On the Origin of Cognition

How Childhood Conditions Shape Cognitive Function in Old Age

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Introduction

- The impact of nutrition and health in early life on
    - Childhood cognitive development.
    - Adulthood outcomes such as occupation and income, etc.
    - is well documented (Case et al., 2005; Almond, 2006; Chen and Zhou, 2007; Heckman et al., 2013).
- The long-term impact of early-life shocks on cognitive functioning in old age is much less known.

Introduction

- Theoretical explanations for the long-term impact of early-life shocks (Lyu and Burr, 2016; Zhang et al., 2018)
  - The latency model
    - Adverse conditions in the critical periods of brain development (e.g., the in-utero period and childhood).
    - *Direct* effects on the life-course trajectories of cognitive development.
  - The pathway model
    - *Indirectly* impact through the educational attainment, occupational experiences, or living environment in adulthood.

Introduction

- Most previous studies focus on developed countries (Case and Paxson, 2008, 2009; van den Berg et al., 2010; Doblhammer et al., 2013; Aartsen et al., 2019).
- Research from a developing country such as China can be of special interest.
  - Under-developed elderly services with rapidly aging population (United Nations, 2019).
  - The childhood environment of the current Chinese elderly was worse than those in developed countries (Zhang et al., 2008).
    - Most Chinese elderly, who were born in the first half of the twentieth century, experienced severe hunger, wars, infectious diseases, and lacked of educational opportunities during their childhood (Zeng et al., 2007).

What We Do in this Paper

- Examine the long-lasting effects of socio-economic conditions in childhood on
  - cognitive functioning in old age.
  - deterioration rate of cognition at older ages.
- Test the latency model and the pathway model by examining a set of mediators:
  - Education, occupation, marital status, residential place.
  - Evaluate the relative importance of the mediators.

Preview of Main Findings

- People with adverse childhood conditions, measured by the paternal occupation, parental education, nutrition, and medical conditions
  - Have lower cognitive ability
  - Exhibit faster cognitive deterioration at older ages.
- Mechanisms
  - Educational attainment (explaining 16-26%).
  - Occupation (explaining 8-20%)
  - Childhood environment also has direct impacts on cognitive development, conditional on the mediators.
- Heterogeneity
  - Females suffer more from adverse childhood conditions.
  - Persistent effects on both crystallized intelligence and fluid intelligence.

Contributions

1. One of the few papers to examine the deterioration rate of cognition (Case and Paxson, 2008, 2009; Kobayashi et al., 2017; Chan et al., 2019).
2. Complement the literature by using data from China.
3. Extend the examination to people **older than 80**, who experience the greatest decline in cognitive functioning (Pan, 2020; Lin and Chen, 2021).
4. Test predictions of the latency model and the pathway model.

Contributions

- Link to broad economic literature on the association between early-life conditions or interventions and adulthood outcomes (e.g., academic achievement, health).
  - ▸ Little is known whether the impacts persist to old age.
  - ▸ **Policy implication: enhancing conditions during childhood will achieve significant returns by improving cognitive well-being in one's old age.**
- Link to literature on intergenerational transmission of inequality.
  - ▸ Our paper shows that differences in parental education and occupation are mirrored in the inequality of cognitive abilities at older ages.
  - ▸ **Suggest a new channel for the intergenerational transmission of socioeconomic inequality.**

Data

- The Chinese Longitudinal Healthy Longevity Survey (CLHLS).
    - Baseline survey in 1998, follow-up surveys in 2000, 2002, 2005, 2008, 2011, 2014, and 2018.
    - Since 2002, the survey randomly samples the elderly aged 65 and older from about 50% of the counties and urban districts in 23 Chinese provinces.
    - Collect information on the elderly's cognitive function, socio-economic environment in childhood, and other current characteristics.
- The CLHLS oversamples the oldest-old (i.e., ages $\geq$ 80), which is rarely observed in other data sets (Pan, 2020; Lin and Chen, 2021).

Analysis sample

- CLHLS 2005-2014 for the analysis of cognitive level.
  - ▸ Exclude waves 2002 and 2018 as some measures on the childhood conditions are not available.
  - ▸ 36,634 observations from 19,225 individuals who are 65-100 years of age.
- CLHLS 2002-2018 for the analysis of the change in cognitive function.
  - ▸ The sample of individuals who are observed in successive waves.
  - ▸ 27,451 observations from 13,450 individuals who are 65-100 years of age.

Measurement

- Cognitive function
  - Mini-Mental State Examination (MMSE).
  - Includes 24 questions measuring six dimensions.
    - Orientation (sense of time and location)
    - Verbal fluency
    - Memory (immediate recall, delayed recall)
    - Numeracy
    - Visual construction
    - Language
  - Range from 0 to 30. A higher MMSE score indicates better cognitive function.

| Items	Questions	Score (Total = 30)
1. Orientation	What time of day is it right now (morning, afternoon, evening)?	1
	What is the month (Western or Chinese calendar) right now?	1
	What is the date (Chinese calendar day and month) of the mid-autumn festival?	1
	What is the season right now, spring, summer, fall, winter?	1
	What is the name of this county or district?	1
2. Verbal fluency	Please name as many kinds of food as possible in 1 min. (1 point for each food and 7 points for those who name 7 or more foods)	7
3. Immediate recall	Table, apple, clothes. Please repeat these three objects.	3
4. Numeracy	I will ask you to spend 3 dollars from 20 dollars, then you must spend 3 dollars from the number you arrived at and continue to spend 3 dollars until you are asked to stop.	5
5. Visual construction	The interviewee is asked to draw a figure of overlapping pentagons.	1
6. Delayed recall	Name the three objects learned earlier (table, apple, clothes).	3
7. Language	Naming pen and watch.	2
	Repeat the following sentence: "What you plant, what you will get."	1
	The interviewee is asked to follow the interviewer's instruction: "Take the paper using your right hand, fold it in the middle using both hands, and place the paper on the floor."	3

Source: Cai (2021)

Measurement

- Indicators of childhood conditions
  - Paternal occupation in respondents' childhood
    - A dummy indicates that the main occupation of the respondent's father was a farmer.
  - Parental education
    - Dummies indicate receiving no formal schooling for the respondent's father and mother, respectively.
  - Nutrition and health in childhood
    - Whether you often went to bed hungry during childhood?
    - Whether you got adequate medical services during childhood?
    - Two dummies indicate the adverse conditions (i.e., being hungry or lack adequate medical services).
- Index of adverse childhood conditions
  - Add up the five indicators to obtain an index ranging from 0-5.
  - Higher index, worse socio-economic status during childhood.

Measurement

- Other variables
  - Mediators
    - ⋆ Levels of the education attainment (illiterate, primary school, and middle school and above).
    - ⋆ Main occupation before age 60 (farmer, industrial worker, manager, and others).
    - ⋆ Marital status (married or not).
    - ⋆ Place of residence (urban or rural areas).
  - Socio-demographic characteristics
    - ⋆ Age
    - ⋆ Gender (male=1)
    - ⋆ Ethnicity (*Han*=1).

Age Profiles of Cognitive Score by Childhood Conditions
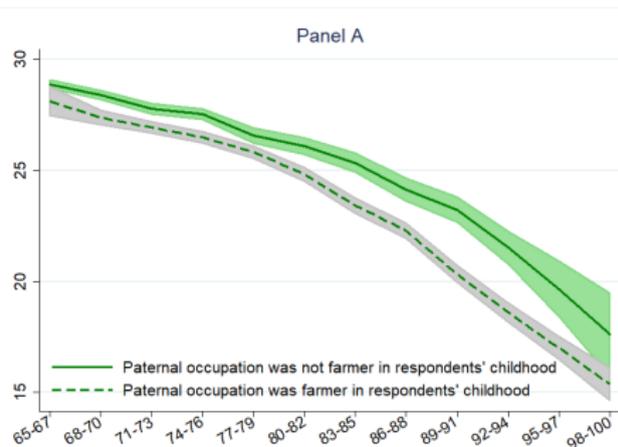
Paternal occupation (farmer)
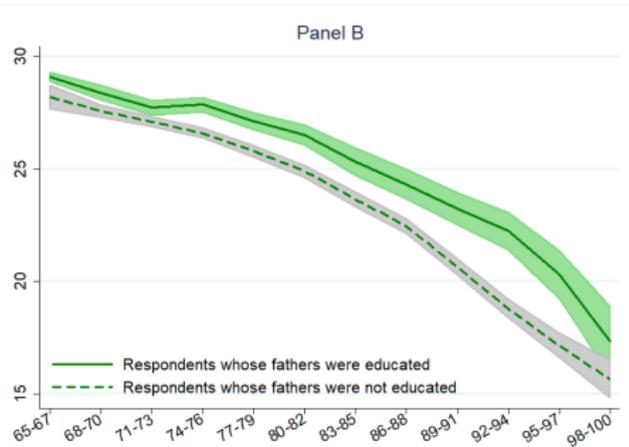
Paternal education

Age Profiles of Cognitive Score by Childhood Conditions
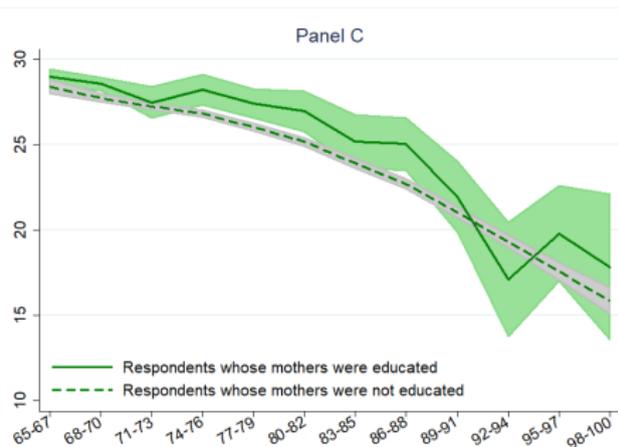
Maternal education
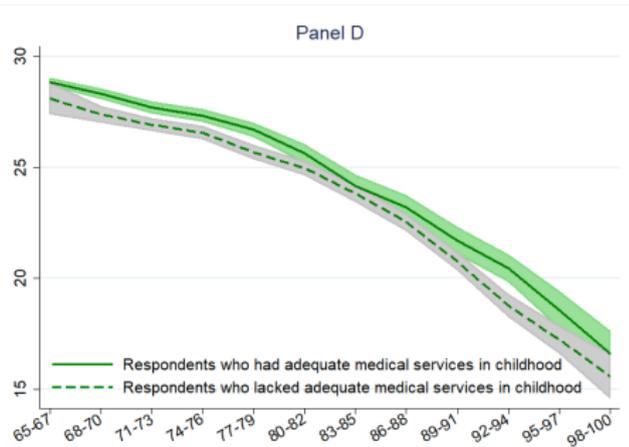
Medical services in childhood

Age Profiles of Cognitive Score by Childhood Conditions
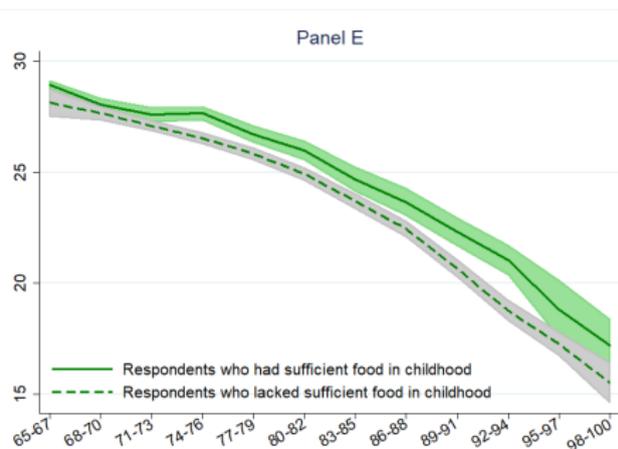
Food sufficiency in childhood
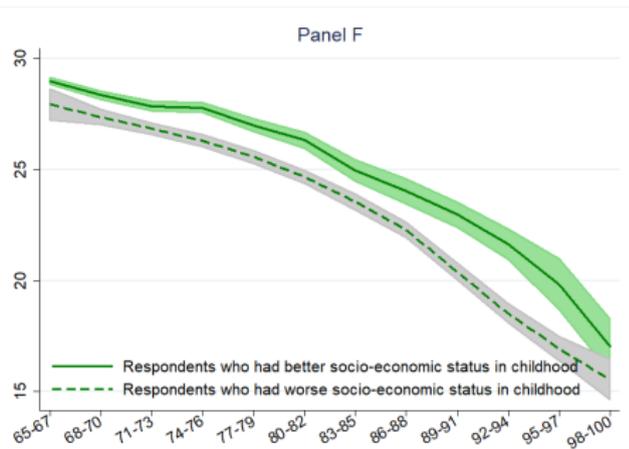
Index of adverse childhood conditions

- A similar pattern: respondents who had worse socio-economic conditions during childhood
  - Not only have lower cognitive function scores in old age.
  - But also exhibit faster deterioration in cognitive function with aging.

Variables	Mean	S.D.
Cognitive function score	26.87	5.20
Have childhood with father working as a farmer	0.63	0.48
Have uneducated father	0.77	0.42
Have uneducated mother	0.96	0.20
Lack adequate medical services in childhood	0.59	0.49
Lack sufficient food in childhood	0.69	0.46
Index of adverse childhood conditions	3.64	1.16
Male	0.49	0.50
Han nationality	0.79	0.41
Age	73.20	6.22
Education: Illiterate	0.43	0.50
Education: Primary school	0.39	0.49
Education: Middle school and above	0.18	0.38
Occupation: Farmer	0.48	0.50
Occupation: Worker	0.14	0.34
Occupation: Manager	0.10	0.30
Occupation: Others	0.28	0.45
Married	0.63	0.48
Live in urban	0.43	0.50
Observations	36634	

Source: CLHLS 2005, 2008, 2011, 2014

$$y_{icpt} = E_{icpt}\alpha + X_{icpt}\gamma + \delta_c + \eta_{pt} + \varepsilon_{icpt} \qquad (1)$$

- i, c, p, and t represent the individual, birth year, residential province, and survey wave, respectively.
- y_{icpt}: Cognitive function.
- E_{icgs}: Five dummies for adverse early-life conditions.
  - Have a childhood with father working as a farmer.
  - Have father who received no formal schooling.
  - Have mother who received no formal schooling.
  - Lack adequate medical services in childhood.
  - Lack suficient food in childhood.
- X_{icgs}: A set of observable socio-demographic characteristics.
  - Age, age^2, dummies for male, and *Han* ethnicity.
- δ_c: Birth year fixed effects.
- η_{pt}: Residential province by wave fixed effects.
- ε_{icpt}: Standard error are clustered at the individual level.

$$y_{icpt} - y_{icpt+w} = E_{icpt}\beta + X_{icpt}\zeta + \delta_c + \eta_{pt} + \varepsilon_{icpt} - \varepsilon_{icpt+w} \qquad (2)$$

- $y_{icpt} - y_{icpt+w}$: The change in cognitive function scores measured in survey wave t compared to that measured in the successive survey wave $t + w$.
- The definitions of the independent variables are the same as in equation (1).

Notes for Regression Analyses

- All regressions use the sampling weights.
- The standard errors reported in parentheses are clustered at the individual level.
- Significance: $***p < 0.01$, $**p < 0.05$, $*p < 0.1$.

Cognitive Function at Older Ages & Childhood Conditions

	Cognitive function score				
	(1)	(2)	(3)	(4)	(5)
Have childhood with father working as a farmer	-1.004***	-0.695***	-0.671***	-0.663***	
	(0.110)	(0.111)	(0.115)	(0.116)	
Have uneducated father	-0.847***	-0.672***	-0.651***	-0.652***	
	(0.108)	(0.102)	(0.109)	(0.110)	
Have uneducated mother	-0.473***	-0.207	-0.214	-0.220	
	(0.173)	(0.174)	(0.160)	(0.161)	
Lack adequate medical services in childhood	-0.718***	-0.552***	-0.493***	-0.508***	
	(0.111)	(0.105)	(0.087)	(0.087)	
Lack sufficient food in childhood	-0.600***	-0.497***	-0.364***	-0.362***	
	(0.107)	(0.103)	(0.088)	(0.089)	
Index of adverse childhood conditions					-0.521***
					(0.049)
Male		1.041***	1.030***	1.022***	1.024***
		(0.128)	(0.123)	(0.125)	(0.125)
Han ethnicity		-0.220	-0.184	-0.208	-0.293**
		(0.142)	(0.147)	(0.148)	(0.145)
Age		0.990***	0.861***	0.969***	0.974***
		(0.159)	(0.142)	(0.161)	(0.161)
Age squared/100		-0.809***	-0.723***	-0.774***	-0.778***
		(0.099)	(0.094)	(0.092)	(0.092)
Constant	29.441***	-0.480	4.168	-0.917	-0.831
	(0.189)	(6.248)	(5.304)	(7.572)	(7.565)
Birth year fixed effect			Yes	Yes	Yes
Residential province fixed effect			Yes		
Residential province by wave fixed effect				Yes	Yes
Observations	36634	36634	36634	36634	36634

Change in Cognitive Function & Childhood Conditions

	Change in cognitive function scores (difference between waves)				
	(1)	(2)	(3)	(4)	(5)
Have childhood with father working as a farmer	0.386***	0.283***	0.304***	0.298***	
	(0.076)	(0.090)	(0.094)	(0.094)	
Have uneducated father	0.158	0.116	0.150	0.144	
	(0.109)	(0.109)	(0.104)	(0.103)	
Have uneducated mother	0.350*	0.291*	0.324*	0.331*	
	(0.182)	(0.177)	(0.174)	(0.181)	
Lack adequate medical services in childhood	0.071	0.029	0.048	0.057	
	(0.074)	(0.074)	(0.073)	(0.073)	
Lack sufficient food in childhood	0.160**	0.143*	0.149**	0.146*	
	(0.076)	(0.075)	(0.076)	(0.076)	
Index of adverse childhood conditions					0.166***
					(0.035)
Male		-0.086	-0.103	-0.098	-0.094
		(0.076)	(0.072)	(0.072)	(0.072)
Han ethnicity		0.127	0.153	0.229**	0.300***
		(0.095)	(0.095)	(0.100)	(0.088)
Age		-0.766***	-0.963***	-0.961***	-0.959***
		(0.125)	(0.165)	(0.186)	(0.186)
Age squared/100		0.569***	0.698***	0.693***	0.691***
		(0.081)	(0.109)	(0.110)	(0.110)
Constant	0.156	25.767***	33.120***	33.168***	33.240***
	(0.185)	(4.784)	(6.222)	(8.230)	(8.224)
Birth year fixed effect			Yes	Yes	Yes
Residential province fixed effect			Yes		
Residential province by wave fixed effect				Yes	Yes
Observations	27451	27451	27451	27451	27451

Robustness: Sample Attrition in Longitudinal Data

- In the analyses on change in cognitive function, we focus on the sample of respondents observed in successive waves.
  - If the elderly with better health are more likely to be observed successively, then we may underestimate the effect of adverse early-life conditions.
- Apply **the method of inverse probability weighting** following Wooldridge (2010)
  - Estimate a probit model using the full sample of each wave: $Probit(D = 1|Z) = \Phi(Z)$.
    - D is a dummy indicating whether the individual was observed in the next wave. Z is a set of predictors.
  - Predict the probability of being followed up, and construct a new weight variable by timing the inverse of the estimated probability and the original sampling weight.

Robustness: Accounting for Sample Attrition

	Change in cognitive function scores (difference between waves)				
	(1)	(2)	(3)	(4)	(5)
Have childhood with father working as a farmer	0.350***	0.223**	0.258***	0.253***	
	(0.078)	(0.090)	(0.093)	(0.092)	
Have uneducated father	0.209*	0.162	0.199*	0.190*	
	(0.109)	(0.108)	(0.105)	(0.104)	
Have uneducated mother	0.357*	0.289	0.333*	0.333*	
	(0.183)	(0.176)	(0.172)	(0.177)	
Lack adequate medical services in childhood	0.086	0.031	0.052	0.064	
	(0.076)	(0.076)	(0.075)	(0.074)	
Lack sufficient food in childhood	0.159**	0.133*	0.156**	0.148*	
	(0.078)	(0.078)	(0.079)	(0.079)	
Index of adverse childhood conditions					0.169***
					(0.034)
Male		-0.094	-0.109	-0.110	-0.108
		(0.078)	(0.074)	(0.074)	(0.074)
Han ethnicity		0.156	0.184*	0.249**	0.293***
		(0.095)	(0.096)	(0.100)	(0.088)
Age		-0.733***	-1.019***	-1.013***	-1.014***
		(0.113)	(0.159)	(0.174)	(0.174)
Age squared/100		0.548***	0.742***	0.726***	0.726***
		(0.073)	(0.105)	(0.105)	(0.105)
Constant	0.224	24.478***	34.848***	35.152***	35.346***
	(0.185)	(4.361)	(5.987)	(7.573)	(7.569)
Birth year fixed effect			Yes	Yes	Yes
Residential province fixed effect			Yes		
Residential province by wave fixed effect				Yes	Yes
Observations	27451	27451	27451	27451	27451

Robustness: Examination on Recall Bias

- Childhood conditions are measured based on self-reports on retrospective questions.
  - Recall bias may correlate with the cognitive ability of the elderly.
- Conduct the analyses separately among respondents with normal cognition and those who were cognitively impaired (cutting point: 18 of cognitive function scores).

Robustness: Examination on Recall Bias

Subsample	Cognitive function score				Change in cognitive function scores (difference between waves)			
	Score≥18		Score<18		Score≥18		Score<18	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Have childhood with father working as a farmer	-0.245***		-0.204		0.333***		2.772***	
	(0.054)		(0.509)		(0.097)		(1.005)	
Have uneducated father	-0.344***		-0.656		0.241**		2.528**	
	(0.054)		(0.638)		(0.110)		(1.044)	
Have uneducated mother	-0.060		1.005		0.395**		0.503	
	(0.123)		(1.204)		(0.198)		(3.002)	
Lack adequate medical services in childhood	-0.226***		0.111		0.141*		0.953	
	(0.048)		(0.409)		(0.079)		(0.832)	
Lack sufficient food in childhood	-0.265***		0.201		0.121		0.281	
	(0.050)		(0.469)		(0.084)		(0.894)	
Index of adverse childhood conditions		-0.256***		-0.047		0.214***		1.407***
		(0.021)		(0.214)		(0.036)		(0.397)
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Residential province by wave fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	29966	29966	6668	6668	24752	24752	2699	2699

Survivorship Bias

- The data comprises only the survivors of adverse childhood experiences
  - Sample selection problem: the likelihood of being survived by the time of the survey is correlated with adverse childhood conditions
- Prior research has found negative impact of adverse conditions on the longevity (Black, Hsu, and Taylor, 2015; Lee and Li, 2021)
  - Make our estimates to be lower bounds of the true effects.

Main Results: Summary

- The elderly with worse childhood conditions not only have lower scores of cognitive function, but also exhibit a faster rate of deterioration in cognition.
  - Suggest that adverse early-life conditions may have persistent detrimental effects on peoples cognitive functioning at their older ages.
  - The results are robust after accounting for measurement errors in explanatory variables and sample attrition in longitudinal data.

Mechanisms

$$y_{icpt} = E_{icpt}\alpha + X_{icpt}\gamma + M_{icpt}\theta + \delta_c + \eta_{pt} + \varepsilon_{icpt} \tag{3}$$

$$y_{icpt} - y_{icpt+w} = E_{icpt}\beta + X_{icpt}\zeta + M_{icpt}\kappa + \delta_c + \eta_{pt} + \varepsilon_{icpt} - \varepsilon_{icpt+w} \tag{4}$$

- M_{icpt}: a vector of mediators
    - Levels of the education attainment (illiterate, primary school, and middle school and above; taking illiterate as reference).
    - Main occupation before age 60 (farmer, industrial worker, manager, and others; taking farmer as reference).
    - Marital status (married or not; taking unmarried as reference).
    - Place of residence (urban or rural areas; taking rural as reference).

Mechanisms

	Cognitive function score				Change in cognitive function scores (difference between waves)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Have childhood with father working as a farmer	-0.663***	-0.310***			0.298***	0.233**		
	(0.116)	(0.101)			(0.094)	(0.092)		
Have uneducated father	-0.652***	-0.426***			0.144	0.097		
	(0.110)	(0.102)			(0.103)	(0.113)		
Have uneducated mother	-0.220	-0.080			0.331*	0.310*		
	(0.161)	(0.153)			(0.181)	(0.185)		
Lack adequate medical services in childhood	-0.508***	-0.418***			0.057	0.048		
	(0.087)	(0.083)			(0.073)	(0.072)		
Lack sufficient food in childhood	-0.362***	-0.204**			0.146*	0.118		
	(0.089)	(0.088)			(0.076)	(0.075)		
Index of adverse childhood conditions			-0.521***	-0.325***			0.166***	0.126***
			(0.049)	(0.042)			(0.035)	(0.038)
Male	1.022***	0.413***	1.024***	0.418***	-0.098	0.037	-0.094	0.039
	(0.125)	(0.105)	(0.125)	(0.104)	(0.072)	(0.092)	(0.072)	(0.092)
Han ethnicity	-0.208	-0.192	-0.293**	-0.192	0.229**	0.152	0.300***	0.186*
	(0.148)	(0.160)	(0.145)	(0.155)	(0.100)	(0.115)	(0.088)	(0.110)
Age	0.969***	0.950***	0.974***	0.954***	-0.961***	-0.961***	-0.959***	-0.959***
	(0.161)	(0.157)	(0.161)	(0.157)	(0.186)	(0.186)	(0.186)	(0.186)
Age squared/100	-0.774***	-0.752***	-0.778***	-0.756***	0.693***	0.693***	0.691***	0.691***
	(0.092)	(0.090)	(0.092)	(0.091)	(0.110)	(0.110)	(0.110)	(0.110)

Table (continued)

Mechanisms

	Cognitive function score				Change in cognitive function scores (difference between waves)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Education levels (reference: illiterate)								
Primary school		1.127***		1.135***		-0.318***		-0.313***
		(0.169)		(0.169)		(0.114)		(0.111)
Middle school and above		1.336***		1.341***		-0.417***		-0.414***
		(0.193)		(0.192)		(0.147)		(0.142)
Main occupation before age 60 (reference: farmer)								
Worker		0.231		0.228		0.222*		0.204
		(0.160)		(0.159)		(0.132)		(0.133)
Manager		0.452***		0.439***		-0.050		-0.076
		(0.165)		(0.163)		(0.132)		(0.131)
Others		0.512***		0.501***		-0.177*		-0.224**
		(0.137)		(0.137)		(0.105)		(0.104)
Married		0.678***		0.672***		-0.050		-0.055
		(0.161)		(0.162)		(0.097)		(0.097)
Live in urban		0.242*		0.244*		0.105		0.102
		(0.138)		(0.139)		(0.099)		(0.099)
Constant	-0.917	-2.553	-0.831	-2.454	33.168***	33.468***	33.240***	33.622***
	(7.572)	(7.283)	(7.565)	(7.275)	(8.230)	(8.257)	(8.224)	(8.255)
Birth year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Residential province by wave fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	36634	36634	36634	36634	27451	27451	27451	27451

Decomposition (Hsin and Xie, 2014)

- The lower bound for the explanatory power
  - Estimate coefficient α based on Equation (3), denoted as α^{full}.
  - Exclude mediator m_{icpt}^k from Equation (3) and obtain the estimate of α, denoted as α^{full-k}.
  - $\underline{D_k} = \alpha^{full-k} - \alpha^{full}$.
- The upper bound for the explanatory power
  - Estimate coefficient α based on Equation (1), denoted as α^{base}.
  - Add mediator m_{icpt}^k to Equation (1) and obtain the estimate of α, denoted as α^{base+k}.
  - $\overline{D_k} = \alpha^{base} - \alpha^{base+k}$.
- The same procedure applies to the change in cognitive function at older ages.

Decomposition

	Cognitive function score				Change in cognitive function scores (difference between waves)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Magnitude	Percentage			Magnitude	Percentage		
Index of adverse childhood conditions	-0.521				0.166			
Index of adverse childhood conditions (control for all mediation factors)	-0.325	62.4			0.126	75.9		
Magnitude explained by all mediators	-0.196	37.6			0.039	23.5		
	Lower bound		Upper bound		Lower bound		Upper bound	
	Magnitude	Percentage	Magnitude	Percentage	Magnitude	Percentage	Magnitude	Percentage
Magnitude explained by education	-0.083	15.9	-0.137	26.3	0.025	15.1	0.033	19.9
Magnitude explained by occupation	-0.039	7.5	-0.102	19.6	0.012	7.2	0.016	9.6
Magnitude explained by marital status	-0.001	0.2	-0.008	1.5	0.000	0.0	0.001	0.6
Magnitude explained by residential place	-0.006	1.2	-0.036	6.9	-0.003	-1.8	-0.006	-3.6

Heterogeneity by Gender and Age Group

Subsample	By gender		By age group	
	Female	Male	65-80	>80
	(1)	(2)	(3)	(4)
Panel A: Cognitive function score				
Have childhood with father working as a farmer	-0.844***	-0.443***	-0.598***	-1.098***
	(0.178)	(0.121)	(0.129)	(0.206)
Have uneducated father	-0.801***	-0.483***	-0.582***	-1.170***
	(0.185)	(0.131)	(0.120)	(0.220)
Have uneducated mother	-0.251	-0.073	-0.218	-0.571
	(0.214)	(0.249)	(0.167)	(0.461)
Lack adequate medical services in childhood	-0.532***	-0.465***	-0.558***	-0.181
	(0.135)	(0.111)	(0.094)	(0.182)
Lack sufficient food in childhood	-0.501***	-0.266**	-0.317***	-0.600***
	(0.130)	(0.128)	(0.096)	(0.186)
Observations	19160	17474	14202	22427
Panel B: Change in cognitive function scores (difference between waves)				
Have childhood with father working as a farmer	0.406***	0.193	0.229**	0.907***
	(0.135)	(0.131)	(0.102)	(0.241)
Have uneducated father	0.097	0.176	0.136	0.284
	(0.131)	(0.171)	(0.112)	(0.257)
Have uneducated mother	0.210	0.459	0.365*	-0.055
	(0.234)	(0.292)	(0.192)	(0.696)
Lack adequate medical services in childhood	-0.016	0.128	0.103	-0.418*
	(0.099)	(0.107)	(0.078)	(0.223)
Lack sufficient food in childhood	0.147	0.152	0.192**	-0.242
	(0.105)	(0.114)	(0.082)	(0.239)
Observations	14353	13098	14053	13395

Heterogeneity by Gender and Age Group

- The associations of childhood conditions with cognitive scores are stronger among females than males.
  - Given limited resources, parents will give priority to their sons over their daughters.
  - Son preference (Lhila and Simon, 2007)
- Adverse conditions during childhood accelerate the deterioration of cognitive function at older ages.

Heterogeneity by Cognitive Dimension

- Cognitive function consists of six dimensions.
- Two categories (McArdle et al., 2002; Salthouse, 2006)
  - Crystallized intelligence
    - Recall of stored knowledge and past experiences.
    - Orientation, verbal fluency.
  - Fluid intelligence
    - Comprehension and reasoning.
    - Immediate recall, delayed recall, numeracy, visual construction, and language.

Cognitive function score by dimension	Orientation	Verbal frequency	Immediate recall	Delayed recall	Numeracy	Visual construction	Language
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A							
Index of adverse childhood conditions	-0.077***	-0.068***	-0.053***	-0.072***	-0.093***	-0.130***	-0.089***
	(0.012)	(0.009)	(0.011)	(0.010)	(0.011)	(0.009)	(0.013)
Panel B							
Have childhood with father working as a farmer	-0.111***	-0.105***	-0.032	-0.069***	-0.117***	-0.116***	-0.134***
	(0.032)	(0.024)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)
Have uneducated father	-0.087***	-0.091***	-0.088***	-0.081***	-0.119***	-0.151***	-0.101***
	(0.025)	(0.021)	(0.023)	(0.024)	(0.024)	(0.029)	(0.025)
Have uneducated mother	-0.064**	0.036	0.064	-0.118***	-0.013	-0.136***	-0.099***
	(0.031)	(0.046)	(0.076)	(0.042)	(0.050)	(0.053)	(0.034)
Lack adequate medical services in childhood	-0.066***	-0.054***	-0.075***	-0.082***	-0.092***	-0.135***	-0.092***
	(0.021)	(0.019)	(0.019)	(0.020)	(0.020)	(0.021)	(0.021)
Lack sufficient food in childhood	-0.053**	-0.054***	-0.046**	-0.042*	-0.069***	-0.115***	-0.030
	(0.021)	(0.020)	(0.019)	(0.022)	(0.020)	(0.023)	(0.026)
Individual level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Residential province by wave fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	36634	36634	36634	36634	36634	36634	36634

- Adverse childhood conditions have persistent effects on all dimensions of cognitive function.
- The estimated effects on the fluid intelligence are greater than the crystallized intelligence.

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Conclusions

1. The elderly with favorable early life conditions not only have higher scores of cognitive function, but also exhibit a slower rate of deterioration in cognition.

2. Mechanisms
   - The educational attainment is one of the most important channels (explaining 16-26%).
   - Environments in early life have direct impacts on the trajectory of cognitive development.

3. Heterogeneity
   - Females suffer more from adverse childhood conditions.
     * Traditional values of son preference.
   - Childhood conditions have persistent effects on all dimensions of cognitive function.
     * More pronounced for fluid intelligence than crystallized intelligence.

Any comments are welcome !