Late-life cognition: Do childhood conditions play any role?

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Abstract

Individual's cognitive ability tends to reduce with ageing. Recently, whether and how to buffer this age-related decline is one of the greatest concerns. One well-established hypothesis argues that early life conditions play a particularly crucial role in developing individual's cognitive skills. People who grew up in good conditions are more likely to obtain a higher level of cognitive stocks and are more efficient producers of cognitive skills. In this paper, we analyze the impact of childhood conditions on the individuals' late life cognitive functioning by addressing the question whether the same change in age will have different consequences on the late life cognition given different levels of childhood conditions based on the China Health and Retirement Longitudinal Study (CHARLS) data. Our empirical evidence supports that more advantageous childhood conditions can shave off the decline of cognition with ageing after controlling for individual fixed effects.

Key words: childhood conditions, cognitive decline, ageing

JEL codes: I1, I31, J14

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1. Introduction

Individual's cognitive functioning involves perception, memory, thinking, and creation of imagery (Levy, 1994). It is commonly accepted that cognitive skills are of great importance for both the individuals and the society. They are closely related to tackling information in daily life, making decisions on saving, health and retirement, as well as the ability to live independently, which could further determine the entire quality of life.

However, cognition is associated with a decline at old ages. Mazzonna and Peracchi (2012) adapted a health capital model by Grossman (1972). They show that an individual's life-time utility depends on the cognitive investment and consumption, constrained by the life-time budget. An increase of the cognitive investment for a given period will raise the stocks of cognitive capital along the entire life cycle. Simultaneously, cognitive capital suffers from a natural deterioration rate over the time in lack of investing in any cognitive-repair activities, which indicates a fall in cognition with age. Their model also suggests that some factors such as early investment in education could lead to a lower deterioration rate of cognitive abilities.

In addition, the skill production function proposed by Todd and Wolpin (2003, 2007) stresses that child development is a cumulative process depending on the history of inputs invested by families and schools as well as on children's inherited endowments. An increase in the investment of families during childhood can be considered as a way to accumulate stocks of cognitive skills during life, resulting in a higher cognitive achievement.

As an extension, Cunha et al. (2010)'s model presents an evolution of both children's cognitive and non-cognitive skills at different phases of life cycle. They emphasize the importance of early life interventions for developing the subsequent evolution of cognitive skills, where family inputs and parental characteristics are treated directly as an input into the accumulation of their children's cognitive skills. Cognitive skills obtained in a given period not only increase the total stocks but also raise the productivity of developing subsequent skills of the following periods. In other words, a higher cognitive skills you attain now, the more efficient you will be in producing cognitive skills and a higher level will be achieved in the future. They also point out that investment in early stage of childhood is particularly important for the formation of adult cognitive skills. Cunha and Heckman (2010) predict that the effect of parental inputs on child's cognitive ability is stronger especially before 10 years old. Therefore, considering early life conditions, in particular, the period of childhood contributes greatly to the development of life-time cognitive functioning.

Based on the theoretical models, early life conditions impact on late-life cognitive functioning not only through accumulating the total stocks of cognitive skills over the entire life, which results in a higher level of cognitive achievements. They can also affect the efficiency of producing subsequent cognitive skills and the rate of deterioration with age. Hence, if conditions early in life were favorable, the age-related cognitive decline at old ages might be delayed or mitigated. If this is true, it may be worth focusing on monitoring those who were born under worse conditions. Providing social interventions to those children at disadvantage might be satisfactory as it is equivalent to improve the efficiency of care for cognitively impaired individuals. Usually the costs of care for those individuals are quite high and are expected to increase in the upcoming decades.

Therefore, this paper addresses this issue by assessing empirically how the age decline of cognitive functioning posited by the theory and documented in empirical works (i.e. Schaie, 1989) is influenced by the childhood conditions. We investigate whether the same change in age will lead to different consequences of late life cognition given different levels of childhood conditions. Specifically, we look at whether the age decline of cognition for individuals who experienced different childhood conditions follow different trajectories (i.e. smoother or steeper). This study also contributes to the economic literature by stressing the intergenerational consequences of public policies designed to improve the well-being of individuals.

This issue is particularly relevant for the elderly in a country such as China, which is facing an increasing ageing population and a decreasing role of families as a source of health care. Moreover, individuals make a decision in lack of professional guide when government-supported health care and pension system are not mature enough to cover all the population. Only until recently has it received particular attention to the research of the cognition of the elderly in China, partly due to the improvement of the collection of data. However, whether and how we can delay or mitigate cognitive decline with ageing is still poorly understood[2]. We draw the data from the China Health and Retirement Longitudinal Study (CHARLS) in 2011, 2013 and 2015 as well as the wave on life history to explore our research question. We will concentrate on the childhood conditions at an early stage in life, which shows to influence the development of cognitive skills more than later stages (i.e. Cunha and Heckman, 2010). We find robust evidence to support that the cognitive functioning of individuals experienced more advantageous childhood conditions start to drop later and less rapidly at old ages after controlling for the individual fixed effect.

The rest of the paper will be organized in four additional sections. Section 2 provides a brief review of the empirical literature. Section 3 will discuss the data and variables. The main results and robustness checks will be presented in Section 4 and 5. Finally,

[2] Few examples of work on the cognition of the elderly in China include Hu et al. (2012) which looks at the effect of social activities on the older Chinese individuals' cognitive functioning and Lei et al. (2014) which examines the gender differences in cognition and the role of community, environment and economic development.

Section 6 will provide the conclusions, policy implications and potential for further researches.

2. Literature review

Empirical work to study the role of childhood conditions on adulthood cognition and other aspects of well-being has been explored extensively (i.e. Cerhan et al., 1998; Kaplan et al., 2001; Aizer et al., 2016; Hoynes et al., 2016; Almond et al., 2017). However, literature on the topic of childhood characteristics and cognition at old ages is limited and the relationship between them is mixed[3].

First, Everson-Rose et al. (2003) explore the impact of childhood socio-economic status on the cognitive abilities of the individuals aged 65 and above in the U.S based on the Chicago Health and Aging Project data. Childhood socio-economic status is measured by a mean score of four questions concerning father's and mother's education, father's occupation, self-reported family financial status during childhood as well as childhood cognitive stimulating activities. Findings by Everson-Rose et al. (2003) support that advantageous socioeconomic and cognitive conditions during early life result in a higher absolute level of cognitive skills but they do not find any relationship between the rate of decline and cognitive functioning at old ages.

The second example from Case and Paxson (2009) looks at whether exposure to disease during childhood is related to the cognitive abilities later in life in the U.S. They argue that early disease environment may influence cognition at old ages indirectly through adult health outcome or directly through cognitive outcome such as the influence of infections on the brain development, later-life cardiovascular health or the effect of inflammation on adult neurogenesis. This study matched the regional-level mortality data of the first half of the twentieth century, including a variety of infectious diseases and total infant mortality, with the individual-level information on the individual cognitive function of older Americans followed by the Health and Retirement Study (HRS) between 1996 to 2004. They prove that early disease environment has a significant impact on the late-life cognitive performance of the elderly, such as on delayed word recall and counting backwards.

Furthermore, individuals born in poor families are less likely to have opportunities to go to school and acquire knowledge (Case et al., 2005), which could further influence their ability to deal with negative life events later in life as found by Van den Berg et al. (2010). They consider the role of early life economic conditions measured by the business cycle at birth on the cognitive functioning of the elderly and analyze

[3] A few recent studies look at childhood condition and other aspects of well-being, such as Bertoni (2015). Bertoni (2015) looks at early life conditions on the subjective well-being and uses vignette questions to correct for different reporting styles. This paper inspires us to use more objective measures of cognitive functioning as self-reported measures may suffer from different reporting styles.

whether an access to beneficial early life economic conditions mitigate the effects of adverse events later in life on cognition using Dutch longitudinal data between 1992 to 2006. In this study, the index of cognition is constructed based on the Mini Mental State Examination (MMSE) score (Folstein et al. 1995), ranging from 0 to 30. They included a series of adverse life events such as diseases, loss of family members, financial problems and so on. Results confirm that the negative effects of suffering from the stroke and the death of family members on the cognitive abilities are stronger for those who were born in a recession than those individuals born in years with a favorable business cycle.

Another recent work by Mazzonna (2014) finds a strong relationship between family socio-economic status (SES) during childhood and later life cognition across 11 European countries based on the Survey of Health, Ageing, and Retirement in Europe (SHARE). His childhood SES index is built upon rooms per capita in one's accommodation, facilities in household during childhood, number of books as well as the occupation of the breadwinner.

Recently emerging studies suggest that childhood conditions may play an important role in shaping cognitive functioning throughout the whole life and it has a long-term consequence on the later-life cognition. Nevertheless, most of previous literature just examines the direct relationship between early life conditions and the level of cognition late in life. Little is known about different paths of age-related cognitive decline between those who experienced favorable and those who experienced unfavorable childhood conditions. Therefore, we intend to fill in this research gap. Above all, we extend this topic by considering different types of cognition. Cognitive abilities are generally divided into two categories: fluid cognitive ability and crystallized cognitive ability. The former includes learning performance and processing of new knowledge such as memory when recalling some past events, which tends to decline with age. The latter involves knowledge and skills obtained in the past which are hard to lose and less sensitive to age-related decline (Schaie, 1994;Peterson et al., 2002; Bäckman et al., 2005). Salthouse (2000) argues that dimensions of cognitive functioning such as orientation, memory, and numeracy are a combination of both fluid and crystallized cognitive abilities, and he suggests that different dimensions of cognition should be used for measuring an individual's cognitive functioning. Hence, results can be variant due to different types of cognitive abilities. Following Salthouse's suggestion, we will include two key measures of cognition, which are word recall and mental intactness to capture both types of cognitive abilities. Moreover, childhood conditions were measured restricting to some specific indicators due to data availability before. A potential question might be raised whether more routine childhood experiences may also affect economics and health outcomes late in life. Therefore, we include a richer set of childhood conditions by constructing a childhood index. More details will be discussed in the following sections.

3. Data and variables

We use the data from the China Health and Retirement Longitudinal Study (CHARLS) to analyze cognitive decline at old ages, which collects information on health, household composition, demographics and social economic conditions. The CHARLS survey is nationally representative, including 28 provinces in China. It is based on a representative sample of the population of Chinese individuals aged 45 or over and their spouses. A pilot survey for CHARLS was conducted in two provinces in 2008 on 2,685 individuals. Based on the pilot survey experience, the main national baseline survey has been conducted in year 2011, 2013 and 2015 as well as a retrospective wave on the life history collected in 2014. Our measures of cognition are based on the main survey in 2011, 2013 and 2015, in which individuals are asked to do a cognition test every two years. Measures of childhood conditions came from the life history survey where respondents were asked to answer retrospective questions in their life course events. However, retrospective questions might suffer from recall bias or less information can be extracted as memory fades. A handful of studies like Garrouste and Paccagnella (2011), Havari and Mazzonna (2015), Brunello et al. (2017) provide validation of retrospective data from The Survey of Health, Ageing, and Retirement in Europe (SHARE). The design of the survey and the method of data collection guarantees that respondents can recall life course events: respondents are helped to mark down the important events along the time line and questions are asked starting from domains that are more easily to remember. CHARLS has followed the same protocols and methods of SHARE and other worldwide ageing data. Hence, we expect that similar conclusions can be reached with respect to the usage of retrospective data in CHARLS.

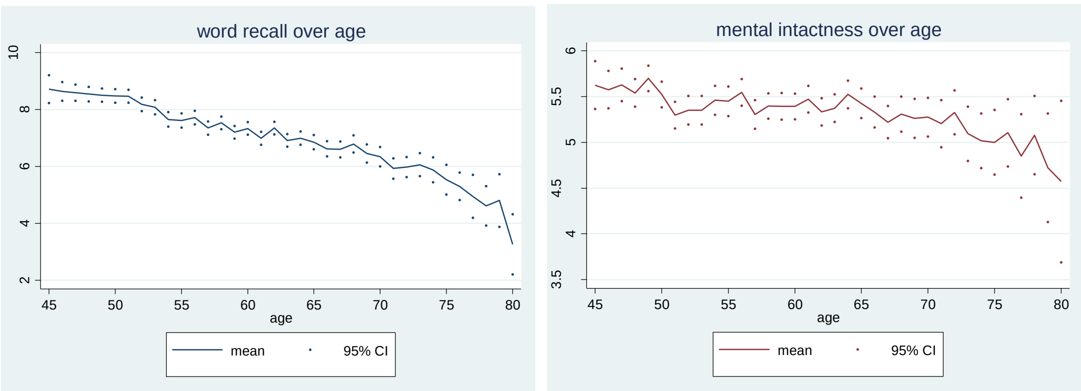
Considering the mortality rate in China, we excluded the oldest-old individuals (age above 80). We also excluded proxy answers because they do not provide valuable information for our purposes. We only included panel samples which individuals answered questions in three waves. The final sample of each model varies according to the dependent variable we use: 18,519 observations for the models with dependent variable of word recall and 13,878 observations for the models using mental intactness as a dependent variable.

3.1 Cognition

The main dependent variable is individual's cognitive functioning. Following Salthouse (2002)'s suggestion, we use two different measures of cognition. In

CHARLS, cognition is measured by simple tests such as word recalls, orientation in time, numeracy, drawing a picture and so on. The first measure is called "word recall", which has been used largely in most of previous papers to capture individual's episodic memory[4] and is included in the fluid ability. After hearing a complete list of words only once, respondents are asked to immediately repeat 10 words (immediate word recall) in any order and to recall the same list of words in a few minutes (delayed word recall). Following the previous literature (i.e. Mazzonna, 2014), word recall is computed as the total number of immediate and delayed recalled scores, ranging from 0 to 20. The second important measure of cognitive functioning is constructed on several mental status questions from CHARLS designed on the Telephone Interview of Cognitive Status (TICS) battery[5], in order to measure intactness or mental status of individuals (Lei et al., 2014). Mental intactness consists of three items- serial 7 subtraction from 100 (up to five times), whether the respondent used paper and pencil or any other aid, and whether the respondent can redraw a picture shown to the respondent. All of these items are eventually summed up to a single score, varying from 0 to 7. On average, respondents can recall 7 words out of 20 while the mean score of mental intactness is around 5.4. Figure 1 indicates a clearly declining pattern of cognition over time in terms of both measures. However, word recall drops more dramatically between 45 and 80 years of age. Unlike word recall, mental intactness shows a more stable pattern as age rises. This is consistent with the previous studies that different measures of cognition have different sensitivity to the age decline.

Figure 1 Average score of word recall and mental intactness between age 45 to 80



Notes: sample consists of 18,519 observations for word recall and 13,878 observations for mental intactness, respectively. Dots are the 95% confidence interval. The line represents the mean score of

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[4] According to Tulving (1972), episodic memory is defined as an information processing system that receives and stores information about temporally dated episodes or events and retains various aspects of this information and upon instructions transmit specific retained information to other systems.

[5] TICS are widely used as measures of cognitive functioning that can either be administered over the telephone or face-to-face interviews (Brandt et al.,1988).

mental intactness of each age.

3.2 A general index of childhood condition

The main independent variable, namely individual's childhood conditions, is constructed as a single index. It consists of four dimensions: parental characteristics, childhood wealth, childhood health status and health care as well as quality of neighborhood up to age 16. The information about an individual's childhood conditions is extracted from the retrospective questions on childhood socio-economic background and other childhood information collected in the third wave of the CHARLS. Parental characteristics include paternal and maternal education level and employment status during childhood, whether father or mother suffered from depression during childhood as well as whether father or mother had any of the following bad habits (alcoholism, smoking, drug, gambling) during childhood. Parental education level and employment status reflect the level of income as well as the cultural background of parental household while the habits and mental disorders of parents could affect their children's behavior (i.e. Everson-rose et al.,2003; Bharadwaj et al., 2014). The second dimension consists of one indicator of whether suffering from hunger and four indicators concerning facilities in the accommodation during childhood (clean water, flushable toilet, private toilet, electricity). Indicators of facilities in the accommodation are often used as a proxy for assets and household long-term wealth (McKenzie, 2005; Mazzonna, 2014). Childhood health status and health care is based on five indicators: self-reported childhood health status, whether respondents confined to bed or home for more than a month because of a health problem during childhood, whether respondents stayed in the hospital for more than a month because of a health problem during childhood, whether respondents received any vaccination during childhood, and whether respondents had a usual source of health care when sick or when they needed advice about health during childhood. According to Harden et al. (2007), environment interacts with genes in producing cognitive abilities. Hence, we also include the dimension concerning the neighborhood quality, including the safety, the cleanness of neighborhood where respondent lived in, as well as the relationship with neighbors during childhood. This dimension represents the investment parents put into their children as well as the environment individuals grew up during childhood. The method of constructing multidimensional childhood index is in line with the approach by Mazzonna (2014). Given the extensive battery of indicators considered, it might produce imprecise coefficient estimates if indicators are included separately in the regressions. Hence, all of these indicators are defined as dummy variables where 1 denotes good status and 0 indicates bad status. For the main analysis, equal weights have been given to each indicator under each dimension and to each dimension (1/4). In the end, after aggregating among all indicators and dimensions, each individual will have their own childhood index, ranging from 0 to 1. In addition, the pair wise correlation between every two dimensions does not exceed 16%, which means that each dimension contains their own information and does not completely overlap with each other (see table 1.1 and 1.2). Dimensions are positively correlated with each other, hence it partly reassures the consistency of answers between different domains of the survey. The constructed childhood index will be used to explore the effect of childhood conditions on the later-life cognition.

Table 1.1 Correlation table of four dimensions of childhood index for the sample of word recall

	parental characteristics	childhood wealth	childhood health status and health care	childhood neighborhood
parental characteristic	1			
childhood wealth	0.161	1		
childhood health status and health care	0.104	0.121	1	
childhood neighborhood	0.084	0.097	0.089	1

Notes: Sample include 18,519 observations.

Table 1.2 Correlation table of four dimensions of childhood index for the sample of mental intactness

	parental characteristics	childhood wealth	childhood health status and health care	childhood neighborhood
parental characteristic	1			
childhood wealth	0.156	1		
childhood health status and health care	0.089	0.113	1	
childhood neighborhood	0.090	0.096	0.075	1

Notes: Sample include 13,878 observations.

Table 2 presents the distribution of the childhood index among different percentiles. For both samples, childhood index varies from 0.5 to 0.8 for different percentiles. For instance, the median value of childhood index is around 0.7 for both sample of word recall and mental intactness.

Table 2 The distribution of childhood index

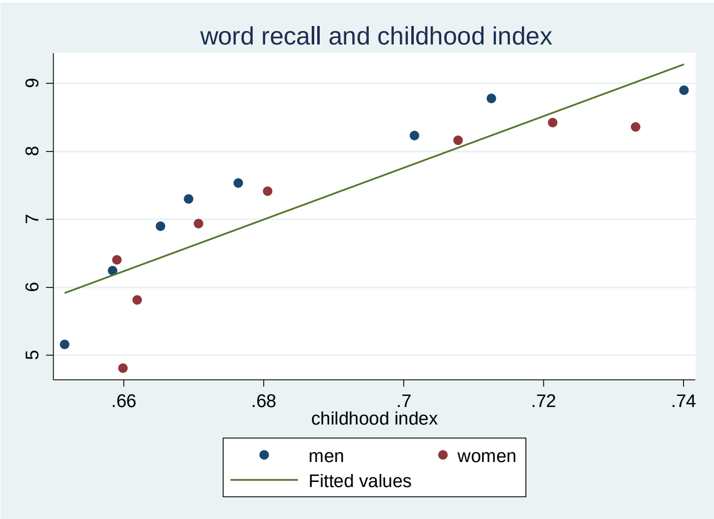
Word recall[1]		10%	25%	50%	75%	90%	mean
	Childhood index	0.560	0.623	0.688	0.738	0.788	0.683
Mental intactness[2]		10%	25%	50%	75%	90%	mean
	Childhood index	0.571	0.625	0.704	0.756	0.806	0.691

Notes: [1]Sample include 18,519 observations.

[2]Sample include 13,878 observations.

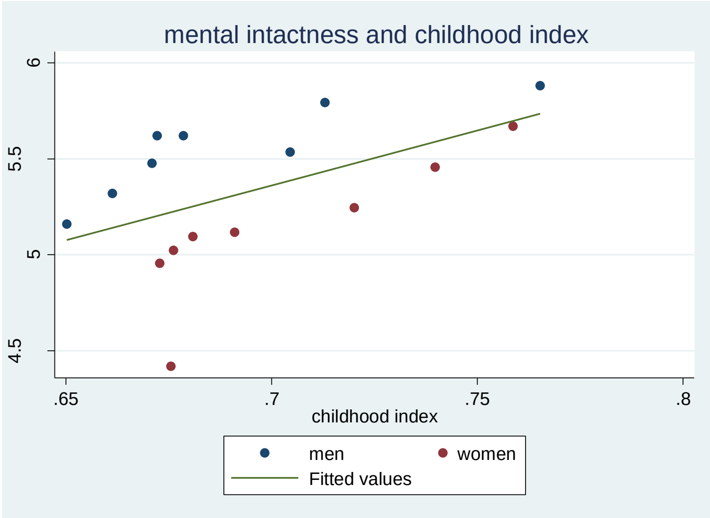
We then plot a graph between two measures of cognitive functioning and childhood index in order to provide an intuition into basic relationship. According to Figure 2.1, word recall is positively associated with childhood index which indicates that the better the childhood conditions, the higher the cognition level will be achieved at old ages. The same pattern is also found for mental intactness in Figure 2.2, but the slope is much flatter. The figure also depicts that Chinese men perform better than women in terms of mental intactness on average.

Figure 2.1 Scatter plot between word recall and childhood index



Notes: sample consists of 18,519 observations. Dots are the average value of word recall scores and childhood index by nine age classes between male and female. The green line represents the linear prediction of word recall on childhood index.

Figure 2.2 Scatter plot between mental intactness and childhood index



Notes: sample consists of 13,878 observations. Dots are the average value of word recall scores and childhood index by nine age classes between male and female. The green line represents the linear prediction of mental intactness on childhood index.

3.3 Other covariates

For the other important covariates, age and age square have been included to model nonlinear age profile of cognitive functioning. In addition, number of children, presence of spouse, cohort dummies, gender, marital status, education level, habit of drinking alcohol and regions are used to control for all other household characteristics and individual socio-economic status that are likely to influence late life cognitive functioning. Notably, the Chinese specific household registration system (known as hukou system), which has started since 1950s, determines the socio-economic policies that urban and rural hukou holders can benefit from during their whole life. This leads to a great urban-rural divide in terms of various aspects of well-being in China[6]. Hence, we controlled for different hukou type (rural or urban hukou holder).

Table A (in Appendix) reports the descriptive statistics for each sample of using word recall and mental intactness as dependent variables. For example, the average age of our sample is around 59.

4. Main results

The descriptive statistics and graphs illustrated above have shown a strong association between childhood conditions and old age cognition. This section is divided into two parts according to the method we used. We start with the simple ordinary least squares(OLS) analysis where we pool the panel information to

[6] For more details, please refer to the paper by Brugiavini et al. (2018).

investigate how childhood index constructed in the last section affects later life cognition. Subsequently, we perform panel data analysis with fixed effect to overcome the limits of the OLS analysis. We assess explicitly whether the same change in age will result in different outcomes of cognition for different levels of childhood index.

4.1 Ordinary least squares analysis

We start to examine the effect of childhood index on cognition based on the entire sample who answered questions and performed cognition test in three regular waves by using the ordinary least squares (OLS) estimation. The empirical specification is shown in equation (1).

$$Y_{it} = \alpha + AGE_{it}^{'}\beta_1 + AGE_{it}^{2'}\beta_2 + CHILD_i^{'}\beta_3 + z_{it}^{'}\gamma_1 + w_i^{'}\gamma_2 + c_i + \varepsilon_{it} \quad (1)$$

Y_{it} is the outcome variable (word recall and mental intactness). The estimated coefficient of $CHILD_i$ is of the main interest to explore the impact of childhood index. We include the quadratic term of age. The set of time-varying control variables are denoted by z_{it}, while time-invariant covariates are denoted by w_i. c_i is the individual-specific unobserved component. In OLS, c_i is assumed to be uncorrelated with all other explanatory variables (it falls in the error term).

We first examine the direct impact of childhood conditions on later-life cognitive functioning. Table 4.1 shows the regression results after adding a complete set of covariates, where Model 1 presents the result of using word recall as a dependent variable and Model 2 shows the outcome of mental intactness. Childhood index has a significantly positive impact on both word recall and mental intactness at critical level 1% as expected. If we consider an extreme case when childhood index improves from 0 (the worst case) to 1 (the best base), individuals can recall two more words and improve their mental intactness scores by 0.48 on average[7]. In other words, the average word recall score will be increased by around 27% (=2/7.38) while mean score of mental intactness can be raised by 9% (=0.48/5.4), considering the percentage variation with respect to the mean. The magnitude of improving the average word recall score is three times as large as that of mental intactness. Furthermore, we have controlled for education in this analysis as we intend to assess the impact of childhood condition on cognitive functioning on top of its education

[7] Everything else constant, if mortality rates are higher for individuals experiencing worse childhood conditions, the estimate of the coefficient on childhood index is likely to be downward biased since the individuals with worse childhood conditions observed in our data are likely to have unobserved characteristics, such as genetic endowments, that improved both their survival chances (CHARLS reference population consist of individuals aged 45 or over) and their cognitive functioning outcome

effects. Increasing childhood index by one is nearly equivalent to improve the education level from illiterate to secondary education level in the case of the word recall.

Table 4.1 Coefficient estimates of OLS regressions of word recall and mental intactness without the interactions

	Model 1	Model 2
VARIABLES	Word recall	Mental intactness
age	0.239***	-0.050
	(0.061)	(0.039)
age^2	-0.003***	0.0003
	(0.001)	(0.0003)
Cohort 1940-1949	-0.259	0.134
	(0.194)	(0.130)
Cohort 1950-1959	-0.477*	0.053
	(0.245)	(0.165)
Cohort 1960+	-0.390	-0.216
	(0.279)	(0.186)
Childhood index	2.094***	0.476**
	(0.318)	(0.195)
urban	0.879***	0.137***
	(0.081)	(0.046)
primary education	1.236***	0.746***
	(0.081)	(0.072)
secondary education	2.386***	1.159***
	(0.093)	(0.075)
tertiary education	3.948***	1.452***
	(0.233)	(0.112)
female	0.351***	-0.276***
	(0.065)	(0.042)
separated	0.280	-0.493
	(0.440)	(0.444)
divorced	0.255	0.0369
	(0.380)	(0.216)
widowed	0.103	0.0748
	(0.159)	(0.111)
never married	-0.628	-0.792*
	(0.868)	(0.480)
# of children	-0.028	-0.021
	(0.028)	(0.017)

(continues)

(continued)

VARIABLES	Word recall	Mental intactness
spouse	0.205*	0.226***
	(0.121)	(0.085)
drinking alcohol	-0.007	-0.027
	(0.064)	(0.040)
east	0.392***	0.405***
	(0.078)	(0.047)
central	0.056	0.336***
	(0.078)	(0.047)
north	0.551***	0.221***
	(0.117)	(0.073)
Constant	-0.382	5.911***
	(1.767)	(1.134)
Observations	18,519	13,878
R-squared	0.190	0.074
joint significance of age,age^2	0	0.002
p-value F-test marital status	0.802	0.264
p-value F-test cohorts	0.112	0.001
p-value F-test regions	0	0
P-value F-test education levels	0	0

Standard errors are clustered to account for intrahousehold correlation in the error term.

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

Next, marginal effects of age are computed at age 45, 50, 55, 60, 65, 70, 75, 80[8] so as to see the trajectory of cognitive functioning across ages. The effect of an additional year of age on word recall has a statistically negative effect since age 50 and its magnitude ascends gradually from -0.029 at age 50 to -0.19 at age 80. This implies that cognitive functioning will deteriorate more than five times faster in 30 years of time for each elderly. The empirical finding is in line with the theoretical model that cognitive ability declines with age. Noticeably, considering a less extreme case, changing childhood condition from 0.6 (first quartile of the childhood indicator distribution) to 0.7 (third quartile) will improve the word recall score by 0.2, which can compensate the effect of an additional year of age at age 80 or the effect of 10 additional years of age at age 50.

[8]For the sample of word recall, the other covariates are set to rural hukou holder, female, the married, primary education, west region, belong to cohort 1950-1959, three children, in presence of spouse, without the habit of drinking alcohol. For the sample of mental intactness, the other covariates are set to rural hukou holder, male, the married, primary education, east region, belong to cohort 1950-1959, two children, in presence of spouse, without the habit of drinking alcohol. The value of each variable is determined according to the category with the highest proportion of the whole sample for categorical variables and the mean for continuous variables. Same values are used in calculating the marginal effect of age for all OLS regressions in this paper.

For mental intactness, the negative marginal effect of age is found to be statistically significant only between age 45 to 65. We did not find any clear pattern as found from word recall. In contrast, mental intactness seems to decline slightly at the beginning of old age and then keeps stable.

Table 4.2 Marginal effect of an additional year of age on expected word recall and mental intactness

AGE	Word recall	Mental intactness
45	-0.002	-0.026**
	(0.016)	(0.010)
50	-0.029**	-0.024***
	(0.012)	(0.008)
55	-0.056***	-0.021***
	(0.009)	(0.006)
60	-0.082***	-0.018***
	(0.009)	(0.006)
65	-0.109***	-0.016**
	(0.011)	(0.007)
70	-0.136***	-0.013
	(0.015)	(0.009)
75	-0.163***	-0.010
	(0.019)	(0.012)
80	-0.190***	-0.008
	(0.024)	(0.015)

18,519 observations for word recall and 13,878 observations for mental intactness.

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

Equation (1) tells us how childhood index can influence late-life cognition. However, it does not allow us to comment on whether the age decline varies with childhood conditions, which is the focus of this paper. Hence, in equation (2), we include interactions between age polynomial and childhood index in order to explore the age-related cognitive decline.

$$\mathrm{Y_{it}} = \alpha + \mathrm{AGE}_{it}'\beta_1 + \mathrm{AGE}_{it}^{2\,\prime}\beta_2 + \mathrm{CHILD}_i'\beta_3 + \mathrm{AGE}_{it}' * \mathrm{CHILD}'_i\beta_4 + \mathrm{AGE}_{it}^{2\,\prime} * \mathrm{CHILD}'_i\beta_5 + z_{it}'\gamma_1 + w_i'\gamma_2 + c_i + \varepsilon_{it} \qquad (2)$$

In equation (2), we include interactions between age and childhood index in order to further assess whether the same change in age has different consequences on cognition depending on the levels of childhood index, holding other covariates being equal. Regression results are presented in Table 5.1. Marginal effect are calculated at every 5 years between 45 and 80 as reported in Table 5.2. We set the value of childhood index to 0 (the worst case) and 1 (the best case) in order to compare the difference in marginal effect of age on cognitive functioning between different levels of childhood index. As shown in Table 5.1 and 5.2, word recall starts to decline slightly earlier for the best case than the worst case as the effect of an additional year of age has a negative impact since age 55 when childhood index is equal to 1, statistically significant at 1% critical level. However, cognition from the worst case seems to drop much faster than the best case. For instance, when skipping the age from 60 to 80, the marginal effect of age on the word recall jumps from -0.073 to -0.32 (4.5 times) for the worst case and it only changes from -0.085 to -0.13 (1.6 times) for the best case. In column three, we test the significance of the difference between two marginal effects at each age. However, we do not find any significant result. Mental intactness is less sensitive to the age-related decline and we do not observe any clear pattern from it.

Furthermore, we also find strong effects of other control variables such as gender, education, hukou status, and regions. For instance, females tend to perform better than males in terms of word recall while the result is reversed for the mental intactness. Lei et al. (2014) also show similar results using CHARLS data in 2011. Once controlling for all the other socio-economic characteristics, Chinese women score somewhat better than Chinese men in terms of word recall while they perform much worse than Chinese men regarding the mental intactness measure. We find that people who obtained a higher education level tend to obtain a higher cognitive score late in life. Urban hukou holders and married people are more likely to have a better cognitive performance than their counterparts in terms of both measures of cognition[9].

To sum up, consistent with the theoretical models, the exposure to better childhood conditions lead to higher levels of cognitive skills later in life. The positive effect of improving childhood conditions on cognition exceeds the negative effect of age. However, the effect of an additional year of age on the late-life cognition seems not to differ between different levels of childhood conditions according to the results of OLS analysis.

[9] We also tried the other specifications by adding the interactions between cohorts and hukou dummies in order to control for the effect of changes in social policies across time and between rural/urban hukou holders. However, we do not find significant impact of the interactions. Results are kept the same.

Table 5.1 Coefficient estimates of OLS regressions of word recall and mental intactness with interactions between childhood index and age

	Model 3	Model 4
VARIABLES	Word recall	Mental intactness
Age	0.674**	0.092
	(0.285)	(0.187)
Age^2	-0.006***	-0.001
	(0.002)	(0.002)
Cohort 1940-1949	-0.287	0.124
	(0.195)	(0.130)
Cohort 1950-1959	-0.499**	0.046
	(0.245)	(0.165)
Cohort 1960+	-0.397	-0.217
	(0.280)	(0.186)
Childhood index	20.59*	6.328
	(11.81)	(7.524)
Childhood index*age	-0.617	-0.201
	(0.399)	(0.256)
Childhood index*age^2	0.005	0.002
	(0.003)	(0.002)
Urban	0.879***	0.137***
	(0.081)	(0.046)
primary education	1.238***	0.747***
	(0.081)	(0.073)
secondary education	2.387***	1.161***
	(0.093)	(0.075)
tertiary education	3.943***	1.452***
	(0.233)	(0.112)
Female	0.350***	-0.276***
	(0.065)	(0.042)
Separated	0.284	-0.484
	(0.439)	(0.446)
Divorced	0.255	0.038
	(0.381)	(0.216)
Widowed	0.101	0.075
	(0.159)	(0.111)
never married	-0.636	-0.794*
	(0.871)	(0.479)
# of children	-0.028	-0.021
	(0.028)	(0.017)
Spouse	0.203*	0.226***
	(0.121)	(0.085)

(continues)

(continued)

VARIABLES	Word recall	Mental intactness
Drinking alcohol	-0.006	-0.027
	(0.064)	(0.040)
East	0.392***	0.405***
	(0.076)	(0.048)
Central	0.057	0.337***
	(0.078)	(0.047)
North	0.552***	0.221***
	(0.117)	(0.073)
Constant	-13.43	1.758
	(8.458)	(5.532)
Observations	18,519	13,878
R-squared	0.190	0.074
joint significance of age,age^2	0	0.435
p-value F-test marital status	0.803	0.268
p-value F-test cohort	0.099	0.002
p-value F-test regions	0	0
p-value F-test education levels	0	0

Standard errors are clustered to account for intrahousehold correlation in the error term.

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

Table 5.2 Marginal effect of an additional year of age on expected word recall and mental intactness by childhood condition groups

AGE	Word recall			Mental intactness		
	CC=0	CC=1	Difference	CC=0	CC=1	Difference
45	0.114	-0.050	-0.164	0.009	-0.040*	-0.049
	(0.076)	(0.035)	(0.104)	(0.049)	(0.02q)	(0.066)
50	0.052	-0.061**	-0.113	-0.001	-0.032**	-0.032
	(0.054)	(0.025)	(0.074)	(0.035)	(0.015)	(0.046)
55	-0.010	-0.073***	-0.063	-0.01	-0.025**	-0.015
	(0.035)	(0.017)	(0.047)	(0.022)	(0.010)	(0.029)
60	-0.073***	-0.085***	-0.012	-0.019	-0.017*	0.002
	(0.025)	(0.014)	(0.035)	(0.017)	(0.009)	(0.023)
65	-0.135***	-0.096***	0.039	-0.029	-0.009	0.019
	(0.034)	(0.020)	(0.049)	(0.023)	(0.013)	(0.033)
70	-0.197***	-0.109***	0.088	-0.038	-0.001	0.036
	(0.053)	(0.029)	(0.076)	(0.036)	(0.019)	(0.051)
75	-0.259***	-0.120***	0.139	-0.047	0.006	0.053
	(0.075)	(0.039)	(0.107)	(0.050)	(0.026)	(0.071)
80	-0.322***	-0.132***	0.189	-0.056	0.014	0.070
	(0.097)	(0.050)	(0.138)	(0.065)	(0.032)	(0.091)

Notes: “CC=0” refers to the case when childhood index is equal to 0. “CC=1” refers to the case when childhood index is equal to 1. 18,519 observations for word recall and 13,878 observations for mental intactness.

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

4.2 Fixed effect analysis

In the previous section, we estimate our specification of interest (equation 2) by OLS. Nevertheless, our specification might suffer from endogeneity issues. First of all, our set of control variables includes education, which can result to be endogenous to cognitive functioning due to innate skills. Individuals endowed with more valuable or better skills might achieve higher educational attainments and maintain higher cognitive functioning late in life. These skills might also be inherited from parents and this pattern would produce a further source of bias in our estimates since such intergenerational transmission of skills might produce a spurious correlation between parental characteristics related to education and employment, which are included in our childhood indicator, and the cognitive functioning of respondents. Moreover, transmission of genes from parents to children might constitute a further source of endogeneity for our childhood indicator as parental genes that make respondents’ parents healthier might positively impact on respondents health during childhood, which is a dimension of our childhood indicator, and positively affect cognitive functioning development along the life course (Stern, 2002). It is also worth noting that unobserved parental characteristics (such as innate skills and genes) can also affect the health of respondents during childhood via their prenatal conditions (see for instance, Case and Paxson, 2002; Sonchak, 2015), which we cannot observe in our data. Based on all these patterns, it might be argued that the unobserved heterogeneity summarized by the c_i component showing up in equation 2 encompasses relevant determinants of cognitive functioning correlated with the covariates included in the model. Neglecting this issue is expected to produce an upward bias in the estimate of the role of childhood condition as a determinant of cognitive functioning. We will exploit the panel dimension of our data to take into account the presence of unobserved fixed effects which affect the current cognitive abilities of respondents and are arbitrary correlated with our covariates.

Finally, our analysis is by construction conditional on the survival of respondents. The reference population of CHARLS includes only individuals aged 45 or over and then discards those who die earlier. As long as the longevity prospects of those who survive are different from those who do not survive due to unobserved characteristics, such as genetic endowment, that can affect cognitive functioning along the life cycle as well (see Van den Berg et al., 2010), the sample selection might be endogenous and our results could not be extended to the whole population. The use of empirical specifications that allow for unobserved fixed effects is useful to take into account this further source of endogeneity.

The childhood indicator variable is by construction time invariant. Although the fixed effect estimation does not allow to identify the parameter on this variable (β_3 in equation 2), it still allows to recover valid estimates of the interaction terms between this variable and the second order polynomial of age, which is of key interest for our study given its focus on understanding whether a given variation in age has an impact on cognitive functioning that depends on childhood conditions. Moreover, in FE, time-invariant explanatory variables like marital status and gender are dropped and c_i is assumed to be arbitrarily correlated with other explanatory variables

Table 6.1 depicts the regression results from the FE analysis. Based on the regression results, marginal effects of age are computed for the worst case (childhood index is equal to 0) and the best case (childhood index is equal to 1)[11] at age 45, 50, 55, 60, 65, 70, 75 and 80. As reported in Table 6.2, for the worst case, word recall starts to decline since age 45 while for the best case, word recall starts to decline much later. According to the table, for individuals experienced the worst childhood conditions, the negative effect of an additional year of age on the word recall reinforces from -0.234 to -0.732 between age 45 to age 80. On the contrary, word recall does not suffer from such a faster deterioration across age in terms of the best case. We then test the statistical significance between the marginal effects of age between two cases. We find a strongly significant difference and such a difference seems to become larger as age increases. Hence, word recall declines faster when the level of childhood conditions is low than when the level of childhood conditions is high. Consistent with the previous results, mental intactness does not show such a pattern and less likely to decline with age.

Comparing the results from the OLS and FE analysis, we find somewhat different evidence in terms of the variation in age decline between different levels of childhood conditions. However, as discussed at the beginning of this section, the OLS analysis might suffer from endogeneity problem while the FE effect can overcome such limits. Hence, the results from the FE analysis are in favor of the importance of controlling for individual fixed effects. We find that the score of word recall when childhood conditions are better tends to drop later and more slowly than that when childhood conditions are worse after controlling for unobserved individual fixed effect. Mental intactness is more stable and less sensitive to the age-related

[11] For both the regressions used word recall and mental intactness as dependent variables, the other covariates are set to the married and no habit of drinking alcohol). We use the same values for all the FE analysis in this paper.

decline[12].

Table 6.1 Coefficient estimates of FE linear regressions of word recall and mental intactness by childhood groups

	Model 5	Model 6
VARIABLES	Word recall	Mental intactness
Age	0.407	0.291
	(0.509)	(0.336)
Age^2	-0.007*	-0.003
	(0.004)	(0.003)
Childhood index*age	0.117	-0.298
	(0.709)	(0.488)
Childhood index*age2	0.003	0.002
	(0.006)	(0.004)
Separated	0.101	-0.472
	(0.600)	(0.521)
Divorced	-0.758	-0.593
	(0.592)	(0.391)
Widowed	-0.582***	-0.254
	(0.204)	(0.156)
never married	-0.846	-0.415
	(0.816)	(0.774)
Drinking alcohol	0.115	-0.055
	(0.084)	(0.059)
Constant	-3.582	4.164***
	(2.306)	(1.396)
Observations	18,519	13,878
R-squared	0.018	0.005
joint significance of age,age^2	0	0.648
p-value F-test marital status	0.040	0.298

Standard errors are clustered to account for intrahousehold correlation in the error term.

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

[12] In addition, results might be amplified (attenuated) by better (worse) social policies due to urban (rural) hukou type. Hence, we also estimated the same regressions separately for rural and urban hukou. We use the whole sample and add interactions between hukou and other covariates to test the difference between rural and urban hukou. However, we did not find any evidence of significant result by hukou type.

Table 6.2 Marginal effect of an additional year of age on expected word recall and mental intactness by childhood condition groups

age	Word recall			Mental intactness		
	CC=0	CC=1	Difference	CC=0	CC=1	Difference
45	-0.234*	0.165***	0.399**	0.060	-0.042	-0.101
	(0.138)	(0.053)	(0.189)	(0.094)	(0.042)	(0.133)
50	-0.305***	0.125***	0.430***	0.034	-0.046	-0.079
	(0.105)	(0.042)	(0.143)	(0.072)	(0.032)	(0.102)
55	-0.376***	0.085**	0.461***	0.008	-0.050*	-0.058
	(0.080)	(0.035)	(0.112)	(0.057)	(0.026)	(0.081)
60	-0.447***	0.045	0.492***	-0.018	-0.053**	-0.036
	(0.075)	(0.038)	(0.110)	(0.054)	(0.027)	(0.078)
65	-0.519***	0.005	0.524***	-0.043	-0.057*	-0.014
	(0.092)	(0.049)	(0.137)	(0.064)	(0.034)	(0.095)
70	-0.590***	-0.035	0.555***	-0.069	-0.061	0.008
	(0.122)	(0.064)	(0.182)	(0.083)	(0.044)	(0.124)
75	-0.661***	-0.075	0.586**	-0.095	-0.065	0.030
	(0.156)	(0.081)	(0.234)	(0.106)	(0.056)	(0.159)
80	-0.732***	-0.115	0.617**	-0.120	-0.069	0.052
	(0.198)	(0.099)	(0.289)	(0.132)	(0.069)	(0.196)

Notes: "CC=0" refers to the case when childhood index is equal to 0. "CC=1" refers to the case when childhood index is equal to 1. 18,519 observations for word recall and 13,878 observations for mental intactness.

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

5. Extensions and sensitivity analysis

For the baseline model, we use the entire sample and include the interactions between age and childhood index in order to examine the effect of age on the late-life cognition given different levels of childhood index. To assess the robustness of our main findings, we first split the sample into favorable and unfavorable childhood condition groups as it is a more flexible way to allow the specification to vary between two groups of people. We then use the alternative weighting scheme to construct childhood conditions index.

5.1 Splitting the sample into favorable and unfavorable childhood condition groups

As an alternative way to assess whether the same change in age has a different outcome for different levels of childhood conditions keeping other variables constant, we divided our sample into two groups: favorable childhood conditions and unfavorable childhood conditions groups. We use the median as a threshold to distinguish two groups of people. The favorable childhood conditions group is defined as those with the childhood index above the median value for each sample

while unfavorable childhood conditions group includes those whose childhood index is equal or below the median value. We use the FE analysis to check the results.
After controlling for unobserved individual effects, the joint significance of age and age square on two measures of cognition is statistically significant at 1% for both favorable and unfavorable childhood conditions groups. Marginal effect of an additional year of age on both measures of cognition are then computed as in the baseline model. According to Table B.1 and Table B.2 (in Appendix), the marginal effect of age on the word recall is found to be negative for unfavorable childhood conditions group since age 50. The deteriorated effect of age will be increased by six times more in 30 years from age 50 to 80. For favorable childhood conditions group, word recall starts to decline 10 years later. The magnitude is much smaller. Moreover, the difference in marginal effect between two groups is statistically significant and the gap rises mildly as age goes up. No clear pattern can be found in terms of mental intactness. Overall, this result confirmed what we found above.

5.2 Alternative weighting scheme

For the main results, we use the equal weights to construct childhood conditions index. Alternatively, we apply the frequency-based weighting scheme to check whether our results keep the same regardless of different weighting schemes. Following Desai and Shah (1988)'s work, each indicator receives a weight equal to the corresponding proportion of the non-deprived in the sample[13]. Result of FE analysis is presented in Table C.1 in Appendix and marginal effect of age for the worst and best cases is shown in Table C.2. As found in the benchmark model, for the worst case, word recall tends to descend earlier than the best case. The path of the age-related decline is steeper for the worst case than the other. The difference in the marginal effect of age is statistically significant. Mental intactness does not have such a pattern. Thus, main conclusion remains the same regardless of weightings scheme we use.

6. Conclusion

This paper investigates the impact of childhood condition on the late-life cognitive functioning based on the CHARLS data collected in 2011, 2013 and 2015. It considers two alternative measures of cognitive functioning: word recall and mental intactness. The word recall measure is based on the respondents' outcomes when performing a recall tests administered within the CHARLS interview and is more related to fluid cognitive ability, which are expected to be more sensitive to the decline over time (i.e. Bäckman, 2005). The mental intactness measure is mostly based on respondents' answers to numerical tests and it is informative to assess the crystallized cognitive

[13] It is standardized to sum up to 1 by construction.

abilities of individuals (i.e. Schaie, 1994).

Our analysis is aimed at investigating whether, everything else constant, the same change in age will have consequences on the two cognition measures considered that depend on the early life conditions experienced by individuals. Childhood conditions are described by a multidimensional indicator based on information about parental characteristics, such as education and employment, hunger and material deprivation, respondents' health during childhood and quality of the neighborhood where respondents grew up.

The main findings of this study are based on empirical specifications exploiting the longitudinal dimension of CHARLS to take into account potential sources of unobserved heterogeneity that affects both cognitive functioning and early life conditions. For instance, intergenerational transmission of health (Currie and Moretti, 2007; Coneus and Spiess, 2012) and skills (Anger and Heineck, 2010) from parents to children might induce a spurious correlation between current cognitive functioning of respondents and several dimensions considered in the childhood index, such as respondents health during childhood as well as parental education and employment outcomes. Moreover, in our empirical analysis it is advisable to control for education in order to rule out the possibility that the influence in early life conditions on cognitive functioning late in life can be entirely explained by heterogeneity in educational attainments. However, it might be argued that education, albeit time invariant for our population of reference, is endogenous with respect to cognitive abilities due to innate skills which might be either individual-specific or inherited from parents due to the intergenerational patterns mentioned above. We will take advantage of the longitudinal dimension of CHARLS to estimate our specifications controlling for unobserved fixed effects arbitrarily correlated with our covariates of interest.

Our findings show that childhood conditions play a strong role in shaping the age decline of fluid cognitive functioning late in life. Everything else constant, the same variation in age is found to have a stronger adverse effect on the word recall outcomes of individuals experiencing poorer childhood conditions. This gap increases with age, suggesting that the gains from better early life conditions remains substantial even at older ages. Noticeably, results deeply change when looking at mental intactness measure. Childhood conditions are not found to affect the marginal effect of age on mental intactness much. This result is in line with the psychology literature (Horn and Cattell, 1967) that shows crystallized cognitive abilities are less likely to decrease over time. Our results also provide evidence that childhood conditions can shape cognition later in life, such as through different channels such as income or education effects (Brunello et al., 2017; Mazzonna, 2014).

To conclude, results are consistent with the hypothesis that the returns from investments in cognitive skills production in the early stages of the life-cycle can shave off the deterioration of these skills at later ages and witness the long-lasting impact of inputs related to the parental characteristics, such as education and economic status, household wealth, health care and quality of neighborhood. Cognitive functioning of those individual experienced more favorable childhood conditions (i.e. higher quality parental investments, better health care systems, more equipped household facilities, higher quality neighborhoods) will start to decline later and less rapidly than those with worse childhood conditions. It also informs policy makers about the intergenerational consequences of public policies designed to improve the social and economic inclusion of individuals. Monitoring and helping those children under worse childhood environment at current generation could help improve old-age cognition and slow down their cognitive decline for the future generation. As China is facing an increasing ageing population, the costs and the inputs of the care for cognitively impaired elderly will undoubtedly increase in the future. For the current younger generations, developing programs that increase the social inclusion of those experiencing adverse conditions during childhood may improve their cognition in the long run and mitigate the demand of care and support services for cognitively impaired individuals in the next decades.

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Appendix

Table A Descriptive statistics for the sample of word recall and mental intactness

	Overall sample of word recall (18,519 observations)		Overall sample of mental intactness (13,878 observations)	
Variable	Mean	Std. Dev.	Mean	Std. Dev.
Cognition measures				
Word recall	7.383	3.368	-	-
Mental intactness	-	-	5.399	1.798
Childhood index	0.683	0.096	0.691	0.095
Age	58.896	8.217	58.660	8.175
Age2	3536.198	983.541	3507.774	976.104
Hukou status				
rural	0.796	0.403	0.752	0.432
urban	0.204	0.403	0.248	0.432
Gender				
male	0.488	0.500	0.579	0.494
female	0.512	0.500	0.421	0.494
Marital status				
married	0.911	0.285	0.921	0.269
separated	0.003	0.050	0.002	0.045
divorced	0.006	0.079	0.006	0.078
widowed	0.079	0.270	0.069	0.254
never married	0.001	0.037	0.002	0.039
# of children	2.562	1.269	2.482	1.244
Spouse	0.869	0.338	0.882	0.322
Drinking alcohol	1.727	0.445	1.687	0.464
Regions				
west	0.324	0.468	0.306	0.461
east	0.310	0.462	0.317	0.465
central	0.290	0.454	0.296	0.457
north	0.077	0.266	0.081	0.273
Cohorts				
<1939	0.044	0.205	0.040	0.196
1940-1959	0.250	0.433	0.248	0.432
1950-1959	0.407	0.491	0.397	0.489
1960+	0.299	0.458	0.315	0.464
Education level				
illiterate	0.208	0.406	0.090	0.286
primary	0.416	0.493	0.436	0.496
secondary	0.356	0.479	0.446	0.497
tertiary	0.020	0.141	0.028	0.164

Table B.1 Coefficient estimates of FE of word recall and mental intactness by favorable and unfavorable childhood condition groups

	Model 7		Model 8	
VARIABLES	Word recall		Mental intactness	
	unfavorable	favorable	unfavorable	Favorable
age	0.469***	0.542***	0.159**	0.038
	(0.123)	(0.086)	(0.071)	(0.066)
age^2	-0.005***	-0.005***	-0.002***	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
separated	-0.979	2.232***	-0.619	-0.129
	(0.751)	(0.722)	(0.689)	(0.731)
divorced	-0.831	-1.086	-0.454	-0.700
	(0.733)	(0.933)	(0.597)	(0.493)
widowed	-0.975***	-0.305	-0.474**	-0.044
	(0.274)	(0.290)	(0.221)	(0.220)
never married	-1.920*	0.337	-0.596	-0.247
	(1.080)	(0.917)	(1.216)	(0.532)
Drinking alcohol	0.031	-0.241**	0.101	0.006
	(0.116)	(0.121)	(0.082)	(0.086)
Constant	-1.931	-5.917**	1.368	6.052***
	(3.709)	(2.411)	(2.117)	(1.878)
Observations	8,733	9,786	6,825	7,053
R-squared	0.030	0.010	0.005	0.007
joint significance of age,age2	0	0	0.005	0
p-value F-test marital status	0.003	0.012	0.221	0.720

Standard errors are clustered to account for intrahousehold correlation in the error term.

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

Table B.2 Marginal effect of an additional year of age on expected word recall and mental intactness by favorable and unfavorable childhood condition groups

AGE	Word recall			Mental intactness		
	Unfavorable	Favorable	Difference	Unfavorable	Favorable	Difference
45	-0.003	0.083***	0.086***	0.020	-0.035**	-0.055**
	(0.034)	(0.021)	(0.039)	(0.020)	(0.016)	(0.025)
50	-0.056**	0.032**	0.088***	0.005	-0.043***	-0.048***
	(0.025)	(0.016)	(0.030)	(0.015)	(0.012)	(0.019)
55	-0.108***	-0.019	0.089***	-0.011	-0.051***	-0.040***
	(0.018)	(0.014)	(0.023)	(0.012)	(0.010)	(0.015)
60	-0.161***	-0.070***	0.090***	-0.026**	-0.059***	-0.033*
	(0.015)	(0.016)	(0.022)	(0.011)	(0.011)	(0.016)
65	-0.213***	-0.121***	0.092***	-0.042***	-0.067***	-0.025
	(0.019)	(0.021)	(0.028)	(0.013)	(0.015)	(0.020)
70	-0.266***	-0.173***	0.093**	-0.057***	-0.075***	-0.018
	(0.026)	(0.028)	(0.037)	(0.017)	(0.020)	(0.026)
75	-0.318***	-0.224***	0.095*	-0.073***	-0.083***	-0.011
	(0.035)	(0.035)	(0.048)	(0.022)	(0.025)	(0.033)
80	-0.371***	-0.275***	0.096	-0.088***	-0.091***	-0.003
	(0.044)	(0.042)	(0.060)	(0.028)	(0.030)	(0.041)

Notes: “Favorable” is defined as those with the childhood index above the median value for each sample while “Unfavorable” includes those whose childhood index is equal or below the median value.18,522 observations for word recall and 13,878 observations for mental intactness.

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

Table C.1 Coefficient estimates of FE of word recall and mental intactness using frequency-based weighting scheme

	Model 9	Model 10
VARIABLES	Word recall	Mental intactness
age	0.866	0.708
	(0.702)	(0.514)
age^2	-0.0114*	-0.00582
	(0.00588)	(0.00427)
separated	0.0836	-0.481
	(0.604)	(0.519)
divorced	-0.757	-0.594
	(0.594)	(0.391)
widowed	-0.570***	-0.253
	(0.204)	(0.156)
Never married	-0.862	-0.409
	(0.800)	(0.779)
Drinking alcohol	0.113	-0.0560
	(0.0838)	(0.0593)
Childhood index*age	-0.430	-0.746
	(0.818)	(0.617)
Childhood index*age^2	0.00757	0.00571
	(0.00691)	(0.00516)
Constant	-4.318*	3.996***
	(2.370)	(1.403)
Observations	18,519	13,878
R-squared	0.018	0.005
joint significance of age,age2	0	0.387
p-value F-test marital status	0.0450	0.296

Standard errors are clustered to account for intrahousehold correlation in the error term.

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

Table C.2 Marginal effect of an additional year of age on expected word recall and mental intactness using frequency-based weighting scheme

AGE	Word recall			Mental intactness		
	CC=0	CC=1	Difference	CC=0	CC=1	Difference
45	-0.163	0.0883**	0.251	0.184	-0.0487	-0.233
	(0.191)	(0.0358)	(0.220)	(0.142)	(0.0302)	(0.169)
50	-0.277*	0.0496*	0.327**	0.126	-0.0499**	-0.176
	(0.143)	(0.0269)	(0.165)	(0.107)	(0.0225)	(0.127)
55	-0.392***	0.0109	0.403***	0.0673	-0.0510***	-0.118
	(0.106)	(0.0220)	(0.124)	(0.0790)	(0.0173)	(0.094)
60	-0.506***	-0.0278	0.478***	0.00902	-0.0522***	-0.061
	(0.0953)	(0.0236)	(0.115)	(0.0684)	(0.0171)	(0.083)
65	-0.621***	-0.0665**	0.554***	-0.0492	-0.0534**	-0.004
	(0.118)	(0.0309)	(0.144)	(0.0823)	(0.0221)	(0.101)
70	-0.735***	-0.105***	0.630***	-0.107	-0.0546*	0.052
	(0.160)	(0.0408)	(0.194)	(0.112)	(0.0296)	(0.138)
75	-0.849***	-0.144***	0.705***	-0.166	-0.0557	0.110
	(0.210)	(0.0519)	(0.253)	(0.148)	(0.0384)	(0.182)
80	-0.964***	-0.183***	0.781**	-0.224	-0.0569	0.167
	(0.264)	(0.0635)	(0.317)	(0.187)	(0.0476)	(0.229)

Notes: "CC=0" refers to the case when childhood index is equal to 0. "CC=1" refers to the case when childhood index is equal to 1. 18,519 observations for word recall and 13,878 observations for mental intactness.

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