

# The Technology for the Formation of Skills

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# Facts

## The Technology for the Formation of Skills

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### 1 Skills matter.

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# Skills Matter: Heckman, Stixrud, and Urzua (2006)

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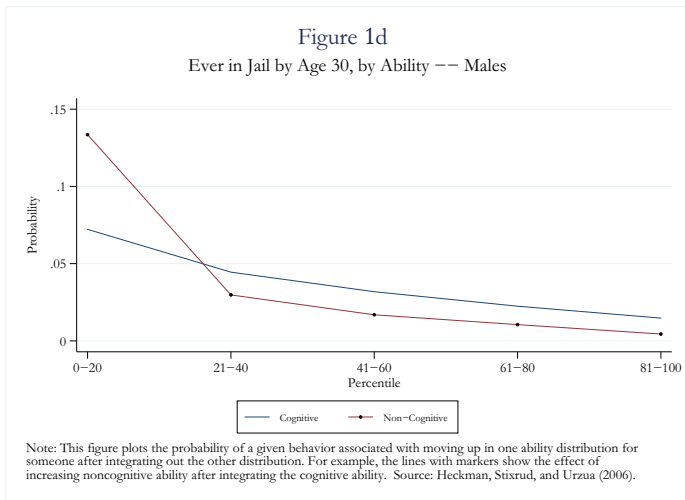
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- 1 Skills matter.
- 2 Gaps in skills open up at early ages.

# The Gaps in Skill Open Up at Early Ages

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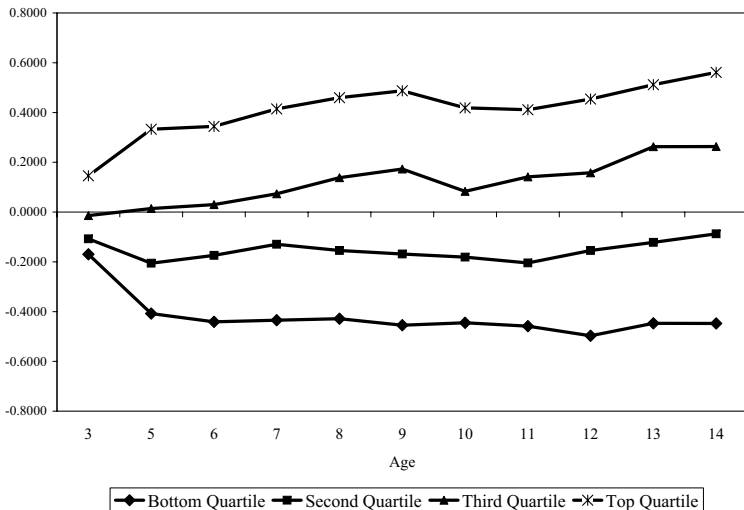
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- 1 Skills matter.
- 2 Gaps in skills open up at early ages.
- 3 Evidence from Perry Preschool, Abecedarian, CPC, IHDP, Romanian children provide support that there exists a causal link.

# Experiments Suggest Causal Link: Barnett (2004)

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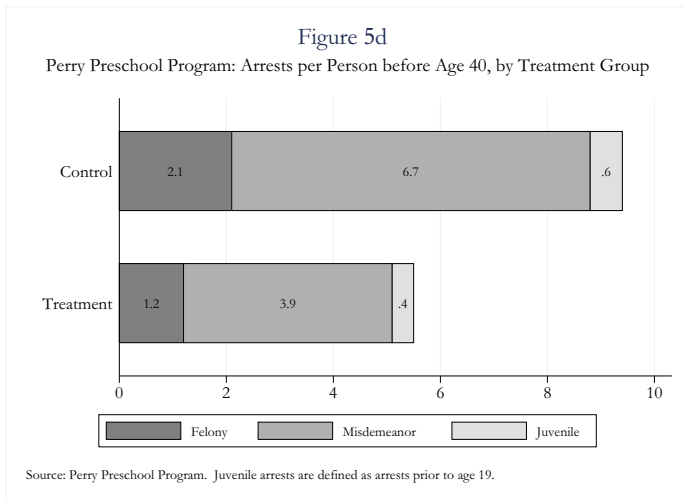
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# Our Work

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- In previous work (Cunha and Heckman, AER, 2007) we proposed simple economic models that organized the evidence on the development of skills in children.
- The evidence comes from many different fields: economics, psychology, education, and neurology (Cunha, Heckman, Lochner, and Masterov, 2006).
- The past theoretical literature on child development in economics treated childhood as a single period.
- It was implicitly assumed that inputs at different stages of childhood are perfect substitutes.

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- To account for a large body of evidence, it is important to build models of skill formation with multiple stages of childhood, where:
  - 1 Self-Productivity: Early investments produce early skills as well as late skills.
  - 2 Complementarity: Early investments complement late investments.
- Cunha and Heckman (JHR, 2008) show evidence that supports (1).
- In Cunha, Heckman, and Schennach (2007), we find evidence supporting (2).

# The Model in a Picture

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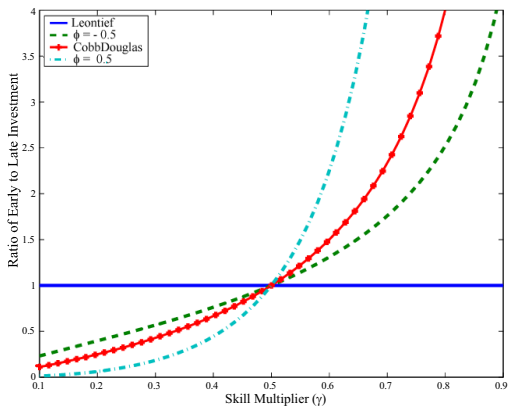
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The Ratio of Early to Late Investment in Human Capital  
As a function of the Skill Multiplier for Different Values of Complementarity



# The Economic Model and The Evidence from Neurology

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- Knudsen (2004) shows that early experience can modify the biochemistry and architecture of neural circuits.
- When this modification occurs during a limited time frame, it is called a sensitive period.
- When this modification occurs during a limited time frame *and* it is crucial for normal development, it is called a critical period.
- Sensitive and critical periods have been documented extensively for:
  - 1 Binocular vision in the cortex of mammals;
  - 2 Filial imprinting in the cortex of ducks and chickens;
  - 3 Language acquisition in humans;

# Our Findings

- We show that early investments is important for the optimal development of both cognitive and noncognitive skills;
- There are different patterns of complementarity in investments and skills:
  - 1 Self-Productivity becomes stronger as children become older.
  - 2 Complementarity between cognitive skills and investment becomes stronger as children become older.
  - 3 Complementarity between noncognitive skills and investments is roughly constant as children become older.
  - 4 Complementarity tends to be weaker for noncognitive skills than cognitive skills.

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# Interpretation of Findings

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- Investments at early stages are very efficient in producing both cognitive and noncognitive skills.
- Noncognitive skills are more elastic to late investments.
- The evidence on complementarity suggests that starting early is important.
- It also says that high early investments must be followed up with high late investments.

# Outline of the Talk

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- Policy Simulations
- Conclude

# Technology of Skill Formation

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- $\theta_t^c$  denotes cognitive skills of the child at age  $t$ .
- $\theta_t^n$  denotes non-cognitive skills of the child at age  $t$ .
- $x_t$  is parental investment in skills when child is  $t$  years-old.
- There are  $S$  different developmental stages:  $s = 1, \dots, S$ .
- The cognitive technology is:

$$\theta_{t+1}^c = A_s^c \left[ \gamma_{1,s}^c (\theta_t^c)^{\phi_s^c} + \gamma_{2,s}^c (\theta_t^n)^{\phi_s^c} + \gamma_{3,s}^c x_t^{\phi_s^c} + \dots \right]^{\frac{1}{\phi_s^c}}$$

- The noncognitive technology is:

$$\theta_{t+1}^n = A_s^n \left[ \gamma_{1,s}^n (\theta_t^c)^{\phi_s^n} + \gamma_{2,s}^n (\theta_t^n)^{\phi_s^n} + \gamma_{3,s}^n x_t^{\phi_s^n} + \dots \right]^{\frac{1}{\phi_s^n}}$$

# Technology of Skill Formation

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- This is a simple specification. Few parameters capture the essence of the story.
- The parameters  $\gamma$  are informative about the degree of self-productivity.
- Example: For a given  $\phi$  suppose we find:

Early Stage:  $\gamma_1$  is low and  $\gamma_3$  is high  $\implies$  Invest Early  
Late Stage:  $\gamma_1$  is high and  $\gamma_3$  is low

# Technology of Skill Formation

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- The parameter  $\phi$  are informative about the degree of complementarity.
- Example: Given  $\gamma$  suppose we find:
  - 1) At Early Stage  $\phi$  is high
  - 2) At Late Stage  $\phi$  is low $\implies$  Late Remediation is Costly
- **It also implies that high levels of early investment must be followed up with high levels of late investments.**

# Characteristics of the Sample

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- 1098 firstborn white males (birth to age 14) from CNLSY/79.
- We are extending the analysis to other demographic groups.

# Measurements of Cognitive Skills

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- At year of birth:
  - 1 Components of the Bailey Score
  - 2 Weight at birth.
- From age one on:
  - 1 Components of the Bailey Score
  - 2 Parts of Body and Memory for Locations
  - 3 PPVT-R, PIAT-Math, PIAT-Reading Recognition.

# Measurements of Noncognitive Skills

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- Up to age four: Components of Child's Temperament Score
  - 1 Predictability: Sleepy at same time .
  - 2 Fearfulness: Upset when parents leave.
  - 3 Compliance: Child obeys going to bed.
  - 4 Insecure Attachment: Stays close when playing.
- From age four on: Behavior-Problem Index
  - 1 Antisocial: Trouble getting along with teachers.
  - 2 Anxious/Depressed: Depressed.
  - 3 Headstrong: Strong temper, loses it easily.
  - 4 Hyperactive: Difficulty concentrating.
  - 5 Peer Problems: Withdrawn, not involved with others.

# Measurements of Parental Investments

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- The components of the Home Observation Measurement of Environment (HOME-SF):
  - 1 Number of books child has;
  - 2 How often mother reads to the child;
  - 3 How often child is taken to museums;
  - 4 How often child receives special lessons;
  - 5 How often child eats with mom/dad.

# Defining a Meaningful Metric

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- Tests scores have no natural metric.
- Use adult outcomes that are affected by cognitive and noncognitive skills:
  - 1 High School Graduation;
  - 2 Participation in Crime;
  - 3 Drug Consumption;
  - 4 Grade Repetition;
  - 5 Need for Special Education.
- We report the policy simulations in terms of these outcomes and not in terms of skills.

# The Technology for Cognitive Skills

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Parameter	Stage 1 Birth to age 4	Stage 2 Age 5 to 9	Stage 3 Age 10 to 14
Self-Productivity	0.5904	0.8537	0.9705
	0.1217	0.1733	0.0488
Cross-Productivity	0.0193	0.0292	0.0048
	0.0003	0.0062	0.0136
Investment	0.2664	0.0335	0.0058
	0.0598	0.0056	0.0312
Complementarity	-0.7178	-0.9286	-1.7638
	0.1870	0.1961	0.7029

# The Technology for Noncognitive Skills

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Parameter	Stage 1 Birth to age 4	Stage 2 Age 5 to 9	Stage 3 Age 10 to 14
Self-Productivity	0.5942	0.8711	0.8917
	0.1194	0.1759	0.1322
Cross-Productivity	0.0510	0.0114	0.0119
	0.0084	0.0023	0.0216
Investment	0.2018	0.0777	0.0572
	0.0436	0.0179	0.0216
Complementarity	-0.9381	-0.4051	-0.6290
	0.2383	0.0625	0.0814

# Effects of Early Intervention as costly as Perry

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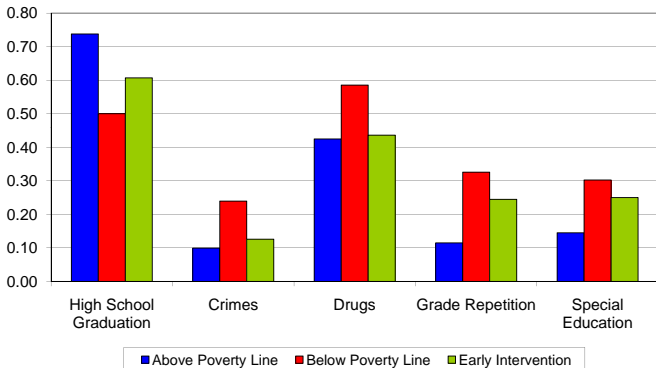
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Figure  
Effects of Early Intervention Targeted at Children Born in Families Below  
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# How do Early and Late Interventions Compare?

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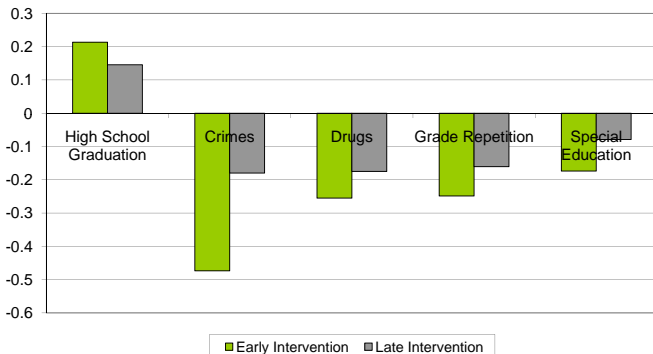
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Percentage Change as Response to Early or Late Interventions  
Targeted to Children Born in Families Below Poverty Line



# What do we learn from this research?

- The economic returns to early investment are high.
- They promote efficiency and reduce inequality.
- The reason is the technology of skill formation:
  - 1 Skill begets skill.
  - 2 Early skill increases the efficiency of later investments.
- There is a strong case for public support for funding interventions in early childhood for disadvantaged children.
- The technology of skill formation also says that early childhood investment is a necessary, but not sufficient condition.
- Early investments must be followed up with late investments.

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