The Economics and Psychology of Inequality and Human Development

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Marshall Lecture
European Economics Association
Milan, Italy
August 29, 2008

I. Introduction: Victorian Economics

- Marshall had a passionate interest in inequality.

  I have devoted myself for the last twenty-five years to the problem of poverty, and very little of my work has been devoted to any inquiry which does not bear upon that.

  — Alfred Marshall (Report to Royal Commission on the Aged Poor, 1893)

- Marshall analyzed how markets priced skills, studied the role of human capital in creating earnings capacity, and the role of the family (especially the mother) in creating human skills.

The most valuable of all capital is that invested in human beings; and of that capital the most precious part is the result of the care and influence of the mother.

— Alfred Marshall (1890, paragraph VI.IV.11)

- He emphasized the development of "character" — personality traits, motivation, sociability and conscientiousness — as a way to elevate the poor out of poverty and promote their attachment to the larger society.

  The human will, guided by careful thought, can so modify circumstances as largely to modify character; and thus to bring about new conditions of life still more favourable to character; and therefore to the economic, as well as the moral, well-being of the masses of the people.

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- He, and many other Victorians, thought that it was possible to build "character" and "morals" through education and by way of example in families and institutions.

- Describing Marshall, Schumpeter wrote

  He had no objection to commonplaces about human values and loved to preach the Gospel of the Noble Life . . . I confess that few things are so irritating to me as is the preaching of mid-Victorian morality, seasoned by Benthamism, the preaching from a schema of middle-class values that knows no glamour or passion.

  — Schumpeter, AER, 1941

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  1. Mothers matter, as Marshall thought, but through what channels? Can we improve mothering? Supplement it? Substitute for it?
  2. We better understand what adversity in environments means.
  3. The correct measure of disadvantage is not income *per se*. The scarce resource is parenting or mothering.

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  3. Health (physical and mental)
- In my talk today, I focus on (i) and (ii)

II. Recent Evidence on Inequality and Human Development

1. Ability matters and abilities are multiple in nature

- Abilities create capabilities: capacities to achieve.

Cognitive abilities

crystallized and fluid intelligence
different age profiles in their development

Noncognitive abilities

perseverance,	motivation,	time preference,
risk aversion,	self-esteem,	self-control,
preference for leisure,	conscientiousness,	forward-looking behavior

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- Substantial evidence that cognitive traits are *not* solely situational specific.

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- Substantial evidence that cognitive traits are *not* solely situational specific.
- They evolve over time but they are positively correlated over time.

Both abilities have direct causal effects on

wages (controlling for schooling),	schooling,	health,
performance on achievement tests,	crime,	teenage pregnancy,
compliance with health protocols,	smoking	

and many other aspects of social and economic life.

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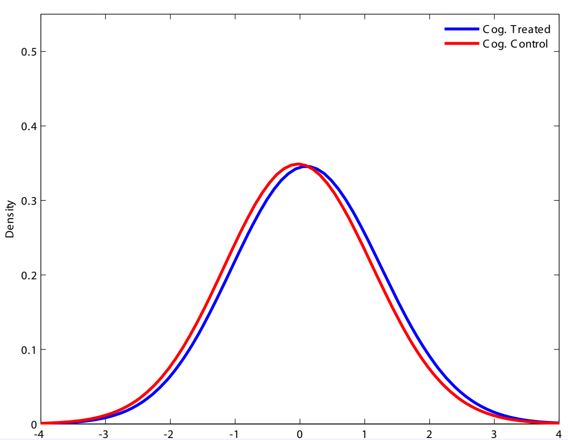
- They adjust for reverse causality—measured traits may be determined in part by the outcome being analyzed.
- They also show substantial *heterogeneity* in these latent traits so that Marshall's "representative agent" is an inadequate framework for analyzing human capabilities.

Distributions of Cognitive Skills, Perry Males Treated and Untreated



Source: Heckman, Malofeeva, Pinto and Savelyev (2008)

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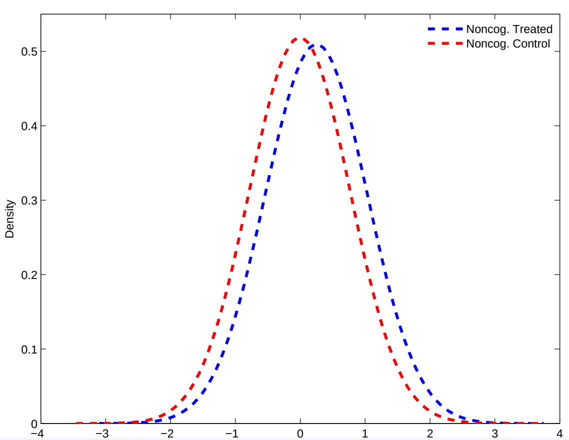

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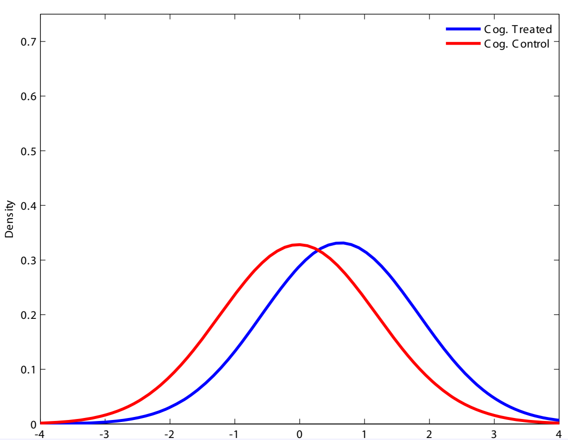
Distributions of Cognitive, Perry Females Treated and Untreated



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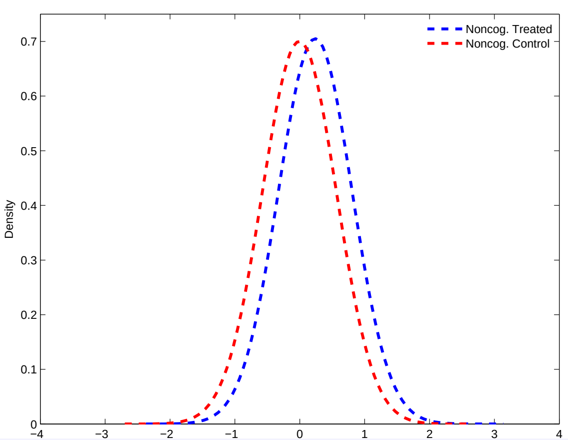

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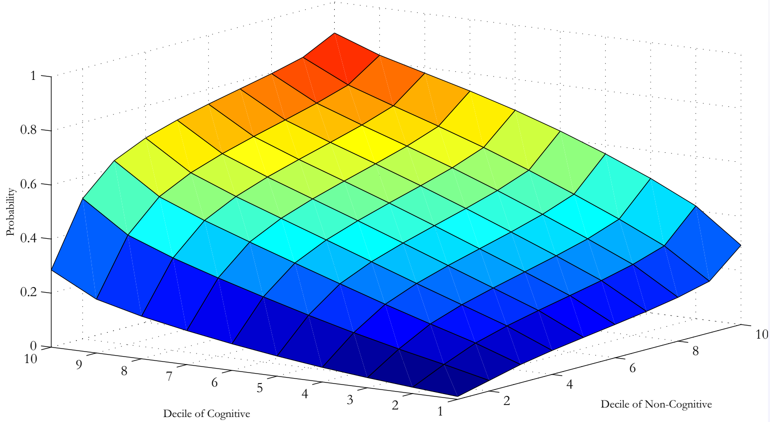
Probability of Being a White Collar Worker by Age 30 – Males



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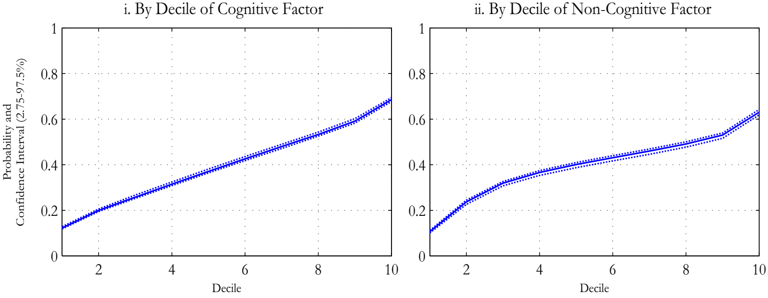

Notes: The data are simulated from the estimates of the model and our NLSY79 sample. We use the standard convention that higher deciles are associated with higher values of the variable. The confidence intervals are computed using bootstrapping (50 draws).

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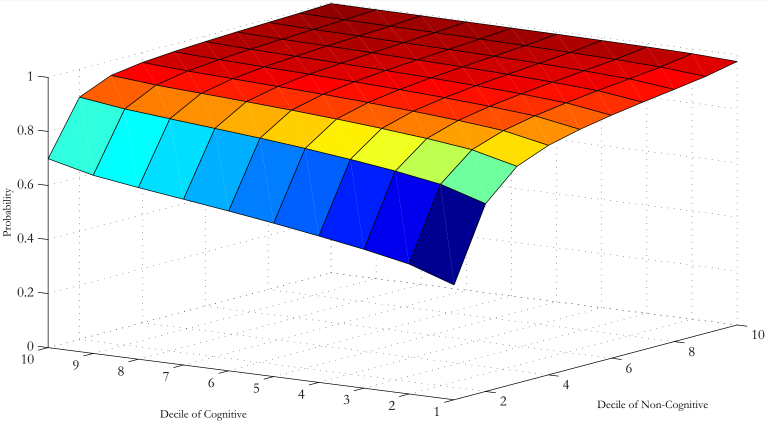

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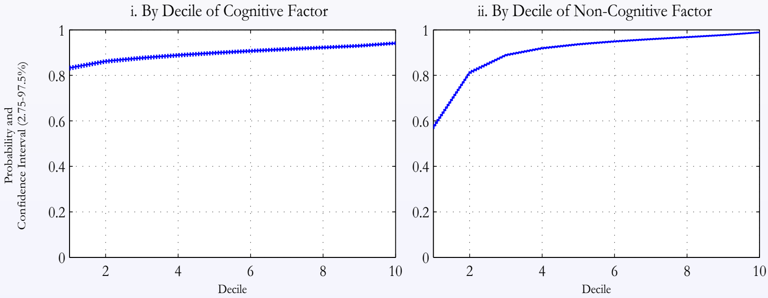

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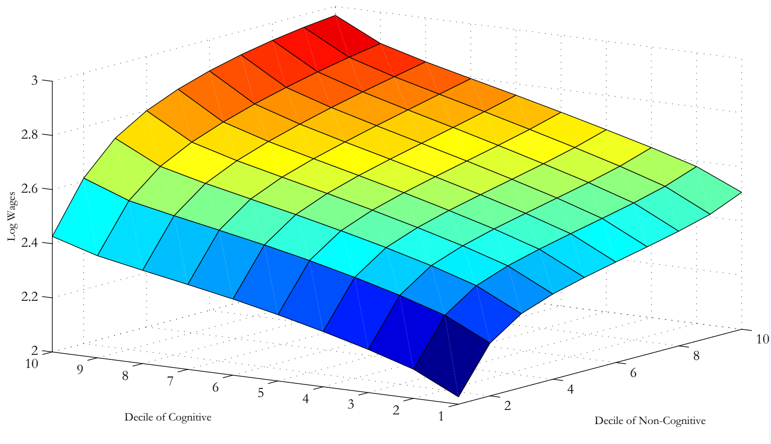

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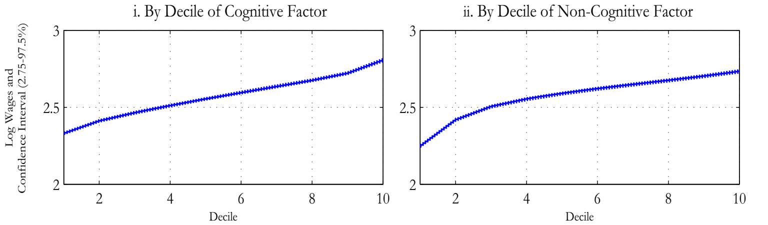

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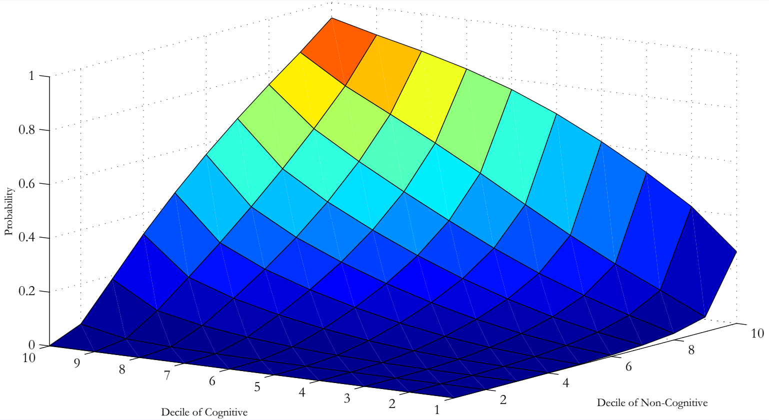
Probability of Being a 4-yr College Graduate by Age 30 – Males



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- Relate economic preferences to psychological measurements.

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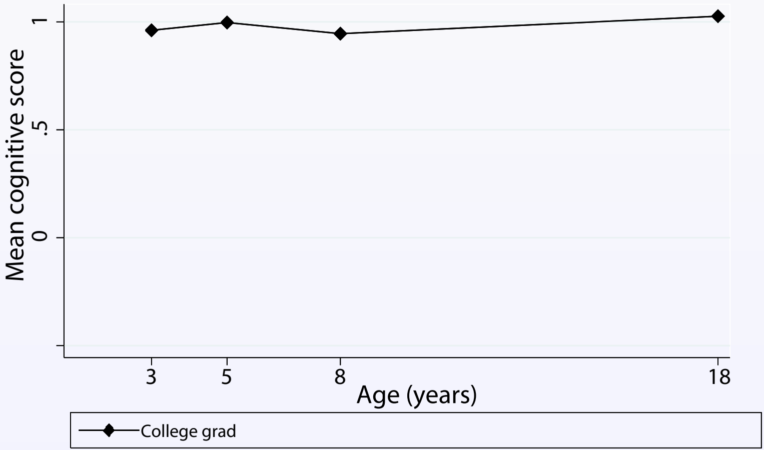
  1. Ability to forecast the future (Cognition)
  2. Restraint or self control (Noncognitive features)

3. For both cognitive and noncognitive traits, ability gaps among individuals and across socioeconomic groups open up at early ages and persist.

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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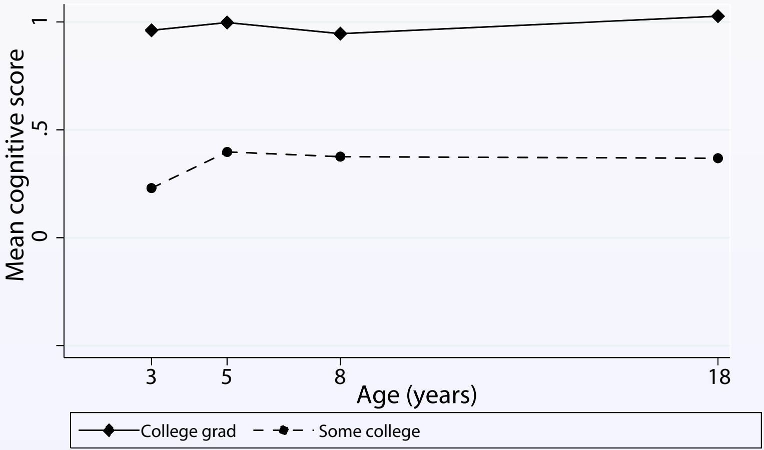

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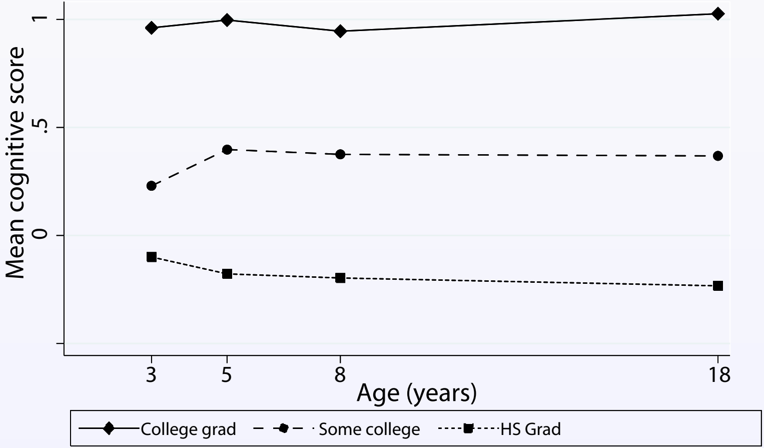

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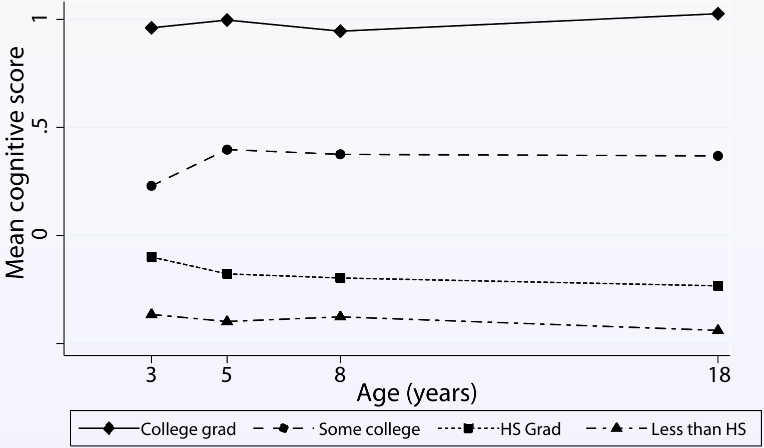

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- These and other findings establish the powerful role of the family in creating differences in capabilities among persons.
- Such analyses do not settle whether the gaps are due to genes or environments or some interaction.

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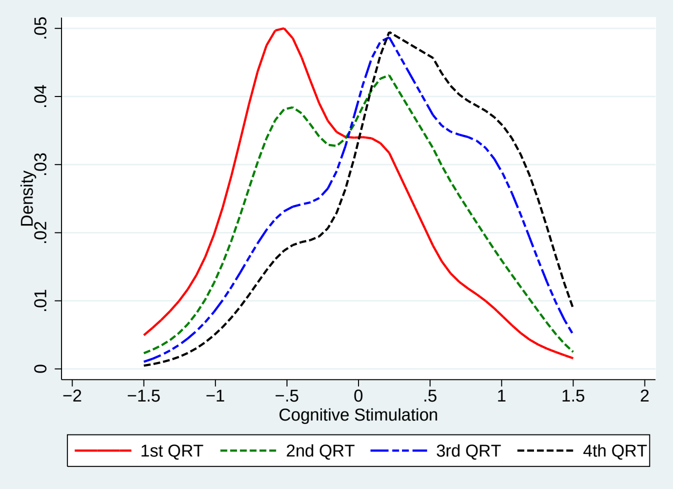
- Investment in children varies substantially by family type.
- Differences are persistent over the age of the child.

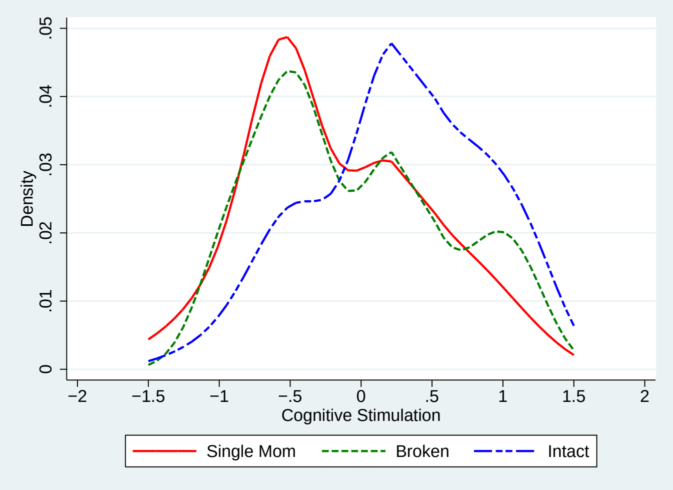
Cognitive Stimulation: Age 0-2, White, By Family Income Quartile



Males

Source: Seong Hyeok Moon (2008) analysis of CNLSY data

Cognitive Stimulation: Age 0-2, White, By Family Type



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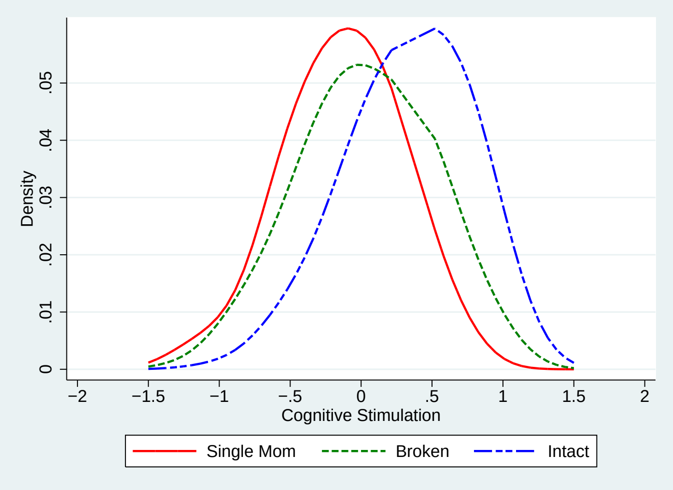
Source: Seong Hyeok Moon (2008) analysis of CNLSY data

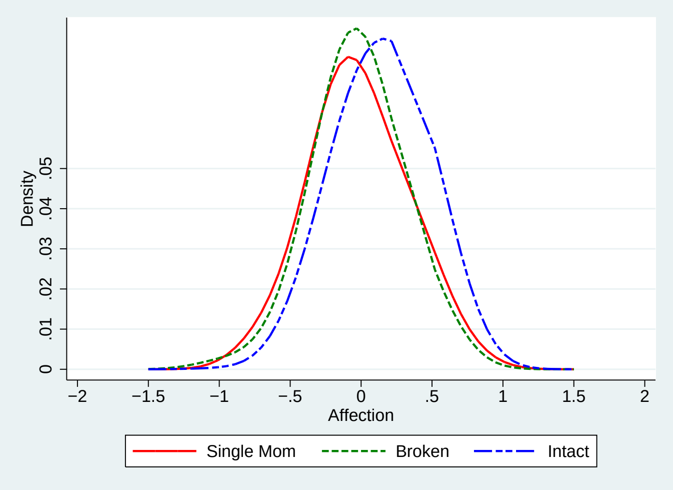
Cognitive Stimulation: Age 10-11, White, By Family Type



Females

Source: Seong Hyeok Moon (2008) analysis of CNLSY data

Affection: Age 6-7, White, By Family Type



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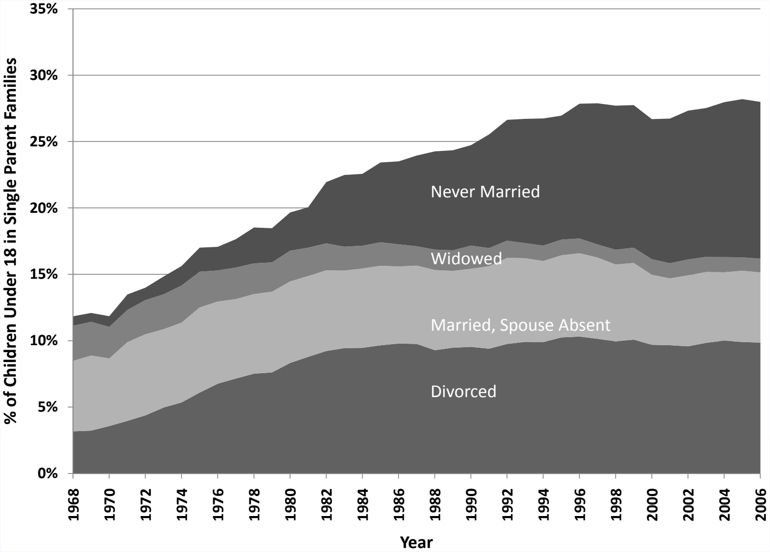
- Likely fosters persistence of inequality across generations.

Percent of Children Under 18 Living with One Parent, By Marital Status of Single Parent



5. Capabilities are not Solely Determined by Genes

- Differential methylation patterns affect gene expression and hence performance and behavior.

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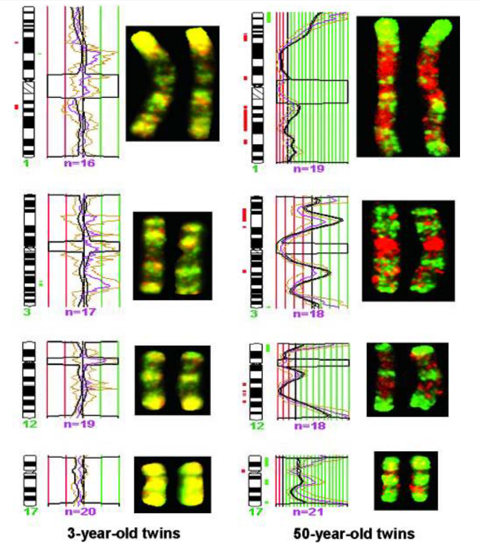
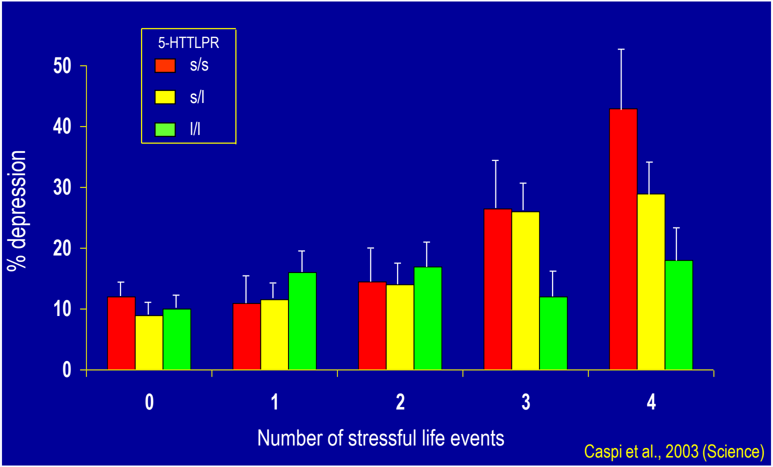
- Evidence of environmental effects on the methylation of the gene.

Methylation patterns in young and old twins



Source: Fraga, Ballestar et al. (2005)

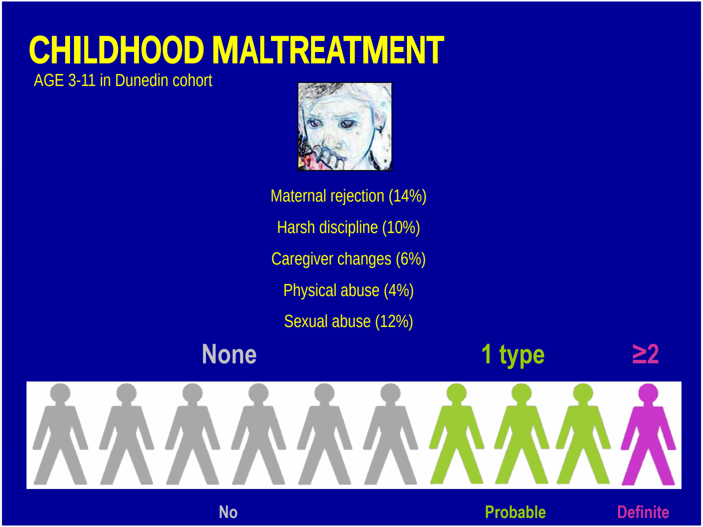
Genes are Triggered by Environments



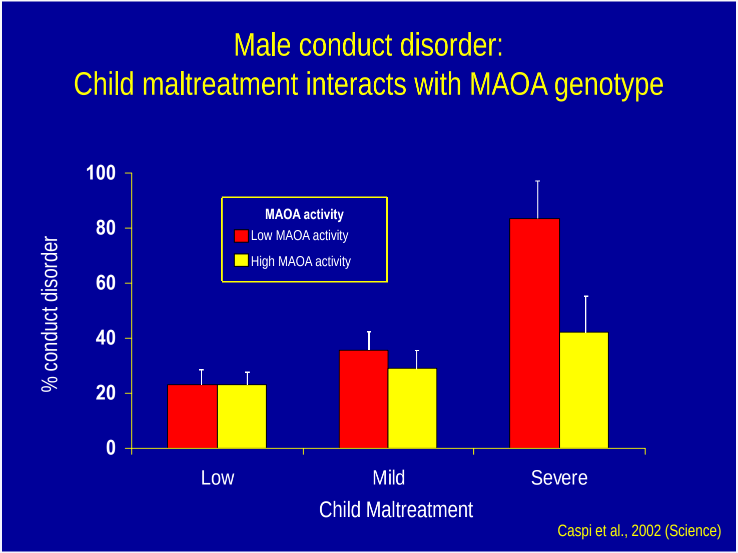
Source: Caspi, Sugden et al. (2003)

- Replicated in 20 studies; failure to replicate in 3.

6. Critical and Sensitive Periods: Early Environments Have Lasting Effects on Child Outcomes



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



Caspi, McClay et al. (2002).

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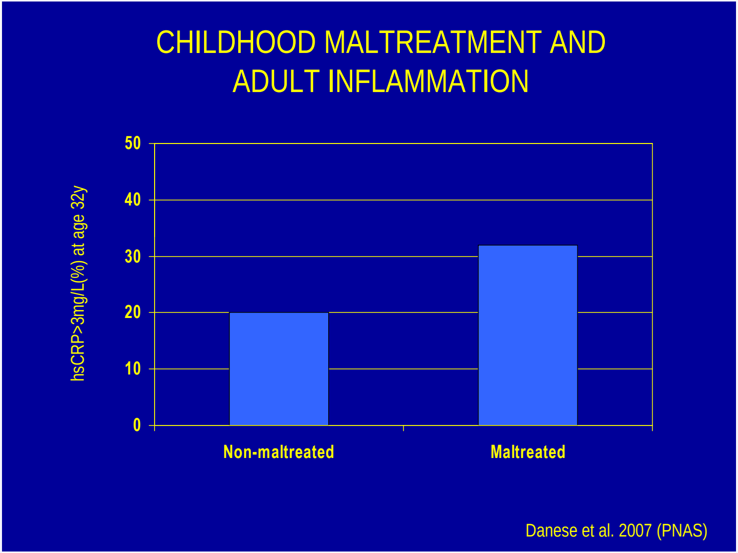
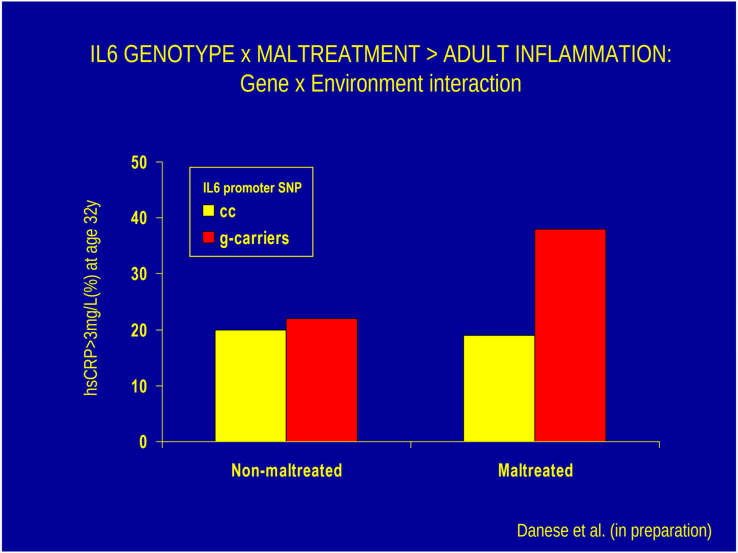
- Even stronger effects for other genes.



Source: Danese, Pariante et al. (2007)



Source: Danese, Moffitt et al. (2008)

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- Protein, iron, zinc, selenium, folate, vitamin A, choline, fatty acids are particularly important for late pregnancy.
- Protein deficiency in particular reduces neuronal DNA and RNA content and alters fatty acid profile.

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- This is why lack of protein is thought to have effects on both recognition and working memory.

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- Socioemotional stimulation fosters learning by providing an environment in which the animal explores.
- Those more open to experience learn from it.

7. Evidence on Critical and Sensitive Periods in Development

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     - E.g., Iron; Vitamin A; Iodine.
     - Blindness, Impaired IQ, etc.
     - Difficult to remediate at later ages.

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- Related animal evidence.

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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.
- The truly binding credit constraint is the inability of a child to buy its parents. (Cunha and Heckman, 2007)

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

- Main mechanism of intervention through noncognitive or personality measurements.

High/Scope Perry Preschool Program

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  - program stops after two years

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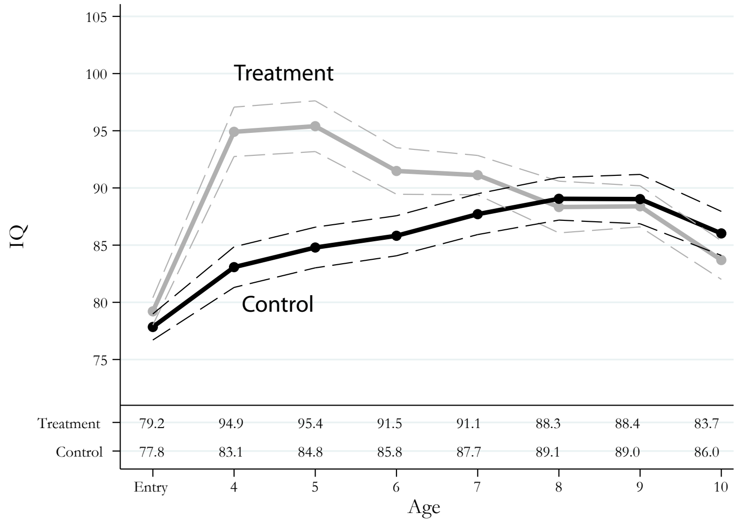
- Contrary to recent claims, strong effects are found for both boys and girls, although different effects at different ages.
- Did not lead to sustained gains in IQ for males.

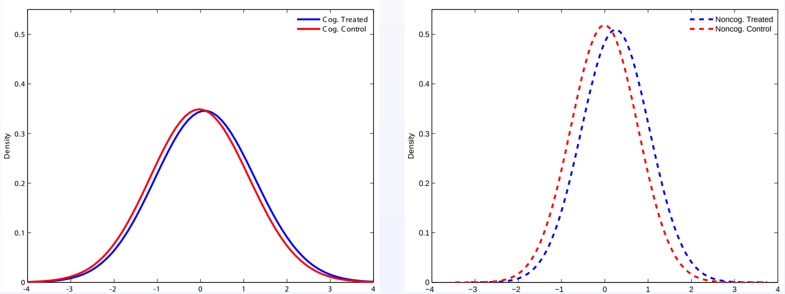
Male Cognitive Dynamics



Late Cognitive and Noncognitive Skills, Perry Males

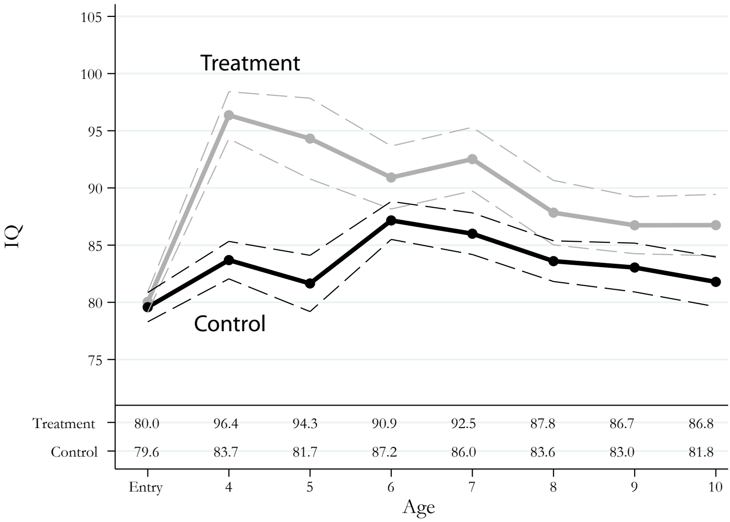
Male PDF of Late Cog. and Noncog. Skills

(a) Cognitive Skills **(b)** Noncognitive Skills



Source: Heckman, Malofeeva, Pinto and Savelyev (2008)

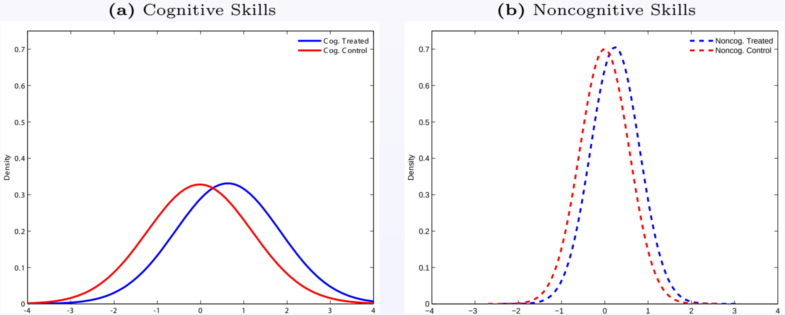
Female Cognitive Dynamics



	Entry	4	5	6	7	8	9	10
Treatment	80.0	96.4	94.3	90.9	92.5	87.8	86.7	86.8
Control	79.6	83.7	81.7	87.2	86.0	83.6	83.0	81.8

Late Cognitive and Noncognitive Skills, Perry Females

Female PDF of Late Cog. and Noncog. Skills



Source: Heckman, Malofeeva, Pinto and Savelyev (2008)

- Yet has a statistically significant rate of return of around 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%.

- The Perry Preschool Program worked primarily through noncognitive channels for men.

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- Both channels for women.

- The Perry Preschool Program worked primarily through noncognitive channels for men.
- Both channels for women.
- Explains part of gender differences in response to treatments (Heckman, 2005; Anderson, 2008).

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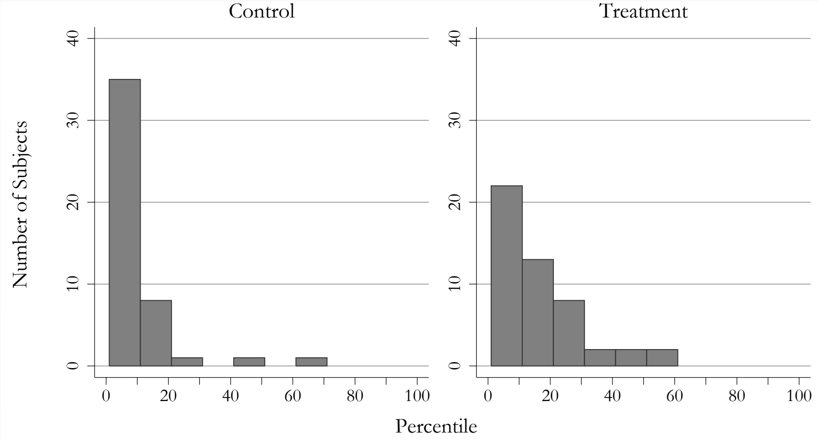
- Noncognitive factors and cognitive factors explain performance on achievement tests (Duckworth, 2006; Borghans et al., 2008).
- Personality factors substantially affect performance on achievement tests.

Perry Age 14 Total CAT Scores, by Treatment Group

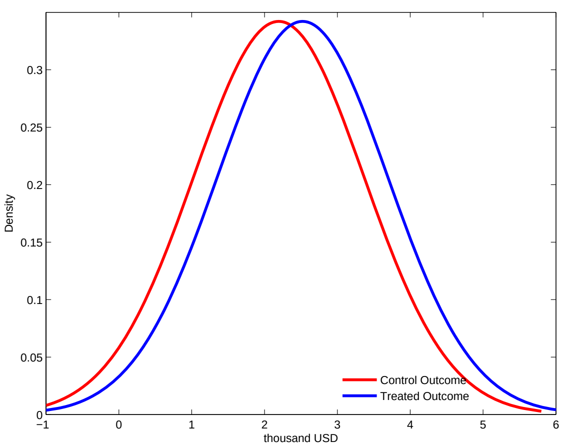


CAT = California Achievement Test
Treatment: $N = 49$; Control: $N = 46$
Statistically Significant Effect for Males and Females (p-values 0.009, 0.021 respectively)

Source: Heckman, Malofeeva, Pinto, and Savelyev (2008).

Impact of Cognitive and Noncognitive Factors on Income at age 40, Males

(a) Unconditional PDF

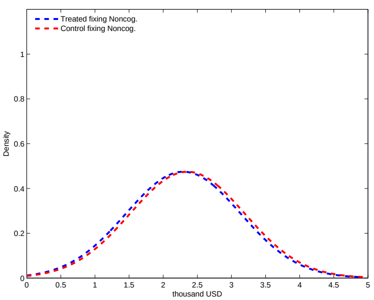


Source: Heckman, Malofeeva, Pinto and Savelyev (2008)

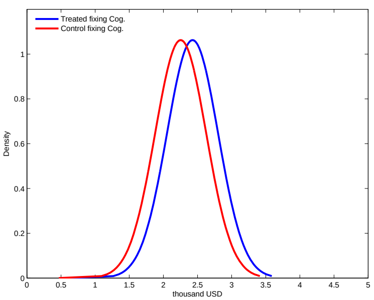
Impact of Cognitive and Noncognitive Factors on Income at age 40, Males

Cog. and Noncog. Impact on Income for Males

(a) Impact due to Cog. Skills



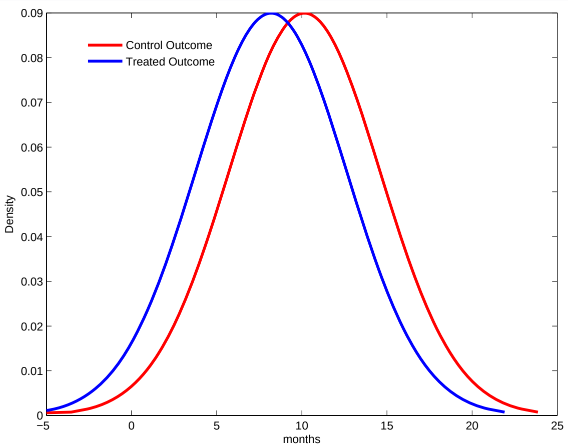
(b) Impact due to Noncog. Skills



Source: Heckman, Malofeeva, Pinto and Savelyev (2008)

Impact of Cognitive and Noncognitive Factors on Unemployment at age 40, Males

(a) Unconditional PDF



Source: Heckman, Malofeeva, Pinto and Savelyev (2008)

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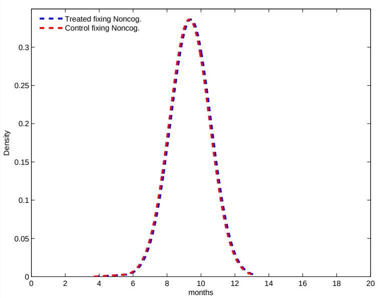
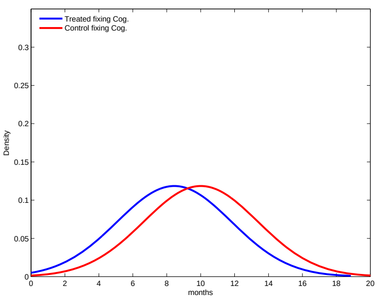
Cog. and Noncog. Impact on Unemp. for Males

(a) Impact due to Cog. Skills



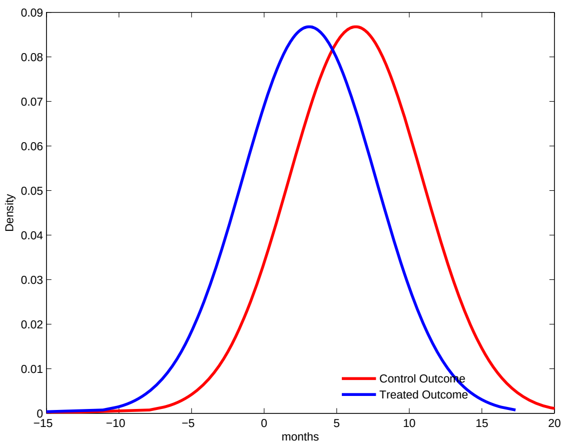
(b) Impact due to Noncog. Skills



Source: Heckman, Malofeeva, Pinto and Savelyev (2008)

Impact of Cognitive and Noncognitive Factors on Unemployment at age 40, Females

(a) Unconditional PDF



Source: Heckman, Malofeeva, Pinto and Savelyev (2008)

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Cog. and Noncog. Impact on Unemp. for Females

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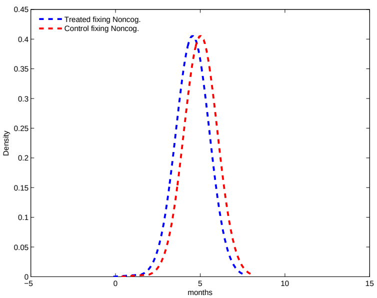
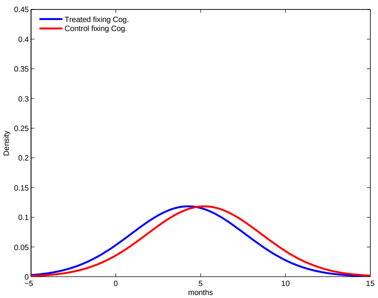


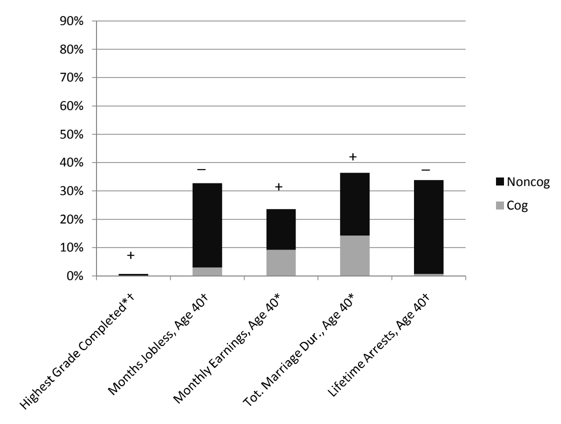
(b) Impact due to Noncog. Skills



Source: Heckman, Malofeeva, Pinto and Savelyev (2008)

Decomposition of Treatment Effect for Males by Factors, Perry Preschool Project, Normalized Relative to Control Mean

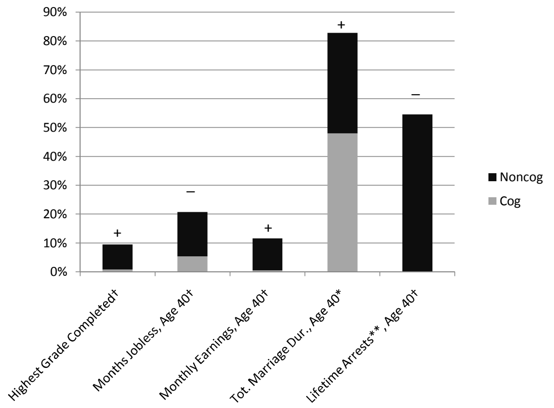
Males



Source: Heckman, Malofeeva, Pinto, Savelyev (2008). Notes: Difference in means is normalized to control mean. Proportion of the effects due to cognitive and noncognitive factors is shown. (*) and (†) denote cases when the associated cognitive and noncognitive factor loadings respectively are statistically significant at level 10% (one-sided test). Such negative estimates are generally statistically insignificant. (+) and (-) denote the sign of the total treatment effect.

Decomposition of Treatment Effect for Females by Factors, Perry Preschool Project, Normalized Relative to Control Mean

Females



Source: Heckman, Malofeeva, Pinto, Savelyev (2008). Notes: Difference in means is normalized to control mean. Proportion of the effects due to cognitive and noncognitive factors is shown. (*) and (†) denote cases when the associated cognitive and noncognitive factor loadings respectively are statistically significant at level 10% (one-sided test). (**) Denotes cases when one of the estimated factor impacts is negative. Such negative estimates are generally statistically insignificant. (+) and (-) denote the sign of the total treatment effect.

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- Early surge in IQ but no statistically significant lasting effects—on IQ—at least for males; small effects for females.
- Main channels: noncognitive skills for males; Both channels for females, but noncognitive effects much stronger.

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- No equity-efficiency tradeoff for early interventions among the less able; substantial tradeoff for the less able for adolescent and young adult interventions.
- Wößmann (2008) presents corroborating evidence on equity-efficiency trade-offs by stage of the life cycle for Europe.

III. Formal Models of Investment in Children

A Model of Investment in Human Capabilities

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- Health stocks include propensities for mortality and morbidity, including infant mortality.
- Capabilities are produced by investment, environments and genes.
- These capabilities are used with different weights in different tasks in the labor market and in social life more generally.

Ingredients: Rewards, Technology, Constraints and Preferences

1. θ_t: a vector of capabilities at age t.

$$\begin{aligned}\theta_t &= (\theta_t^C, \theta_t^N, \theta_t^H), \qquad t = 1, \ldots, T \quad \text{periods of childhood}\\ \theta_t^C &= \text{Cognition at } t\\ \theta_t^N &= \text{Noncognitive Skills at } t\\ \theta_t^H &= \text{Health at } t.\end{aligned}$$

2. Outcome from activity j at time t: $Y_{j,t}$

$$
\begin{aligned}
Y_{j,t} &= \phi_j(\theta_t^C, \theta_t^N, \theta_t^H, R_t^j, e_t^j), \qquad j = 1, \ldots, J \\
R_t^j &= \text{reward to activity } j \text{ at time } t \\
e_t^j &= \text{effort allocated to activity } j \text{ at time } t
\end{aligned}
$$

(Borghans et al., 2008).

   i. Performance in different tasks weights capabilities and incentives in different ways.
   ii. Comparative advantage in different tasks in social and economic life.
   iii. Recall the evidence on the benefits of cognitive and noncognitive factors in occupational choice and other activities.

iv. More conscientious people have lower health risks.

v. To produce better grades: Raise incentives R_t^j (Fryer/Progressa Way) or improve the stocks of skills θ_t.

vi. Latter way likely longer lasting.

3. Technology of skill formation

$$\begin{aligned} \theta_{t+1} &= f_t(\theta_t, I_t, \theta_t^P) \\ I_t &= \text{investments}, \\ \theta_t^P &= \text{parental and other environmental variables}, \\ \bar{\theta}_0 &= \text{initial endowment}. \end{aligned}$$

a. Self-productivity and cross-productivity

$$\frac{\partial f_t}{\partial \theta_t}(\theta_t, I_t, \theta_t^P) \geq 0 \quad \text{(self-productivity)}$$

Examples: "learning begets learning", "motivation begets motivation"

$$\frac{\partial^2 f_t(\theta_t, I_t, \theta_t^P)}{\partial \theta_t \partial \theta_t'} \geq 0 \quad \text{(cross-productivity)}$$

Example: people with a greater stock of health are more self-productive in learning

b. Dynamic Complementarity in Investment:

$$\frac{\partial^2 f_t(\theta_t, I_t, \theta_t^P)}{\partial \theta_t \partial I_t'} \geq 0$$

Examples:

i. People more open to experience learn more and have more productive investments.
ii. An unexplored health policy is to invest in cognitive and noncognitive skills (Heckman, 2007).

- Critical and sensitive periods for investment:
  1. If
  $$\frac{\partial f_t(\theta_t, I_t, \theta_t^P)}{\partial I_t} = 0 \qquad \text{for } t \neq t^*$$
  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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- Multiple pathways.
- Early investment moderated by later investment.

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    - Nagin and Nagin/Tremblay model:

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

(initial conditions fully determinative, no investment, no feedback).

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    (initial conditions fully determinative, no investment, no feedback).
  - They postulate that initially-determined trajectories are fully determinative of life cycle evolution ("Types" as in Keane and Wolpin (1997)).
  - McArdle (2001) models evolution of fluid and crystallized intelligence (θ_t is a vector for cognitive abilities only):

$$\theta_{t+1} = f_t(\theta_t, I_t, \theta_t^P) = f_t(\theta_0)$$

    (no role for investment or parental factors, just evolution of an initial endowment).

- Van der Maas et al. (2006)

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- Dynamic cross effects explain Flynn effect as well as "g" from a model with interactions among initially independent capabilities.

4. Parental (or Social) preferences for child outcomes

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    - Parents value specific outcomes, not necessarily child utility.

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   - E.g., even Ireland in the 1960s.

6. Model is linked intergenerationally

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   - Laitner (1992) OLG model.

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- Abstract from health.

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- When the child is t years-old, the parents (who are $T+t$ years-old) face the budget constraint:

$$C_t + I_t + S_t^P = Y_t^P + (1+r)\, S_{t-1}^P, \;\; t = 1, \ldots, T$$

where:

$$Y_t^P = h_t\left(\eta_t^y, \theta_t^P\right), \;\; t = 1, \ldots, T$$

where η_t^y are income shocks not in the information set $\mathcal{I}_s$, for all $s < t$.

Budget Constraint for the Parents

- Adult consumption in period t is C_t, r is deterministic interest rate, S_t^P is asset stock at time t.
- When the child is t years-old, the parents (who are $T+t$ years-old) face the budget constraint:

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- At the end of period T, parents die.
- Cannot leave debts to the children:

$$S_T^P \geq 0.$$

Characterization of the Problem of the Parents

- When the child is t years-old, for $t = 1, \ldots, T-1$ the problem is:

$$\begin{aligned} &V_t\left(\theta_t^C, \theta_t^N, S_t^P, Y_t^P, \theta_t^P\right) \\ &\quad = \max\left\{u\left(C_t\right) + \beta E_{\mathcal{I}_t}\left[V_{t+1}\left(\theta_{t+1}^C, \theta_{t+1}^N, S_{t+1}^P, Y_{t+1}^P, \theta_t^P\right)\right]\right\} \end{aligned}$$

subject to:

$$C_t + I_t + S_t^P = Y_t^P + (1+r)\, S_{t-1}^P$$

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

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

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- The binding constraint is that the child cannot trade on θ_t^P.

Special Case: Analysis of Technology of Skill Formation (Cunha and Heckman, 2007)

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(4)
$$\theta_3^N = \left\{\gamma_1^N \left(\theta_1^C\right)^{\phi^N} + \gamma_2^N \left(\theta_1^N\right)^{\phi^N} + \gamma_3^N \left(I_2^N\right)^{\phi^N} + \gamma_4^N \left(\theta_2^P\right)^{\phi^N}\right\}^{\frac{1}{\phi^N}}$$

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- Distinguish parental environmental variable from investments.

- Assume investments are general in nature:
$I_t^C = I_t^N = I_t$ for $t = 1, 2$:

$$(5) \qquad \theta_3^C = \left\{ \gamma^C \left(I_1\right)^{\phi^C} + \gamma_3^C \left(I_2\right)^{\phi^C} + \gamma_4^C \left(\theta_2^P\right)^{\phi^C} \right\}^{\frac{1}{\phi^C}}$$

$$(6) \qquad \theta_3^N = \left\{ \gamma^N \left(I_1\right)^{\phi^N} + \gamma_3^N \left(I_2\right)^{\phi^N} + \gamma_4^N \left(\theta_2^P\right)^{\phi^N} \right\}^{\frac{1}{\phi^N}}$$

$$\text{where } \gamma^C = \gamma_1^C + \gamma_2^C, \;\; \gamma^N = \gamma_1^N + \gamma_2^N$$

- Adult human capital is produced by combining cognitive and noncognitive skills:

$$(7) \qquad Y = \left\{ \gamma_1^Y \left(\theta_3^C\right)^{\phi^Y} + \left(1 - \gamma_1^Y\right) \left(\theta_3^N\right)^{\phi^Y} \right\}^{\frac{\rho}{\phi^Y}}, 0 < \rho < 1.$$

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- Can make task j specific. (Y_j) with associated elasticity and share parameters.

- If $\phi^Y = \phi^C = \phi^N = \phi$:

$$Y = \left\{ \gamma_e \left(I_1 \right)^{\phi} + \gamma_\ell \left(I_2 \right)^{\phi} + \gamma_P \left(\theta_2^P \right)^{\phi} \right\}^{\frac{\rho}{\phi}} \tag{8}$$

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- Its relaxation turns out to have important empirical consequences.

A Simple Model of Parental Investments

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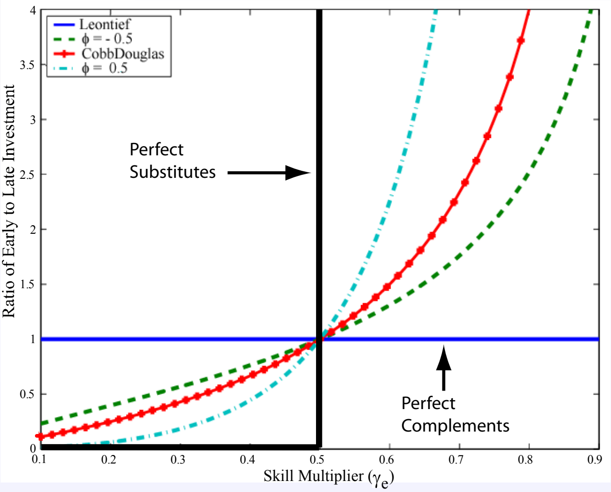
- Ignore all credit market imperfections except the one that has children being unable to buy their parents (stuck with θ_t^P).
- Parents maximize the present value of net wealth of their children.

- When $-\infty < \phi < 1$, ratio of early to late is

$$\log\left(\frac{l_2}{l_1}\right) = \left(\frac{1}{1-\phi}\right)\log\left(\frac{\gamma_\ell}{\gamma_e}\right) + \left(\frac{1}{1-\phi}\right)\log(1+r)$$

Ratio of early to late investment in human capital as a function of the skill multiplier for different values of complementarity.



Assumes $r = 0$, Fix $\gamma_P = 0$

Source: Cunha and Heckman (2007).

- l_1 and l_2 are perfect substitutes.

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- Parents invest early if $\gamma_e \geq (1 + r)(\gamma_\ell)$.
- Important message for epidemiologists and biologists.
- Even though perfect remediation is possible, it may be too costly.

- I_1 and I_2 are perfect complements $\Rightarrow$

$$Y = [\min\{I_1, I_2\}]^{\rho}$$

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- Optimal strategy is $I_1 = I_2$.
- Investments in the young are essential.
- But, at the same time, early investments should be followed up by later investments if the early investment is to have any payoff.

IV. Estimating the Technology of Skill Formation

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- We can identify the technology under many different credit market structures.
- Many of the measures for investment and outcomes that are used in the child development, personality and health literatures are only crude proxies for the true variables that they proxy.
- Important to account for the proxy nature of variables measuring θ_t and to account for measurement error, which is substantial.

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- Cunha, Heckman, and Schennach generalize this to a nonlinear setting.

Estimates of the Technology of Skill Formation

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Cunha and Heckman (2008) estimate linear approximations to the technologies of skill formation.

- Convenient, easy to compute and the econometrics is simple.
- However, imposes perfect substitutability among inputs and leads to corner solutions.
- Consider estimates from nonlinear models after considering the body of evidence from linear models.

- Stage-specific technology,

$$\theta_{t+1} = A_t \theta_t + B_t I_t + \eta_t .$$

Model for the Measurements

- Measurement systems represented by a dynamic factor structure:

$$Y_{j,t}^{k} = \mu_{j,t}^{k} + \alpha_{j,t}^{k}\theta_{t}^{k} + \varepsilon_{j,t}^{k}, \text{ for } j \in \{1, \ldots, m_{t}^{k}\}, \; k \in \{C, N, H, I\},$$

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- These problems are harder, but not intractable, in nonlinear models.
- Anchor scales of θ using observed outcomes (Y).

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Multistage Linear Technology (Cunha and Heckman, 2007)

Empirical Estimates from the Linear Model

- CNLSY data (Children of the National Longitudinal Study of Youth).

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Empirical Estimates from the Linear Model

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- Children of NLSY data; white males, 1253 children.
- Multiple measurements on investments and cognitive and noncognitive skills.

Implications of the Linear Estimates:

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- Investment effects for cognitive skills stronger at earlier ages then at later ages.
- Investment effects for noncognitive skills stronger in middle childhood.

Multistage Technology

Anchor: Log Earnings of the Child Between Ages 23-28

Independent Variable	Noncognitive Skill (θ^N_{t+1})			Cognitive Skill (θ^C_{t+1})		
	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
Lagged Noncognitive	0.9849	0.9383	0.7570	0.0216	0.0076	0.0005
Skill, (θ^N_t)	(0.014)	(0.015)	(0.010)	(0.004)	(0.003)	(0.003)
Lagged Cognitive	0.1442	-0.1259	0.1171	0.9197	0.8845	0.9099
Skill, (θ^C_t)	(0.120)	(0.115)	(0.115)	(0.023)	(0.021)	(0.019)
Parental Investment,	0.0075	0.0149	0.0064	0.0056	0.0018	0.0019
(θ^I_t)	(0.002)	(0.003)	(0.003)	(0.002)	(0.001)	(0.001)
Maternal Education	0.0005	-0.0004	0.0019	-0.0003	0.0007	0.0001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Maternal Cognitive Skill	0.0001	-0.0011	-0.0019	0.0025	0.0002	0.0010
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)

Source: Cunha and Heckman (2008)

- Consider channels of influence of investment.

The Percentage Impact on Log Earnings at Age 23 of an Exogenous increase by Ten Percent in Investments at Different Periods
White Males, CNLSY/79

Total Percentage Impact on Earnings	Percentage Impact on Log Earnings Exclusively through Cognitive Skills	Percentage Impact on Log Earnings Exclusively through Noncognitive Skills
	Period 1	
0.2487	0.1247	0.1240
(0.0302)	(0.0151)	(0.0150)
	Period 2	
0.3065	0.0445	0.2620
(0.0358)	(0.0052)	(0.0306)
	Period 3	
0.2090	0.0540	0.1550
(0.0230)	(0.0059)	(0.0170)

The Percentage Impact on the Probability of Graduating from Secondary School of an Exogenous Increase by Ten Percent in Investments of Different Periods
White Males, CNLSY/79

Total Percentage Impact	Percentage Impact through Cognitive Skills	Percentage Impact Exclusively through Noncognitive Skills
	Period 1	
0.6441 (0.0789)	0.5480 (0.0672)	0.0961 (0.0118)
	Period 2	
0.3980 (0.0466)	0.1951 (0.0229)	0.2029 (0.0238)
	Period 3	
0.3565 (0.0389)	0.2366 (0.0258)	0.1198 (0.0131)

Cunha and Heckman (2008)

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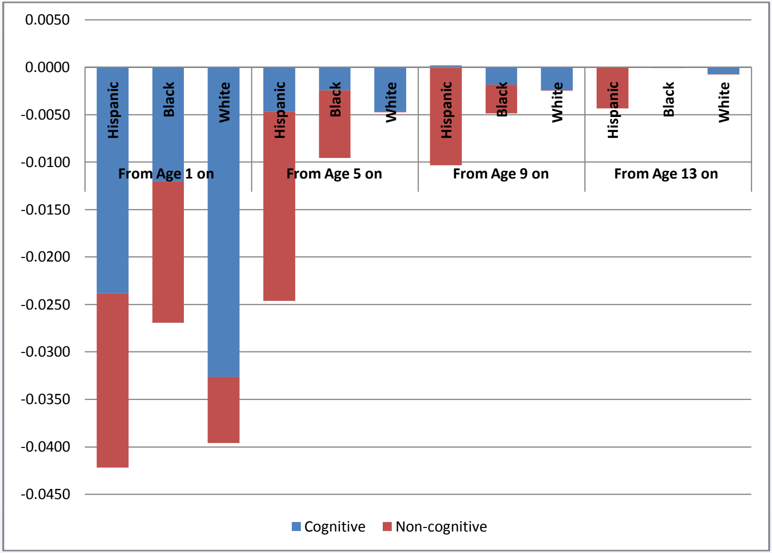
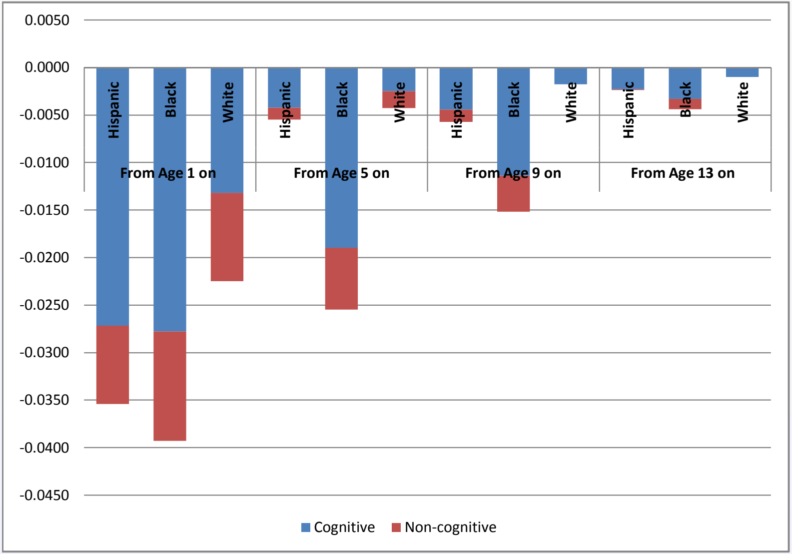
- Moon (2008) explains much of this by trends in family structures and their effects on investment.

Effect of Family Disruption on HS Graduation: Male



Source: Seong Hyeok Moon (2008)

Effect of Family Disruption on HS Graduation: Female



Source: Seong Hyeok Moon (2008)

Variance of HS Graduation Rate Explained by Skills

Male	Hispanic	Black	White	All
Cognitive Skill	0.0961	0.0701	0.1103	0.1027
Non-cognitive Skill	0.0937	0.0415	0.0443	0.0546
Female	**Hispanic**	**Black**	**White**	**All**
Cognitive Skill	0.1342	0.0817	0.0462	0.0736
Non-cognitive Skill	0.0541	0.0607	0.0477	0.0523

Note: R-squared of linear regressions.

Source: Seong Hyeok Moon (2008).

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- Gives corner solutions for optimal policies.
- Estimate nonlinear technologies to learn about key substitution parameters.

- Test $\phi^C = \phi^N = \phi^Y$.

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- The noncognitive technology is:

$$\theta_{t+1}^{N} = A_{\ell}^{N}\left[\gamma_{C,\ell}^{N}\left(\theta_{t}^{C}\right)^{\phi_{\ell}^{N}} + \gamma_{N,\ell}^{N}\left(\theta_{t}^{N}\right)^{\phi_{\ell}^{N}} + \gamma_{I,\ell}^{N} I_{t}^{\phi_{\ell}^{N}} + \gamma_{P,\ell}^{N}\left(\theta_{t}^{P}\right)^{\phi_{\ell}^{N}}\right]^{\frac{1}{\phi_{\ell}^{N}}}$$

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The Technology of Skill Formation: Nonlinear Estimates

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$$\left.\begin{array}{r}\text{Early Stage: } \gamma^{C}_{C,early} \text{ is low and } \gamma^{C}_{I,early} \text{ is high}\\ \text{Late Stage: } \gamma^{C}_{C,late} \text{ is high and } \gamma^{C}_{I,late} \text{ is low}\end{array}\right. \Longrightarrow \text{Invest Early}$$

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- High levels of complementarity imply that high levels of early investment must be followed up with high levels of late investments.

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- Establish semiparametric identification of measurement and technology equations.

Findings

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  4. These patterns produce profiles of optimal investment that depend on the desired target and the weight of θ_T^C and θ_T^N on target outcomes.
  5. Shows heterogeneity is important and indicates the optimality of profiling disadvantage and targeting interventions.

The Nonlinear Technology for Cognitive Skills: Two Stage Model

Parameter	Stage 1 Birth to age 4	Stage 2 Age 5 to 14
Self-Productivity	0.5651	0.8870
	(0.0260)	(0.0116)
Cross-Productivity	0.1151	0.0028
	(0.0247)	(0.0129)
Investment	0.1766	0.0656
	(0.0223)	(0.0034)
Complementarity	0.2306	-1.5442
	(0.0034)	(0.2427)
Elasticity of Substitution	~ 1.3	~ 0.4

Source: Cunha, Heckman, and Schennach (2008)

The Nonlinear Technology for Noncognitive Skills: Two Stage Model

Parameter	Stage 1 Birth to age 4	Stage 2 Age 5 to 14
Self-Productivity	0.61623	0.7259
	(0.0452)	(0.01537)
Cross-Productivity	0.0360	0.0001
	(0.0227)	(0.0108)
Investment	0.1011	0.1183
	(0.0245)	(0.0236)
Complementarity	-1.4913	-0.6241
	(0.0087)	(0.4943)
Elasticity of Substitution	~ 0.4	~ 0.6

Source: Cunha, Heckman, and Schennach (2008)

Implications of the Nonlinear Estimates

A Model of Parental (Social) Investments

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- State variables: Ω_t.

- In initial periods, $t = 1, 2$, the problem of the parent is:

$$V_t\left(\Omega_t\right) = \max\left\{u\left(C_t\right) + \beta E\left[\left. V_{t+1}\left(\Omega_{t+1}\right)\right| \Omega_t\right]\right\}$$

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- Constraints as before, tailored to this case.

The Problem of the Parent: Third Period

In the last period, parents "retire":

$$V_3(\Omega_3) = \max \left\{ u(c_3) + E\left[\left. \underbrace{\begin{array}{c} \omega_e V^e(\text{education}) - \omega_c V^c(\text{crime}) \\ -\omega_d V^d(\text{drug}) - \omega_p V^p(\text{teenage pregnancy}) \end{array}}_{\text{Merit Good Preferences}} \right| \Omega_3 \right] \right\}$$

$$C_3 = (1+r) S_2^P$$

$V^j, \quad j \in \{\text{education, crime, drug, pregnancy}\}$

Terminal valuation of j by parents.

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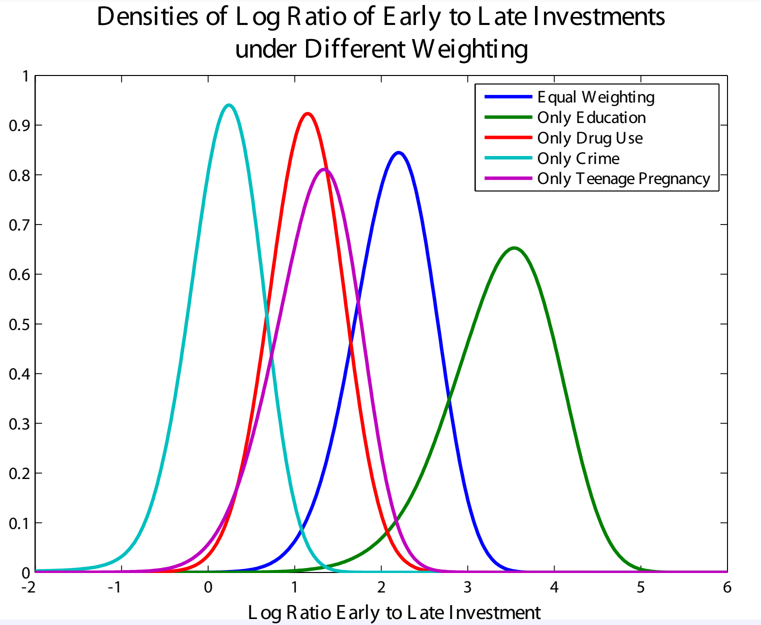
  b. Depends on initial endowments of mother and the child.



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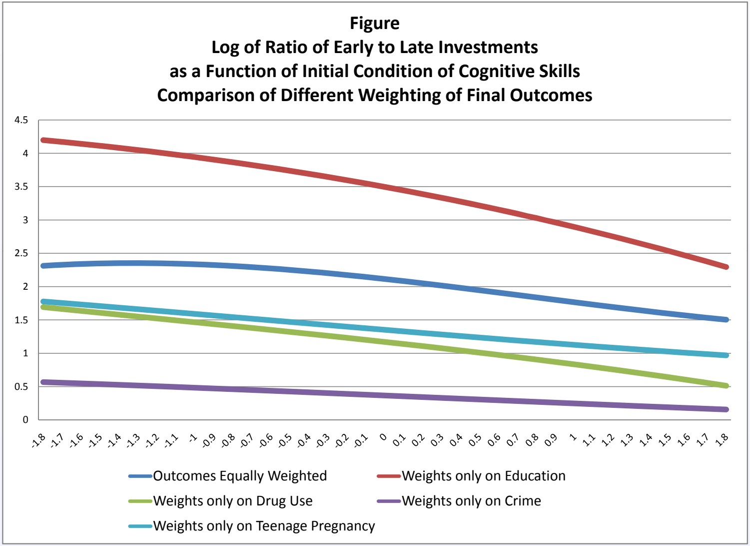

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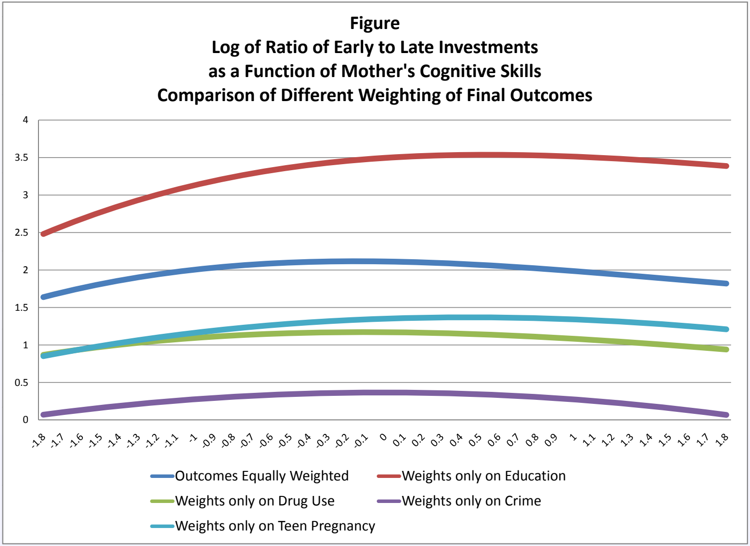

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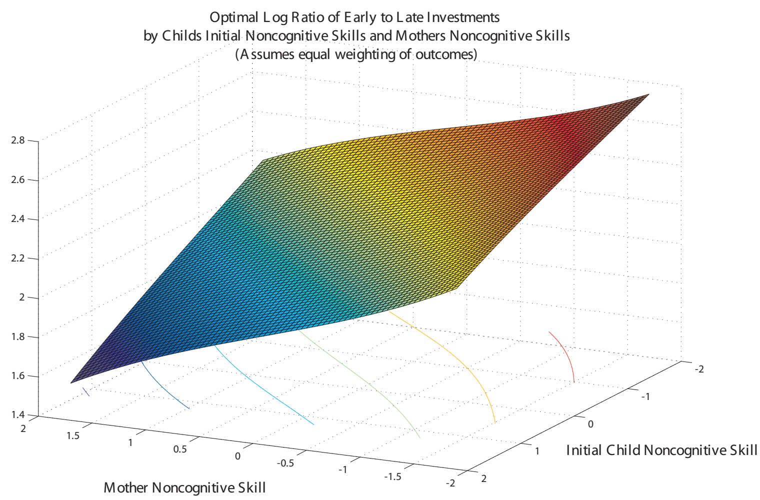
Optimal Log Ratio of Early to Late Investments by Childs Initial Noncognitive Skills and Mother's Noncognitive Skills (Assumes equal weighting of outcomes)



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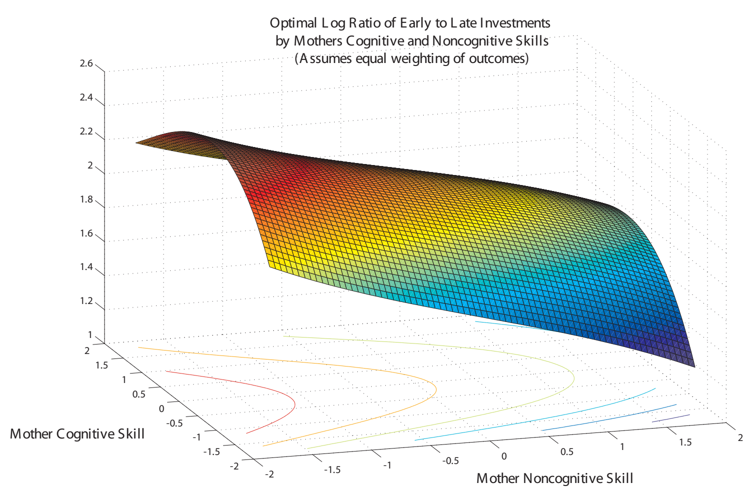
Optimal Log Ratio of Early to Late Investments by Mother's Cognitive and Noncognitive Skills (Assumes equal weighting of outcomes)



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- Evidence of comparative advantage and sorting in economic and social life.

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- Traits are not fixed or invariant and are causally affected by parental investment and experience.
- Early intervention programs for disadvantaged children that have been studied have more substantial effects on noncognitive skills than cognitive skills.

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- The optimal intervention strategy depends on age and endowments at each age.
- Compensation and subsidy may be better responses to disadvantage at later ages.

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- However, as Marshall argued, incentives matter too.
- If we can enhance capabilities, we can reduce poverty.
- We are still exploring the right mix, and, as this work matures, we will have a greater understanding of how to create people who will lead the noble life that Marshall aimed for.