Eliciting Maternal Beliefs about the Technology of Skill Formation

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Gaps in skills in early childhood

Hart and Risley (1995)

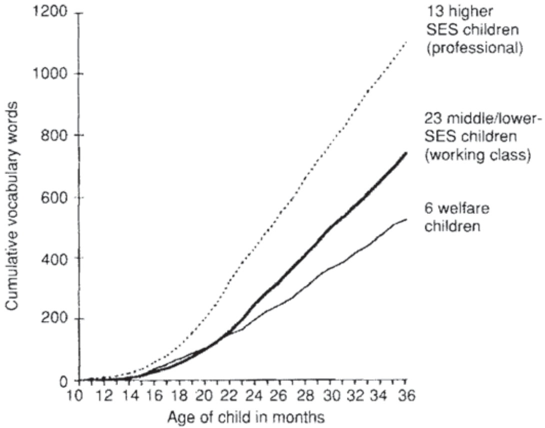
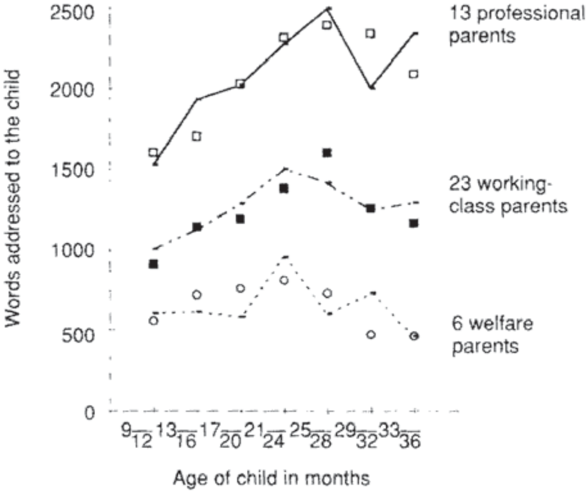


Figure 2. The widening gap we saw in the vocabulary growth of children from professional, working-class, and welfare families across their first 3 years of life. (See Appendix B for a detailed explanation of this figure.)

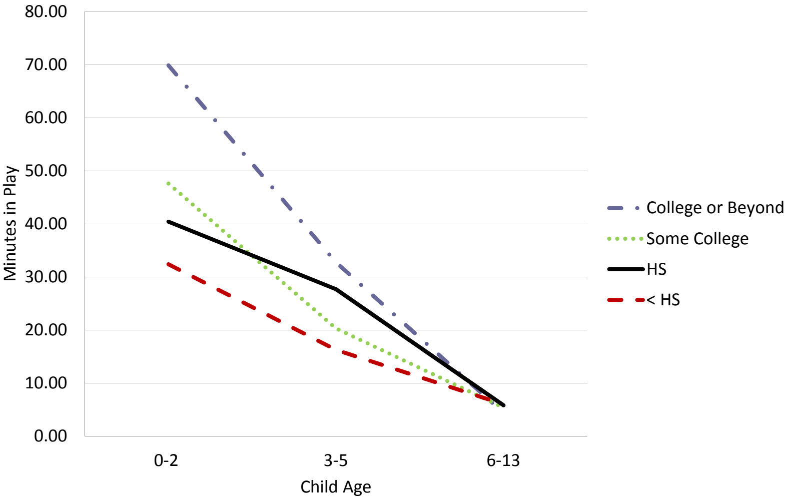
Gaps in investments in early childhood

Hart and Risley (1995)



Gaps in investments in early childhood

Kalil, Ryan, and Corey (2012)



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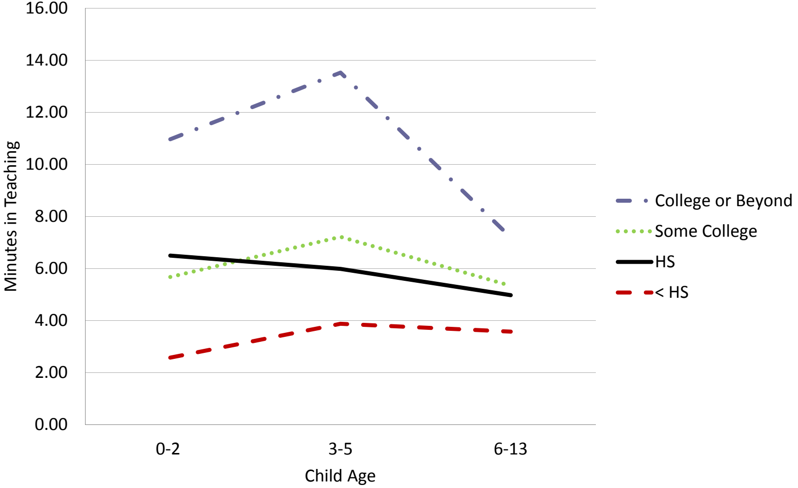

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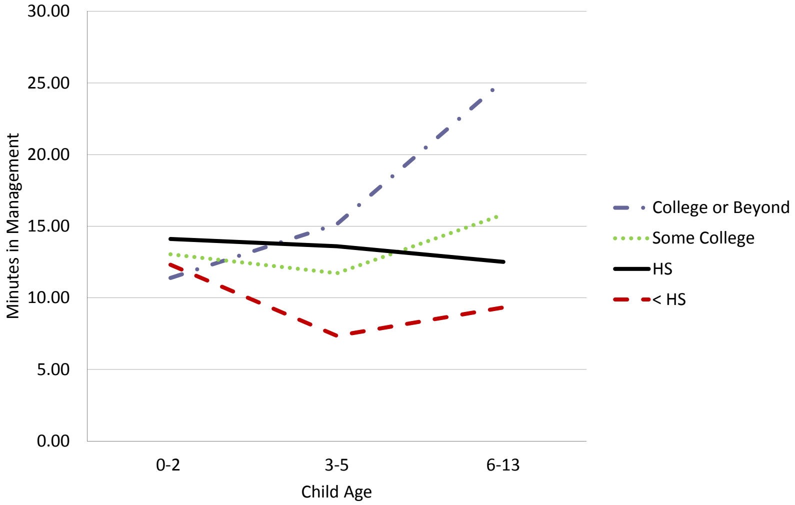


Why heterogeneity in beliefs?

- Language acquisition: Hart and Risley (1995); Rowe (2008).
- Time spent in activities that are appropriate for the child's age (Kalil et al, 2012).
- Home visitation programs on parenting:
  - Nurse-Family Partnership (Olds et al, 2012).
  - Jamaican Nutrition Supplementation and Cognitive Stimulation Program (Gertler et al, 2014; Attanasio et al, 2014).
  - HIPPY Program (Baker et al, 2002).
  - Parent as Teachers (PAT, Wagner et al, 1998)
  - Thirty Million Words Program (Suskind and Lefler, 2013).
  - Many others (Healthy Families, Healthy Start, CHIP of Virginia, MOM of Philadelphia, etc.)

Roadmap

- Simple model of human capital formation.
- Identification
  - Elicitation of Maternal Beliefs
  - Elicitation of Preferences
- Empirical results:
  - Data
  - Beliefs
  - Preferences
  - How important are beliefs?

Model: The technology of skill formation

- The technology of skill formation is:

$$\ln h_{i,1} = \psi_0 + \psi_1 \ln h_{0,i} + \psi_2 \ln x_i + \psi_3 \ln h_{0,i} \ln X_i + \nu_i$$

Model: The mother's information set

- Let Ψ_i denote the mother's information set.
- Let $E\left(\psi_j \middle| h_{0,i}, x_i, \Psi_i\right) = \mu_{i,j}$ and assume that $E\left(\nu_i \middle| \Psi_i\right) = 0$.
- From the point of view of the mother:

$$E\left(\ln h_{i,1} \middle| h_{0,i}, x_i, \Psi_i\right) = \mu_{i,0} + \mu_{i,1} \ln h_{0,i} + \mu_{i,2} \ln x_i + \mu_{i,3} \ln h_{0,i} \ln x_i$$

Model: Preferences and budget constraint

- Consider a simple static model. Parent's utility is:

$$u\left(c_i, h_{i,1}; \alpha_{i,1}, \alpha_{i,2}\right) = \ln c_i + \alpha_{i,1} \ln h_{i,1} + \alpha_{i,2} \ln x_i$$

- Budget constraint is:

$$c_i + px_i = y_i.$$

Model

- The problem of the mother is to maximize expected utility subject to the mother's information set, the budget constraint, and the technology of skill formation.
- The solution is

$$x_i = \left[\frac{\alpha_{i,1} \left(\mu_{i,2} + \mu_{i,3} \ln h_{0,i} \right) + \alpha_{i,2}}{1 + \alpha_{i,1} \left(\mu_{i,2} + \mu_{i,3} \ln h_{0,i} \right) + \alpha_{i,2}} \right] \frac{y_i}{p}$$

- Clearly, we cannot separately identify α_i from $\mu_{i,\gamma}$ if we only observe x_i, y_i, and p.

Identification

- Elicit maternal beliefs.
- Elicit maternal preferences.
- Estimate the technology of skill formation (work in progress).

Eliciting beliefs: Steps

- Measure actual child development: MSD and Item Response Theory (IRT).
- Develop the survey instrument to elicit beliefs $E\left[\ln h_{i,1} \middle| h_0, x, \psi_i\right]$:
  - Reword MSD items.
  - Create hypothetical scenarios of h_0 and x.
- Estimate beliefs from answers allowing for error in responses.

SECTION 3: MOTOR AND SOCIAL DEVELOPMENT

PART H: (22 MONTHS - 3 YEARS, 11 MONTHS)

MOTHER/GUARDIAN:

If ______________________ is **at least 22 months** old, but **not yet 4 years** old, please answer these 15 questions.
Child's Name

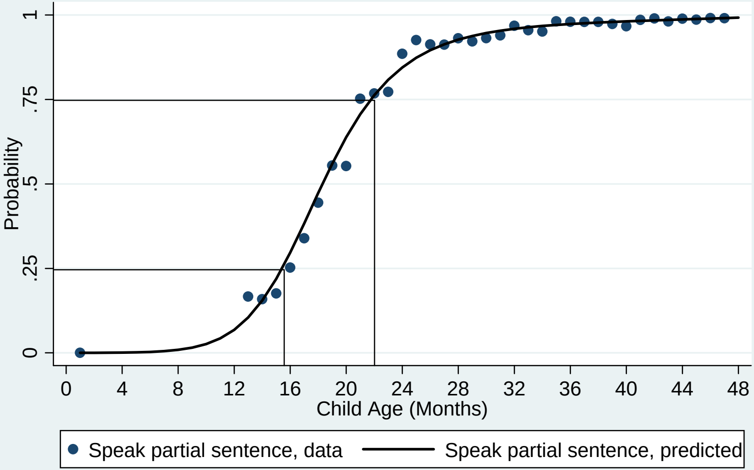
1.	Has your child ever let someone know, without crying, that wearing wet (soiled) pants or diapers bothered him/her?	YES.... 1 NO..... 0	72/
2.	Has your child ever spoken a partial sentence of 3 words or more?	YES.... 1 NO..... 0	73/
3.	Has your child ever walked upstairs by himself/herself without holding on to a rail?	YES.... 1 NO..... 0	74/
4.	Has your child ever washed and dried his/her hands without any help except for turning the water on and off?	YES.... 1 NO..... 0	75/
5.	Has your child ever counted 3 objects correctly?	YES.... 1 NO..... 0	76/

Eliciting beliefs: Item response theory

- Let $d^*_{i,j} = b_{0,j} + b_{1,j} \left(\ln a_i + \frac{b_{2,j}}{b_{1,j}} \theta_i \right) + \eta_{i,j}$
- We observe $d_{i,j} = 1$ if $d^*_{i,j} \geq 0$ and $d_{i,j} = 0$, otherwise.
- Measure of (log of) human capital: $\ln a_i + \frac{b_{2,j}}{b_{1,j}} \theta_i$.
- In this sense, θ_i is deviation from typical development for age.

Figure 4

Probability as a Function of Child's Age



Eliciting beliefs: Changing wording of the MSD Instrument

- In order to measure $E\left[\ln h_{i,1} \middle| h_0, x, \psi_i\right]$, we take the tasks from the MSD Scale, but instead of asking: *"Has your child ever spoken a partial sentence with three words or more?"*, we ask:
- **Method 1**: **How likely is it that a baby will speak a partial sentence with three words or more by age 24 months?**
- **Method 2: What is the youngest and oldest age a baby learns to speak a partial sentence with three words or more?**

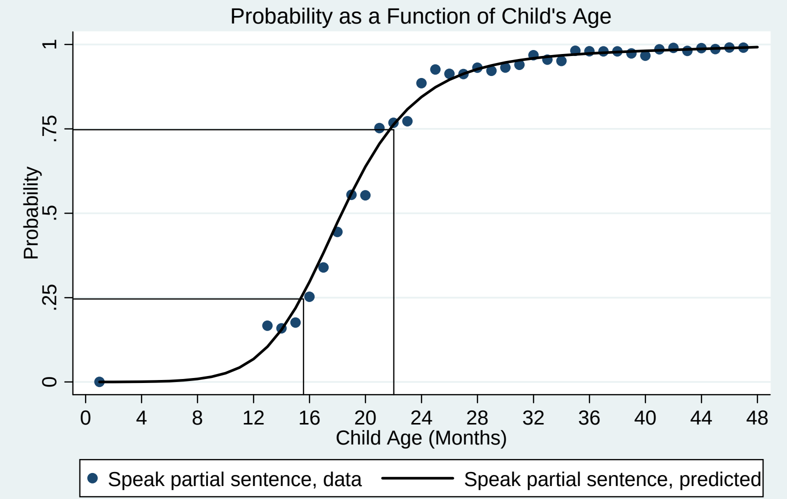
Eliciting beliefs: Scenarios of human capital and investments

- We consider four scenarios:
  - Scenario 1: Child is healthy at birth (e.g., normal gestation, birth weight, and birth length) and investment is high (e.g., six hours per day).
  - Scenario 2: Child is healthy at birth and investment is low (e.g., two hours per day).
  - Scenario 3: Child is not healthy at birth (e.g., premature, low birth weight, and small at birth) and investment is high.
  - Scenario 4: Child is not healthy at birth and investment is low.
- Scenarios are described to survey respondents through a video.

Method 1: Transforming probabilities into mean beliefs

- **Method 1: How likely is it that a baby will speak a partial sentence with three words or more by age 24 months?**
- Let's say that when investment is high – that is, when $x = \overline{x}$ – the mother states that there is a 75% chance that the child will learn how to speak a partial sentence with three words or more.
- And when investment is low– that is, when $x = \underline{x}$ – the mother states that there is a 25% chance that the child will learn how to speak a partial sentence with three words or more.
- We convert this probability statement into an age-equivalent statement using the NHANES data.

Figure 4



Probability as a Function of Child's Age
Probability
0
.25
.5
.75
1
0
4
8
12
16
20
24
28
32
36
40
44
48
Child Age (Months)
Speak partial sentence, data
Speak partial sentence, predicted

Method 2: Transforming age ranges into probabilies

- **Method 2: What is the youngest and oldest age a baby learns to speak a partial sentence with three words or more?**
- Let's say that when investment is high, so that $x = \overline{x}$, the mother states that the youngest and oldest ages a baby will learn how to speak a sentence with three words or more are, respectively, 18 and 28 months.
- And when investment is low, so that $x = \underline{x}$, the mother states that the ages are 20 and 30 months.
- We need to transform the age ranges into probabilities. We use the age ranges to estimate a mother-specific IRT model.

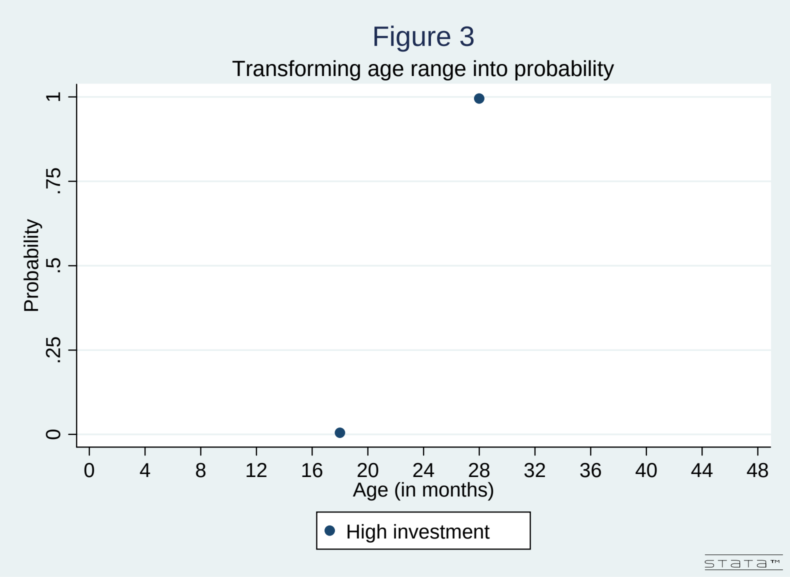
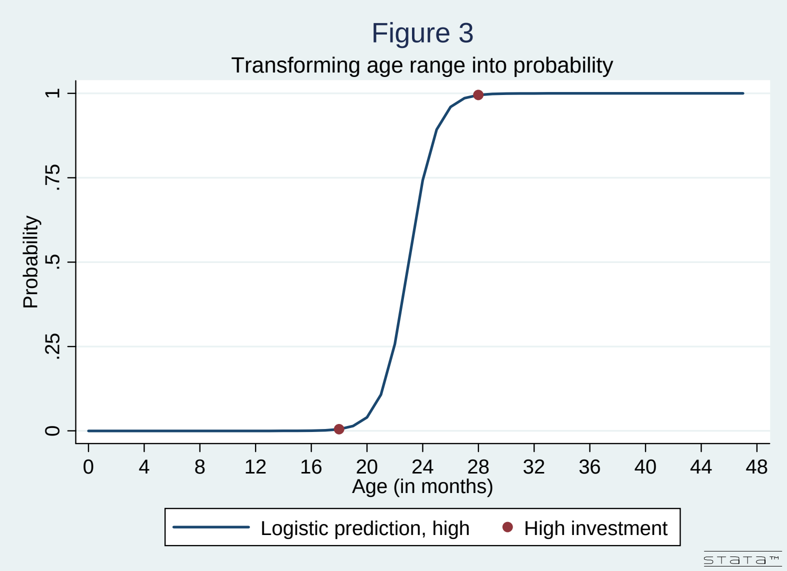


Figure 3
Transforming age range into probability
Probability
0
.25
.5
.75
1
0
4
8
12
16
20
24
28
32
36
40
44
48
Age (in months)
High investment
stata™



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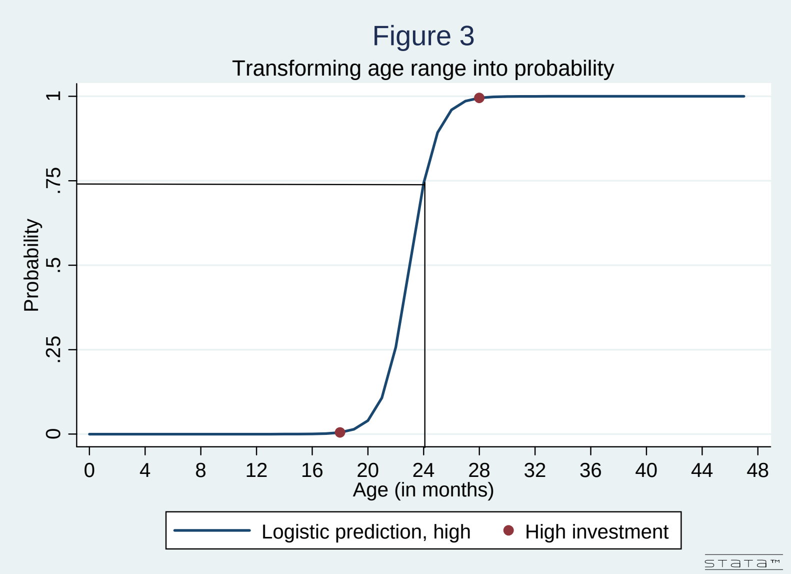
Transforming age range into probability
Probability
0
.25
.5
.75
1
0
4
8
12
16
20
24
28
32
36
40
44
48
Age (in months)
Logistic prediction, high
High investment
STATA™



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Transforming age range into probability
Probability
0
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.5
.75
1
0
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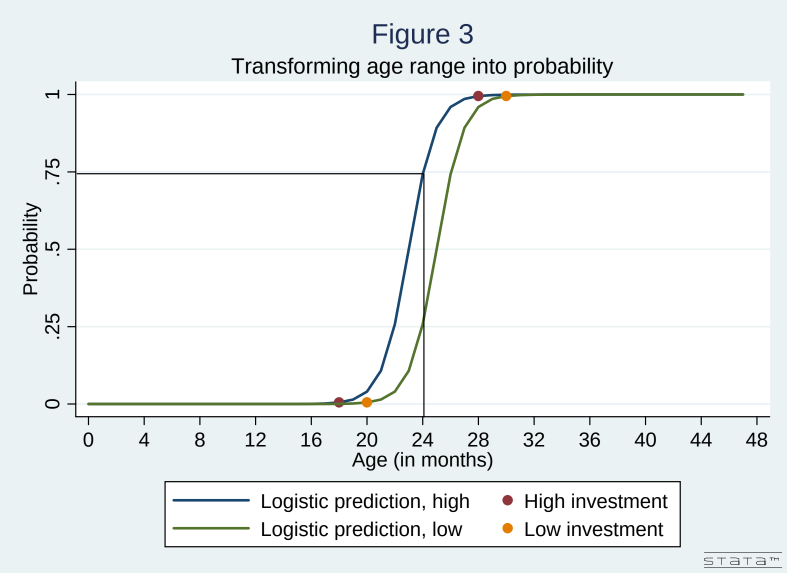
Age (in months)
Logistic prediction, high
High investment



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Probability
0
.25
.5
.75
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4
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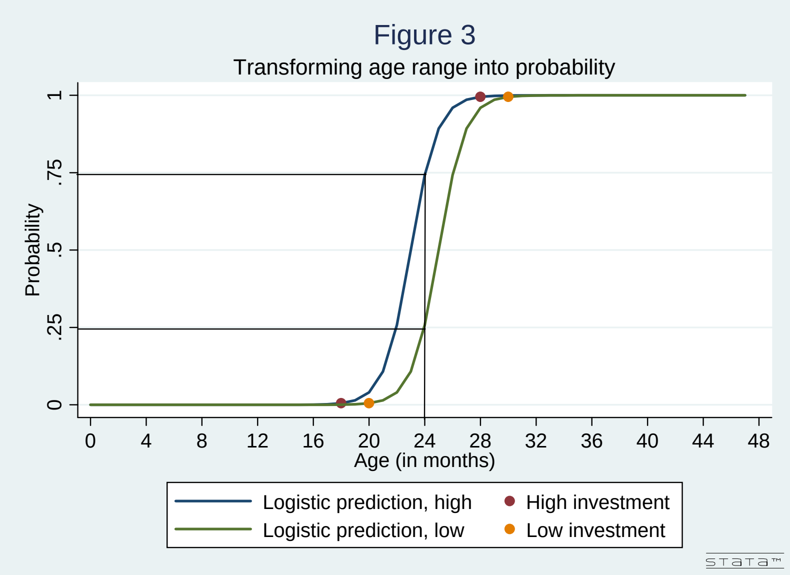
16
20
24
28
32
36
40
44
48
Age (in months)
Logistic prediction, high
Logistic prediction, low
High investment
Low investment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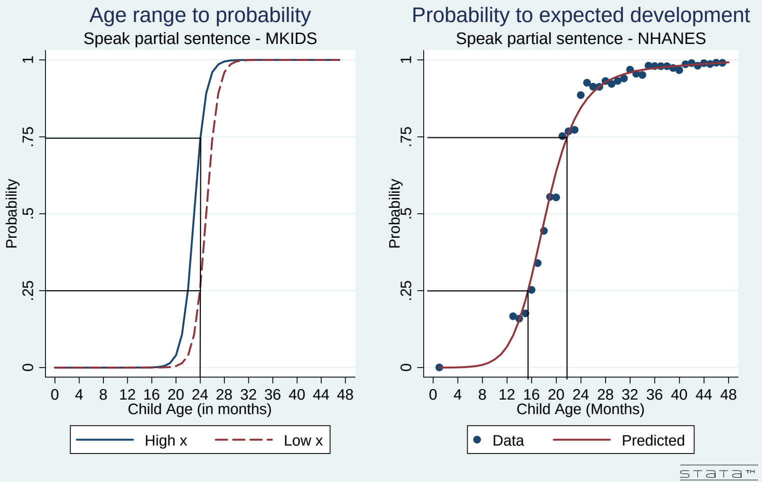
32
36
40
44
48
Age (in months)
Logistic prediction, high
Logistic prediction, low
High investment
Low investment
stata™

Method 2: Transforming probabilities into mean beliefs

- **Method 2: Given scenario for h_0 and x, how likely is it that a baby will speak a partial sentence with three words or more by age 24 months?**
- Given maternal supplied age range and the logistic assumption, we conclude that when $x = \overline{x}$, the mother believes that there is a 75% chance that the child will learn how to speak a partial sentence with three words or more.
- Analogously, when $x = \underline{x}$, the mother believes that there is a 25% chance that the child will learn how to speak a partial sentence with three words or more.
- We convert this probability statement into an age-equivalent statement using the NHANES data.

Figure 3

Expected development for two levels of investments (x)



Recovering mean beliefs: Measurement error model

- Let $\ln q^L_{i,j,k}$ denote an error-ridden measure of $E\left[\ln h_{i,1} \middle| h_{0,k}, x_k, \psi_i\right]$ generated by "how likely" questions:

$$\ln q^L_{i,j,k} = E\left[\ln h_{i,1} \middle| h_{0,k}, x_k, \psi_i\right] + \epsilon^L_{i,j,k}.$$

- Let $\ln q^A_{i,j,k}$ denote an error-ridden measure of $E\left[\ln h_{i,1} \middle| h_{0,k}, x_k, \psi_i\right]$ generated by "age range" questions:

$$\ln q^A_{i,j,k} = E\left[\ln h_{i,1} \middle| h_{0,k}, x_k, \psi_i\right] + \epsilon^A_{i,j,k}.$$

- For each scenario, we have multiple measures of the same underlying latent variable.

Recovering mean beliefs:

- Use technology of skill formation, and the mother's information set, to obtain:

$$\ln q^{L}_{i,j,k} = \mu_{i,0} + \mu_{i,1} \ln h_{0,k} + \mu_{i,2} \ln x_k + \mu_{i,3} \ln h_{0,k} \ln x_k + \epsilon^{L}_{i,j,k}$$

.

$$\ln q^{A}_{i,j,k} = \mu_{i,0} + \mu_{i,1} \ln h_{0,k} + \mu_{i,2} \ln x_k + \mu_{i,3} \ln h_{0,k} \ln x_k + \epsilon^{A}_{i,j,k}.$$

- We have a factor model where:
  - $\mu_i = (\mu_{i,0}, \mu_{i,1}, \mu_{i,2}, \mu_{i,3})$ are the latent factors;
  - $\lambda_k = (1, h_{0,k}, \ln x_k, \ln h_{0,k} \ln x_k)$ are the factor loadings;
  - $\epsilon_{i,j,k} = \left(\epsilon^{L}_{i,j,k}, \epsilon^{A}_{i,j,k}\right)$ are the uniquenesses.

Eliciting beliefs: Intuitive explanation

- Let $E\left[\ln h_{i,1} \middle| h_0, h, \Psi_i\right]$ denote maternal expectation of child development at age 24 months conditional on the child's intial level of human capital, investments, and the mother's information set.
- Assume, for now, technology is Cobb-Douglas.
- Suppose we measure $E\left[\ln h_{i,1} \middle| h_0, x, \Psi_i\right]$ at two different levels of investments:

$$E\left[\ln h_{i,1} \middle| h_0, \overline{x}, \Psi_i\right] = \mu_{i,0} + \mu_{i,1} \ln h_0 + \mu_{i,2} \ln \overline{x}$$

$$E\left[\ln h_{i,1} \middle| h_0, \underline{x}, \Psi_i\right] = \mu_{i,0} + \mu_{i,1} \ln h_0 + \mu_{i,2} \ln \underline{x}$$

- Subtracting and re-organizing terms:

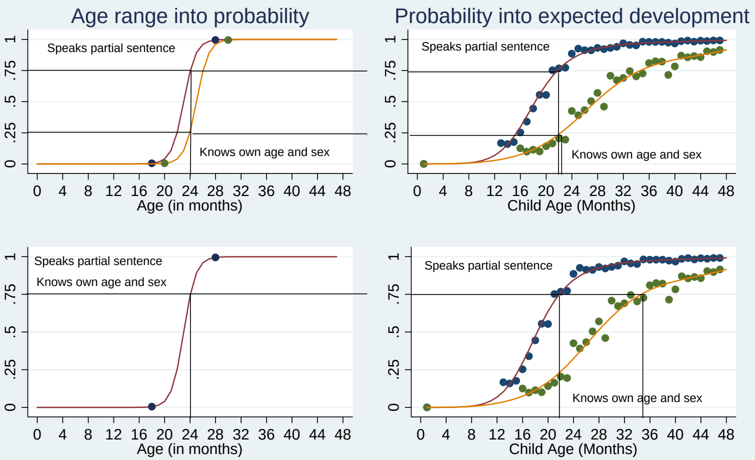
$$\mu_{i,2} = \frac{E\left[\ln h_{i,1} \middle| h_0, \overline{x}, \Psi_i\right] - E\left[\ln h_{i,1} \middle| h_0, \underline{x}, \Psi_i\right]}{\ln \overline{x} - \ln \underline{x}}$$

Important issue

- We could use only one MSD item to elicit beliefs.
- But, if we use more items, we can relax assumptions about measurement error.
- And, we can check for consistency in answers.

Figure 5

Comparing answers across scenarios



Estimation of Preferences

- The investment policy function is:

$$x_i = \left[\frac{\alpha_{i,1} \left(\mu_{i,2} + \mu_{i,3} \ln h_{0,i} \right) + \alpha_{i,2}}{1 + \alpha_{i,1} \left(\mu_{i,2} + \mu_{i,3} \ln h_{0,i} \right) + \alpha_{i,2}} \right] \frac{y_i}{p}$$

  where $\alpha_{i,1}$ and $\alpha_{i,2}$ captures heterogeneity in preferences.
- The usual procedure is to work with observed investment data.
- We are in the field collecting these investment data.

Estimation of Preferences

- Today, we elicit the preference parameters by stated-choice data (as it is commonly applied in Marketing).
- We tell the respondent to assume that the child's initial level of human capital is high.
- Then, we create nine hypothetical scenarios of monthly income and prices:

		Price		
		$30	$45	$60
Income	$1500	Scenario 1	Scenario 2	Scenario 3
	$2000	Scenario 4	Scenario 5	Scenario 6
	$2500	Scenario 7	Scenario 8	Scenario 9

Estimation of Preferences

- In order to link investment to time, we prepared a three-minute video in which we explain to the respondent that the more time that the mother interacts with the child, the more money she has to spend every month buying educational goods such as child books and educational toys.
- Our goal is to pass on to the respondent the idea that investment is costly.
- Respondents are not familiar with the concept of "opportunity cost."

Estimation of Preferences

- For each combination of prices and income, we ask the respondents the following question: *Suppose that your household income is \$$y$ per month and that for each hour per day that the mother spends interacting with the child she has to spend \$$p$ per month on educational goods. Consider the following four options:*
- The four options correspond to two, three, four, and five hours of investments per day.
- Thus, if the respondent reports $x_{i,m,n}$ hours of investment per day when price is p_m and income is y_n, then share of income allocated to investments, $s_{m,n}$ is:

$$s_{i,m,n} = \frac{p_m x_{i,m,n}}{y_n}$$

Estimation of Preferences

- Note that the ratio, $r_{i,m,n}$ is:

$$r_{i,m,n} = \frac{s_{i,m,n}}{1 - s_{i,m,n}} = \alpha_{i,1} \left(\mu_{i,2} + \mu_{i,3} \ln h_{0,i} \right) + \alpha_{i,2} + \xi_{i,m,n}$$

.

- The parameters $\alpha_{i,1}$ and $\alpha_{i,2}$ can be estimated as a simple random-effects model.

Descriptive Information about Participants: MKIDS and PHD

- 777 participants, all African-American.
- MKIDS: 60% are primiparous; PHD: 100% are primiparous.
- 80% are single (not cohabiting or married).
- 80% are at most 25 years-old.
- Median household income is below the second decile of U.S. distribution.
- Low education sample: only 12% of respondents have a two-year college degree or more.

Table 1

Comparison of Datasets

	MKIDS		PHD		Total	
Number of observations	323		454		777	
	N	%	N	%	N	%
Type of Elicitation Method						
Only probability	20	6.2	0	0.0	20	2.6
Only age ranges	233	72.1	0	0.0	233	30.0
Both methods	70	21.7	454	100.0	524	67.4
MSD Items						
Wearing wet pants bothers child	323	100.0	0	0.0	323	41.6
Speak partial sentence	323	100.0	454	100.0	777	100.0
Say first and last name	323	100.0	454	100.0	777	100.0
Count 3 objects correctly	323	100.0	454	100.0	777	100.0
Know own age and sex	323	100.0	454	100.0	777	100.0
Says the names of 4 colors	323	100.0	0	0.0	323	41.6
Count out loud up to 10	323	100.0	0	0.0	323	41.6
Draw picture of man/woman	323	100.0	0	0.0	323	41.6
Hypothetical scenarios						
Baseline	158	48.9	454	100.0	612	78.8
Alternative scenario #1	42	13.0	0	0.0	42	5.4
Alternative scenario #2	91	28.2	0	0.0	91	11.7
Alternative scenario #3	32	9.9	0	0.0	32	4.1
Stated choice data						
Hypothetical scenarios for prices of investment and income	158	48.9	0	0.0	158	20.3

Table 2

Basic Features of Raw Data

MSD Items ranked in ascending order of difficulty		NHANES	Probability					Age ranges				
				Scenarios					Scenarios			
Rank	Item Description		Obs.	1	2	3	4	Obs.	1	2	3	4
1	Chils lets someone know that wearing wet pants bothers him/her?	0.99	90	0.78 (0.24)	0.55 (0.27)	0.70 (0.27)	0.51 (0.26)	303	0.64 (0.33)	0.55 (0.36)	0.50 (0.36)	0.43 (0.37)
2	Child speaks a partial sentence of 3 words or more	0.72	544	0.81 (0.18)	0.63 (0.22)	0.61 (0.20)	0.45 (0.20)	757	0.60 (0.36)	0.44 (0.38)	0.42 (0.38)	0.31 (0.36)
3	Child counts 3 objects correctly?	0.39	544	0.84 (0.18)	0.67 (0.22)	0.62 (0.20)	0.47 (0.20)	757	0.41 (0.38)	0.32 (0.36)	0.26 (0.33)	0.19 (0.30)
4	Child knows own age and sex	0.31	544	0.83 (0.19)	0.66 (0.23)	0.62 (0.21)	0.47 (0.21)	757	0.33 (0.36)	0.26 (0.33)	0.23 (0.31)	0.17 (0.29)
5	Child says first and last name together without someone's help	0.26	544	0.80 (0.20)	0.64 (0.22)	0.60 (0.21)	0.46 (0.21)	757	0.31 (0.36)	0.24 (0.33)	0.22 (0.31)	0.17 (0.29)
6	Child says the names of at least 4 colors	0.20	90	0.81 (0.23)	0.59 (0.28)	0.74 (0.22)	0.56 (0.27)	303	0.26 (0.31)	0.22 (0.29)	0.19 (0.28)	0.16 (0.26)
7	Child counts out loud up to 10?	0.07	90	0.80 (0.20)	0.58 (0.27)	0.75 (0.19)	0.53 (0.27)	303	0.24 (0.30)	0.20 (0.28)	0.19 (0.28)	0.16 (0.27)
8	Child draws a picture of a man/woman, 2 parts besides head	0.02	90	0.71 (0.25)	0.51 (0.28)	0.67 (0.21)	0.48 (0.26)	303	0.15 (0.26)	0.15 (0.26)	0.14 (0.26)	0.13 (0.25)

Note: Standard errors in parenthesis.

Beliefs about the technology of skill formation

Table 3

Maternal Beliefs about the Technology of Skill Formation

	25th percentile	Median	75th percentile	Mean	Variance
$\mu_{\psi,0}$	-0.015	0.101	0.236	0.115	0.035
	(0.009)	(0.008)	(0.009)	(0.007)	(0.002)
$\mu_{\psi,1}$	0.077	0.296	0.554	0.365	0.204
	(0.011)	(0.016)	(0.022)	(0.016)	(0.026)
$\mu_{\psi,2}$	0.065	0.166	0.285	0.192	0.046
	(0.006)	(0.007)	(0.010)	(0.008)	(0.005)
$\mu_{\psi,3}$	-0.008	0.094	0.335	0.190	0.320
	(0.007)	(0.010)	(0.024)	(0.020)	(0.051)

Note: Standard errors in parenthesis.

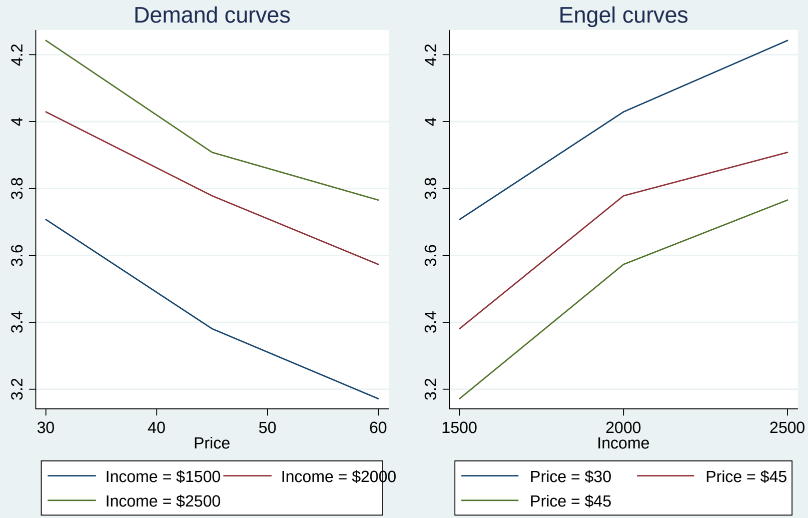
Sensitivity analysis

Table 4
Alternative Definition of Scenarios and Maternal Beliefs

Regressors	Dependent variables				F Test
	$\mu_{\psi,0}$	$\mu_{\psi,1}$	$\mu_{\psi,2}$	$\mu_{\psi,3}$	(p-value)
Intercept (baseline)	0.018	0.147	0.112	0.070	-
	(0.017)	(0.043)	(0.022)	(0.062)	-
Dummy for alternative scenario #1	0.067	-0.027	-0.032	-0.081	1.080
	(0.037)	(0.094)	(0.048)	(0.136)	(0.364)
Dummy for alternative scenario #2	0.280	0.469	0.175	0.424	33.910
	(0.028)	(0.071)	(0.037)	(0.103)	(0.000)
Dummy for alternative scenario #3	0.206	0.027	0.051	0.091	6.750
	(0.041)	(0.104)	(0.054)	(0.152)	(0.000)

Note: Standard errors in parenthesis, except in the F-test column where we report p-values.

Figure 9


Demand curves
Engel curves
4.2
4
3.8
3.6
3.4
3.2
30
40
50
60
Price
1500
2000
2500
Income
Income = $1500
Income = $2000
Income = $2500
Price = $30
Price = $45
Price = $45

Preferences

Table 5

Maternal Beliefs about the Technology of Skill Formation

	25th percentile	Median	75th percentile	Mean	Variance
$\alpha_{i,1}$	0.0261	0.0312	0.0400	0.0313	0.0002
	(0.0004)	(0.0002)	(0.0007)	(0.0004)	(0.0000)
$\alpha_{i,2}$	0.0669	0.0777	0.0942	0.0795	0.0003
	(0.0005)	(0.0008)	(0.0007)	(0.0005)	(0.0000)

Note: Standard errors in parenthesis.

Preferences

Table 7

Comparative Statics of Investments

	Median	75th percentile	% Change in investments	% Change in parameter	Elasticity
α_1	1.70	1.73	1.6%	28.0%	5.8%
α_2	1.70	2.01	18.3%	21.4%	85.2%
$\mu_{\psi,2}$	1.70	1.77	4.1%	72.0%	5.8%
$\mu_{\psi,3}$	1.70	1.70	0.2%	257.1%	0.1%
$\mu_{\psi,3}$	1.70	1.86	9.3%	257.1%	3.6%

This table shows the comparative statics of optimal investments in relation to preference and belief parameters. Each row shows what happens to investments as we move one parameter and fix the other parameters at the median value. In the last row, we replace the human capital at birth from the mean value to the value at the first percentile.

Table 4

Objective Estimation of the Technology of Skill Formation

Dependent variable: Natural log of skills around age 24 months[1]

	FE Procedure			
	13 to 35 Months		16 to 32 Months	19 to 29 Months
	(1)	(2)	(5)	(8)
	Overall	Overall	Overall	Overall
Natural Logarithm of health conditions at birth[2]	0.588***	0.597***	0.517**	0.608*
	(0.17)	(0.17)	(0.21)	(0.34)
Natural logarithm of investments[3]	0.206***	0.204***	0.235***	0.363***
	(0.03)	(0.03)	(0.04)	(0.06)
Constant	2.222***	-1.516***	-1.624***	-1.943**
	(0.38)	(0.39)	(0.50)	(0.91)
Dummy for the child's age at the time of the interview	Yes	No	No	No
Natural logarithm of child's age at the time of the interview	No	Yes	Yes	Yes
Observations	2,984	2,984	2,218	1,400
R-squared	0.775	0.769	0.676	0.502
Number of Mothers	2,168	2,168	1,757	1,202

Robust standard errors in parentheses. All regressions have dummy variables for the child's gender, birthorder, and year of birth to capture cohort effects. All the regressions also have dummy variables for maternal age at the time of the child's birth. In column (1), we add dummy variables for the age of the child at the time of the interview. In columns (2)-(12), we replace the dummies with one continuous variable (the natural log of the child's age at the time of the interview).

*** p<0.01, ** p<0.05, * p<0.1

IVFE Procedure

- The foxed-effect procedure requires strict exogeneity of parental investments.
- This rules out any form of feedback from ν to x.
- We consider two different instruments: permanent income between ages 0-36 months of the child.
- Advantage: allows for some form of feedback from ν to x.
- However, imposes no feedback from ν to permanent income.

Table 4

Objective Estimation of the Technology of Skill Formation

Dependent variable: Natural log of skills around age 24 months[1]

	IV	
	13 to 35 Months	
	(11)	(12)
	Overall	Overall
Natural Logarithm of health conditions at birth[2]	0.602***	0.56
	(0.21)	(0.45)
Natural logarithm of investments[3]	0.428*	0.417**
	(0.25)	(0.21)
Constant	-1.635***	-2.648***
	(0.50)	(0.98)
Dummy for the child's age at the time of the interview	No	No
Natural logarithm of child's age at the time of the interview	Yes	Yes
Observations	2,798	1,254
R-squared		
Number of Mothers	2,134	1,048
First Stage - Dependent variable: Natural logarithm of investments[3]		
Natural logarithm of family income (average between ages 0 and 36 months)	0.142***	
	(0.044)	
Lagged Natural logarithm of investments[3]		-0.298***
		(0.077)

IVFE Procedure

- We consider a second IVFE procedure (Rosenzweig and Wolpin, 1988).
- Let $\triangle \ln h_{3,2,1} = \ln h_{3,1} - \ln h_{2,1}$ denote the difference in child development between the third and second children in the household.

$$\triangle \ln h_{3,2,1} = \psi_1 \triangle \ln h_{3,2,0} + \psi_2 \triangle \ln x_{3,2} + \triangle \ln \nu_{3,2}$$

- Suppose that $\triangle \ln \nu_{3,2} = \eta_3$ which is revealed to the parent only after the third child is born.
- Then, if we look at families in which investments in the first- and second-born children were chosen before the birth of the third child, the difference $\triangle \ln x_{2,1}$ is uncorrelated with η_3.

Table 4

Objective Estimation of the Technology of Skill Formation

Dependent variable: Natural log of skills around age 24 months[1]

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	(11)	(12)
	Overall	Overall
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Natural logarithm of child's age at the time of the interview	Yes	Yes
Observations	2,798	1,254
R-squared		
Number of Mothers	2,134	1,048
First Stage - Dependent variable: Natural logarithm of investments[3]		
Natural logarithm of family income (average between ages 0 and 36 months)	0.142***	
	(0.044)	
Lagged Natural logarithm of investments[3]		-0.298***
		(0.077)

Table 8

Maternal Beliefs and Technology

Cases	Factual investment	Counterfactual investment	% Change	Effect size
$\mu_{\psi,2} = 0.267$ $\mu_{\psi,3} = 0.000$	1.84	1.92	4.4%	10.3%
$\mu_{\psi,2} = 0.454$ $\mu_{\psi,3} = 0.000$	1.84	2.05	11.7%	26.9%

Table 8

Maternal Beliefs and Technology

Cases	Factual investment	Counterfactual investment	% Change	Effect size
$\mu_{\psi,2} = 0.267$ $\mu_{\psi,3} = 0.000$	1.84	1.92	4.4%	10.3%
$\mu_{\psi,2} = 0.454$ $\mu_{\psi,3} = 0.000$	1.84	2.05	11.7%	26.9%

Next steps

- Philadelphia Human Development Study: We are in the field collecting data to see if beliefs predict investments at age 12 months (about 45% of the sample done).
- PADIN Program in Brazil (World Bank, Secretariat of Education of Ceara).
- In Houston (with Ken Wolpin): Alief ISD Jumpstart Program; Houston ISD HIPPY Program.
- In Phildelphia: MOM Program.