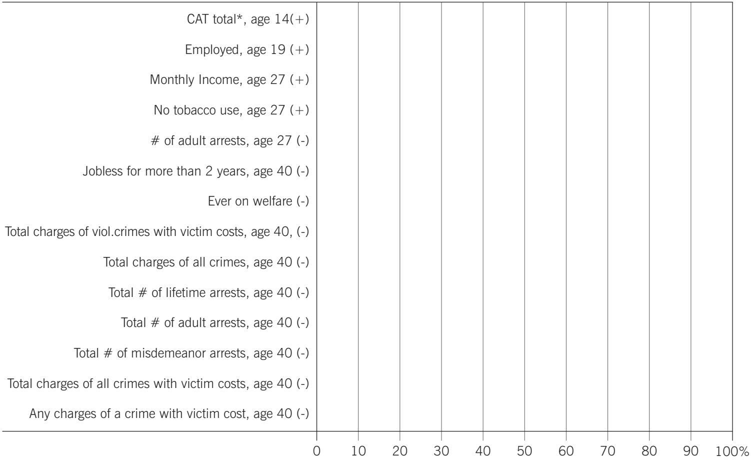
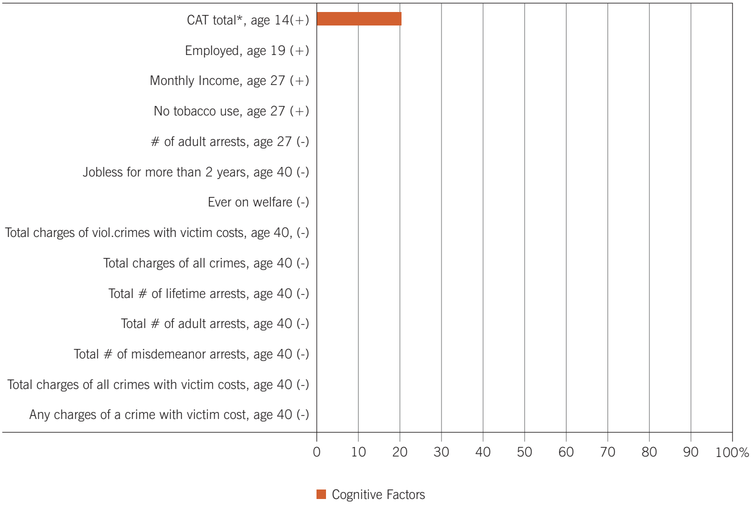
- Treatment effect one-sided p-values is 0.096 (borderline statistically significant).
- The Socio-Emotional index is an unweighted average of four items: "appears depressed", "withdrawn and uncommunicative", "friendly and well-received by pupils", and "appears generally happy".

Decomposing Treatment Effects

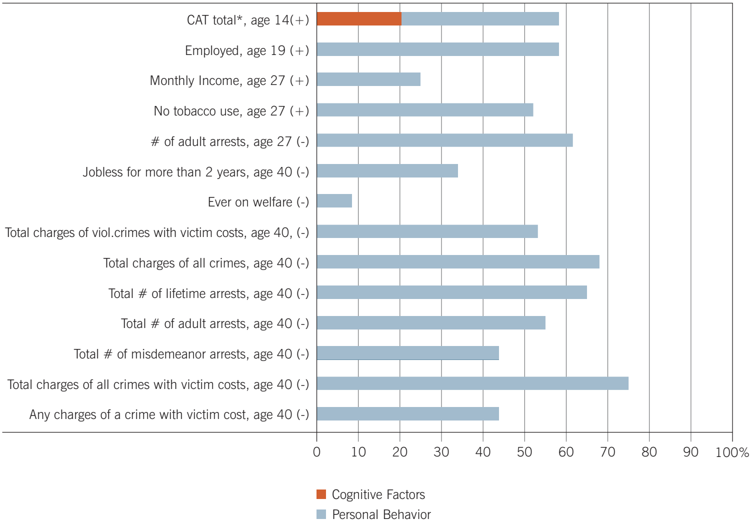
Decomposition of Treatment Effects, Males



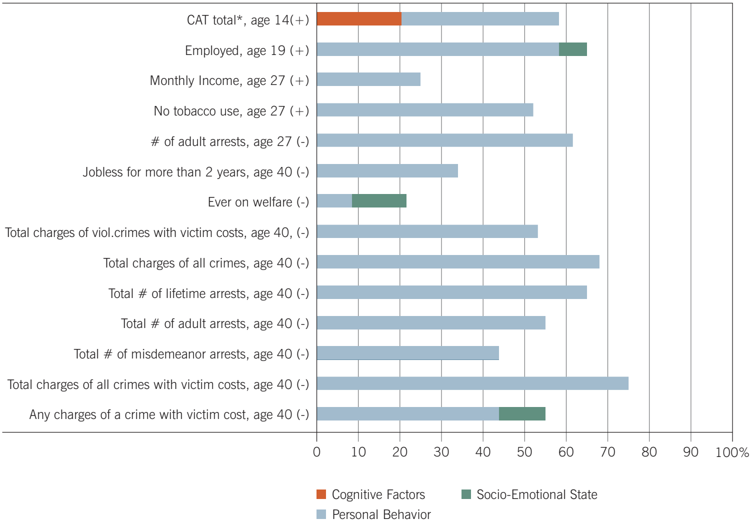
Decomposition of Treatment Effects, Males



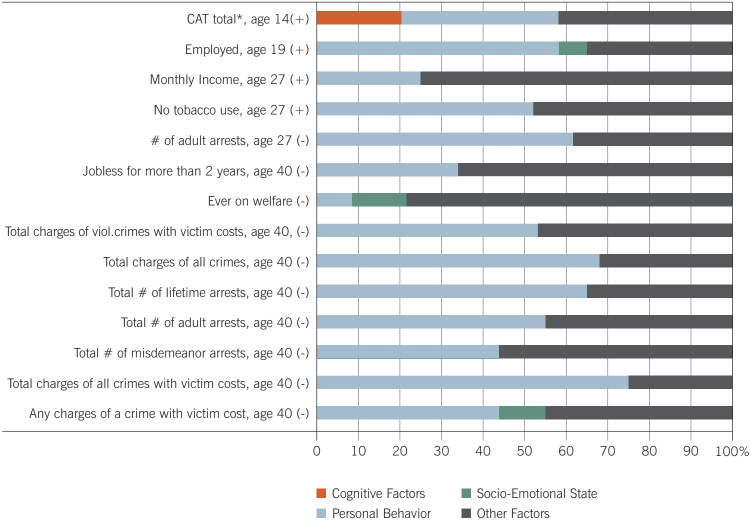
Decomposition of Treatment Effects, Males



Decomposition of Treatment Effects, Males



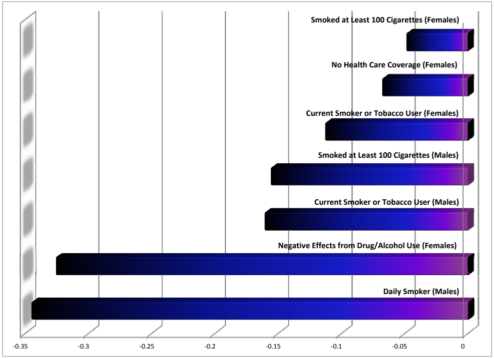
Decomposition of Treatment Effects, Males



Early childhood intervention programs offer a promising avenue for reducing health disparities

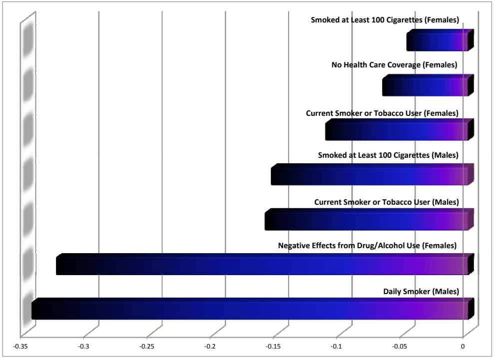
Perry Preschool Intervention, Age 40

Treatment Effects



- Early interventions reducing problem behavior can lower the probability of engaging in unhealthy behaviors in adulthood.

Perry Preschool Intervention, Age 40



Treatment Effects

- Early interventions reducing problem behavior can lower the probability of engaging in unhealthy behaviors in adulthood.

$\Longrightarrow$ **Benefits can carry over into the next generation.**

11. Equity-Efficiency Tradeoffs

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- What is economically efficient need not be socially fair.
- **No equity-efficiency tradeoff for early interventions for those born into disadvantage.**
- Substantial tradeoff for the less able for adolescent and young adult interventions, especially those targeted towards fostering cognitive capabilities.

The Effects of Education on Health and Healthy Behaviors

- Use data from the U.S. and U.K. looking at a variety of measures of education.

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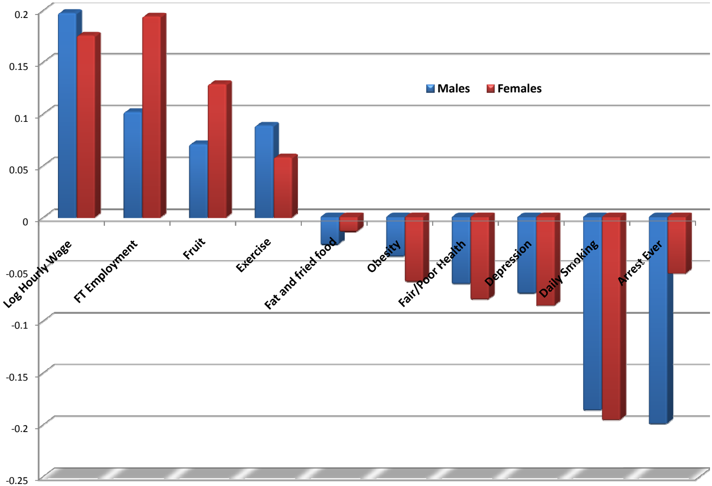
- Decompose observed effects into causal components.
- First consider U.K. differentials at age 30. (BCS70)
- Effect of completing O-levels.

Disparities by Education



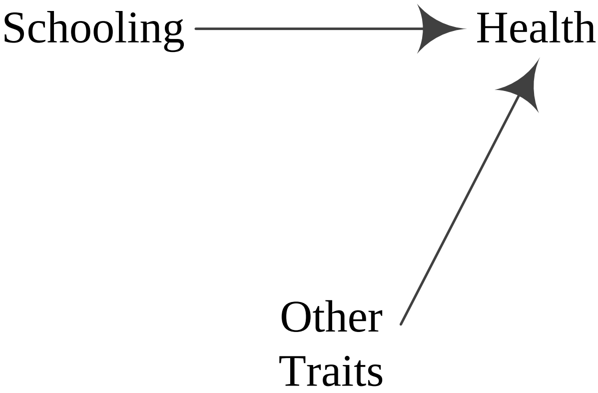
Note: U.K. Data: Authors' calculations using BCS70. The graph shows the raw differentials in the outcomes between individuals with post-compulsory and compulsory level of education. Source: Conti, Heckman and Urzua.

Inferring Causation

Schooling $\longrightarrow$ Health

Other
Traits

Inferring Causation



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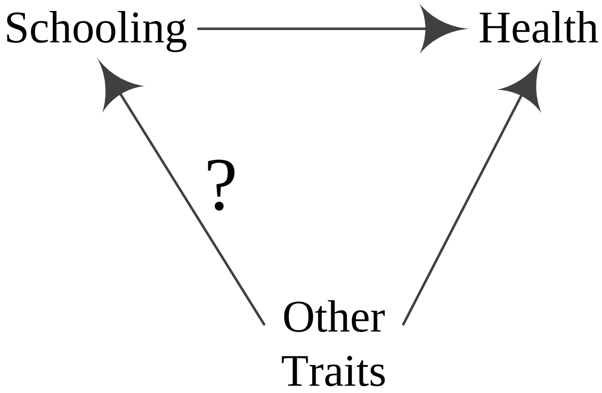
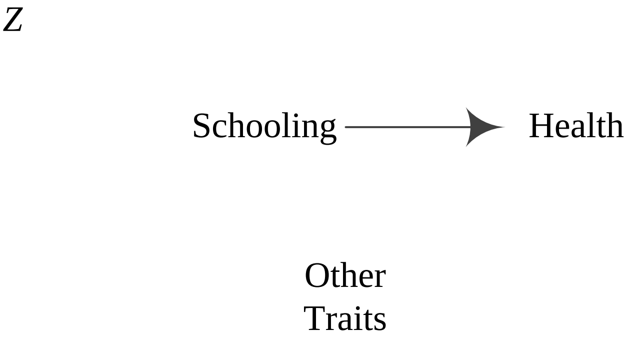


Search for causality: Two strategies

(a) Instruments Z



Random assignment is an instrument

Search for causality: Two strategies

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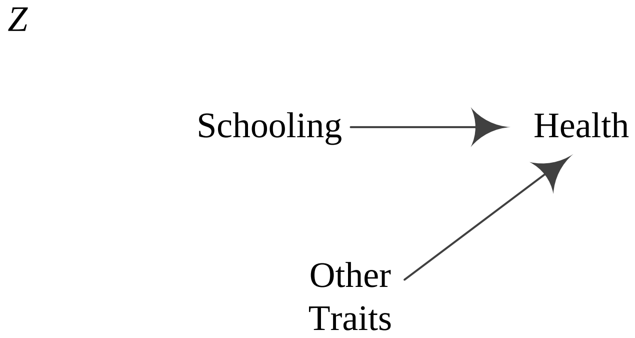

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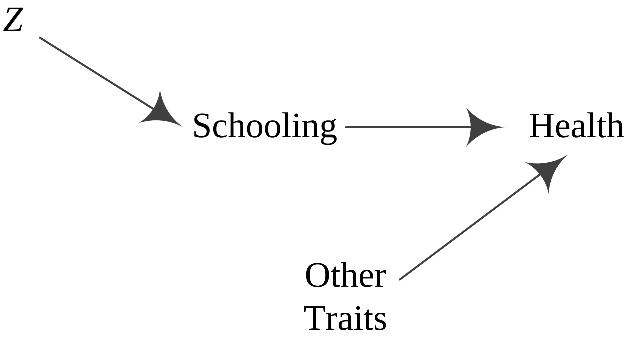

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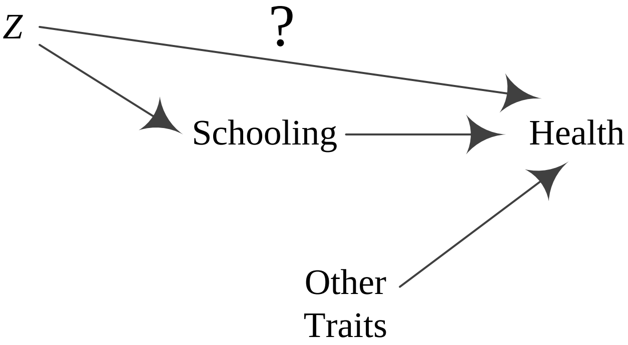

Random assignment is an instrument

b. Control for "other traits" or proxies for "other traits."

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    i. Matching assumes we can perfectly proxy the “relevant” other traits (traits that affect schooling and health).
    ii. Our approach does *not* make the strong assumptions of matching.

Is there a causal effect of education on health?

The Causal Effect of Education

- We consistently find that education has a statistically significant effect that is stronger on healthy behaviors than on health.

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- We consistently find that education has a statistically significant effect that is stronger on healthy behaviors than on health.
- We go beyond mean effects to uncover gains and losses for different individuals.
- We find evidence of substantial heterogeneity in the effects of education across the distribution of early endowments.

How much of the correlation between education and health is due to selection on traits in place before the educational levels we study are selected?

- Some of these traits come from early environments before age 10.

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  - self-regulation and early health are more important determinants of health and healthy behaviors than cognition, especially for men.

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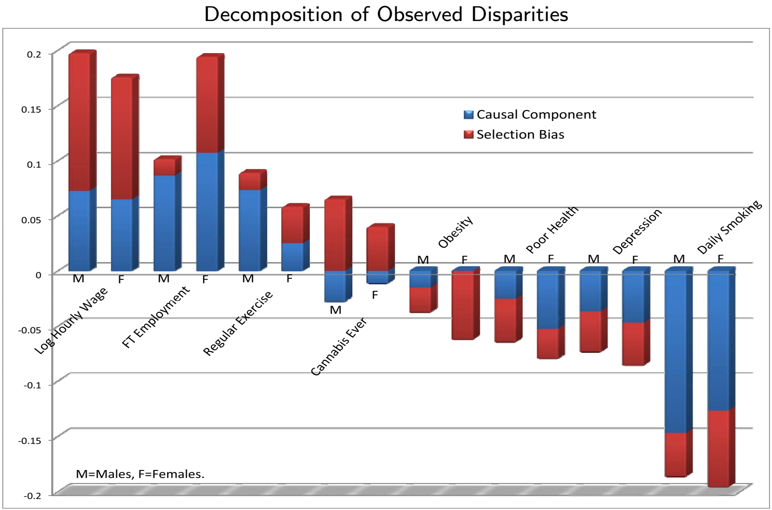
- A substantial part of the observed education-health differential is explained by pre-education factors:
  - self-regulation and early health are more important determinants of health and healthy behaviors than cognition, especially for men.
- Nonetheless, education has a statistically significant causal effect on healthy behaviors.

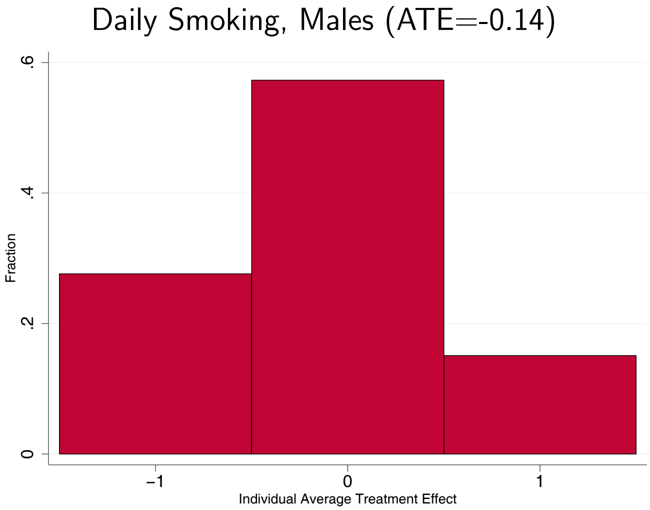
The Causal Effect of Education



Distributional Treatment Effects: Does everybody benefit?

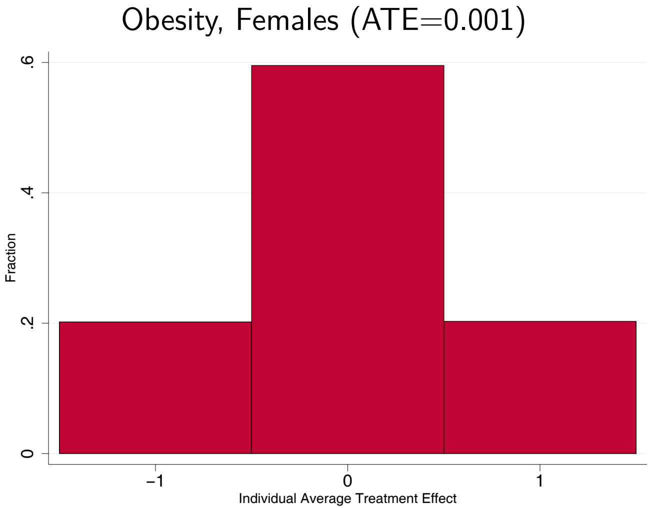
- We also identify **the joint distribution** of the treatment effects.

Distribution of Average Treatment Effects



- Behind the ATE, there are gains and losses for different individuals.

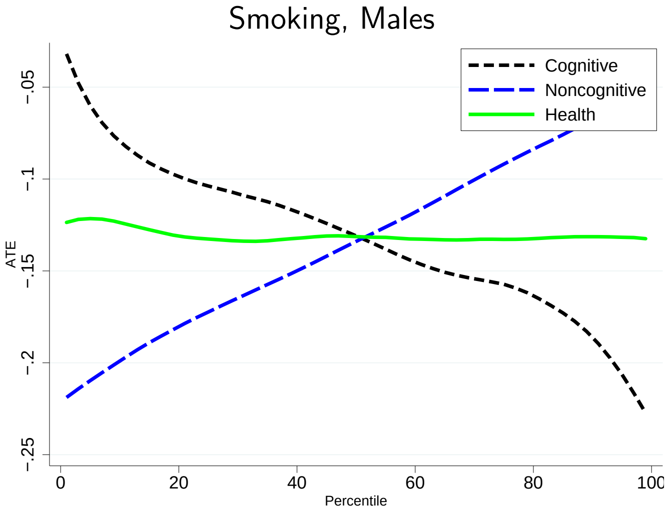
Distribution of Average Treatment Effects



- Which produces essentially a zero average treatment effect.

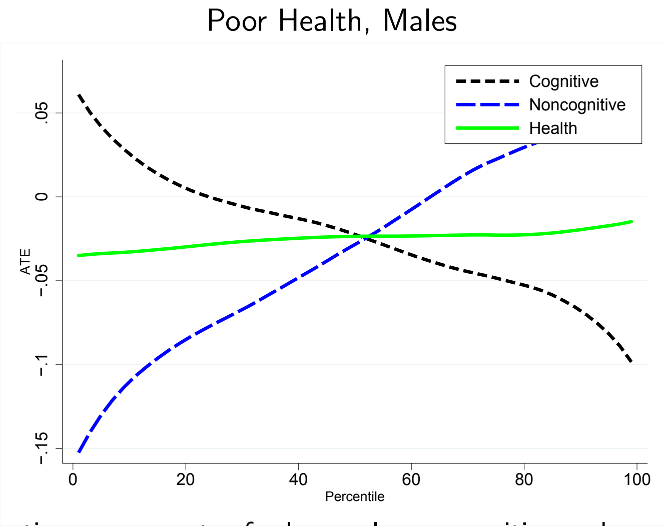
Who benefits?

Treatment Effect Heterogeneity



- Education compensates for low early noncognitive endowments and reinforces high early cognitive endowments.

Treatment Effect Heterogeneity



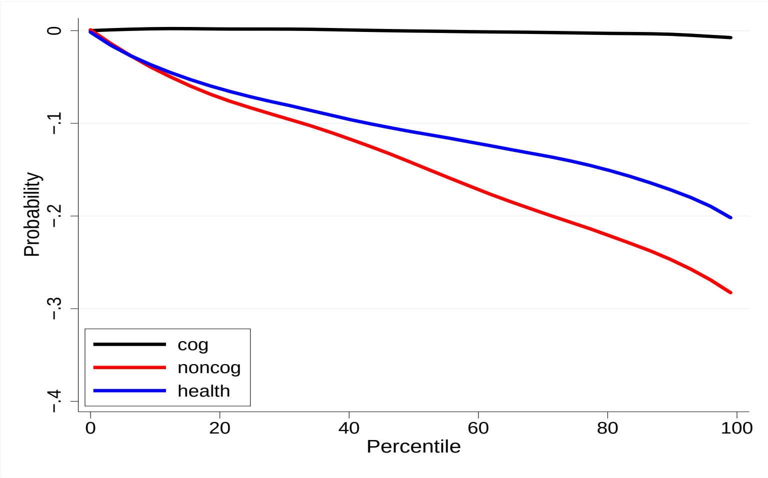
- Education compensates for low early noncognitive endowments and reinforces high early cognitive endowments.

The Role of Factors up to Age 10

- Cognitive ability has a significant effect on health and health behaviors if self-regulation is not included in the model.

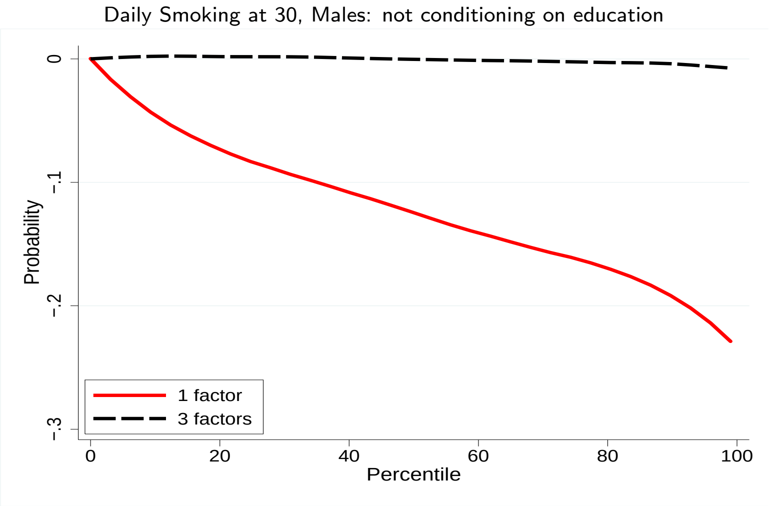
The Role of Factors up to Age 10

Daily Smoking at 30, Males: not conditioning on education



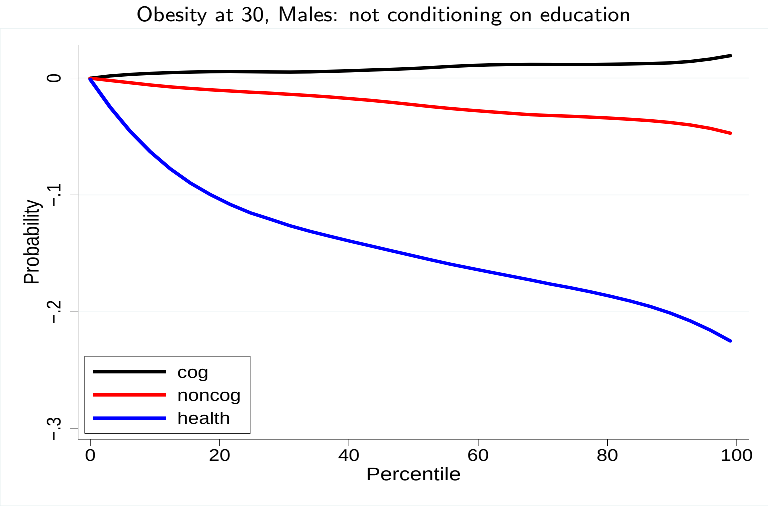
- Both self-regulation and physical health are equally important determinants of smoking.

The Role of Factors up to Age 10



- But not accounting for them *overestimates* the importance of cognition.

The Role of Early Physical Health



- Early physical health is the most important determinant of obesity for men.

Dynamic Sequential Model

Data: The National Longitudinal Survey of Youth (NLSY79)

- U.S. Data

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- Nationally representative sample of men and women aged 14-22 when first interviewed in 1979.

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  2. health status (obesity, PCS-12 scale, MCS-12 scale, Pearlin, CESD)
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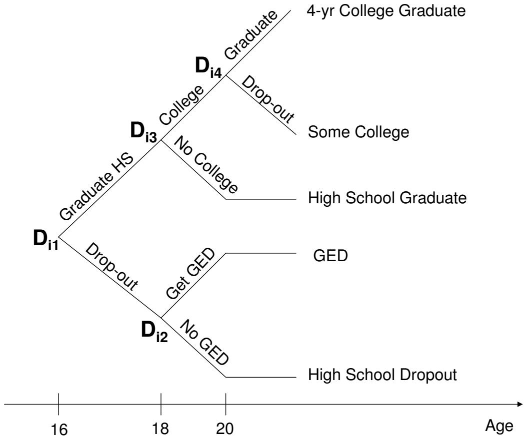
- Measurements (age 14-15):
  1. θ_C: ASVAB components of the AFQT
  2. θ_N: 9^{th} grade GPA in reading social studies, science and math, as well as early measured behaviors.

Figure 35: Sequential model for schooling decisions.



Decomposition of Mean Differences

Pairwise comparisons of a terminal education level to being a dropout