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Can individual conditions during childhood mediate or moderate the long-term cognitive effects of poor economic environments at birth?

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ABSTRACT

Recent analyses revealed that the business cycle at the time of birth influences cognitive functioning at older ages, and that those individuals born during economic boom periods on average display better cognitive functioning later in life. The current study examines the impact of childhood conditions on late-life cognitive functioning and investigates whether they mediate or moderate the effects of the business cycle at the time of birth. The underlying purpose is to find potential starting points for societal interventions that may counterbalance the negative long-term outcomes of adverse living conditions early in life. We use data from 7935 respondents at ages 60+ in eleven European countries from the first three waves of the Survey of Health, Ageing and Retirement in Europe (SHARE). The survey data was collected in 2004, 2006/07, and 2008/09. Country fixed-effects models are used to examine the impact of macro-economic deviations in the year of birth and the indicators of childhood circumstances on late-life cognitive functioning. This study shows that the effects of boom and recession periods at birth are not simply mediated or moderated by living conditions during childhood. Conditions at birth have biological long-run effects on late-life cognitive functioning. Individuals born during boom periods display signs of having better cognitive functioning later in life, whereas recessions negatively influence cognition. Furthermore, a series of childhood conditions in and of themselves influence late-life cognition. Good childhood cognition, high education as well as a high social status, favourable living arrangements, and good health have a positive impact. Policy interventions should aim at a better access to school or measures to improve the economic and social situations of disadvantaged households.

1. Introduction

As a result of ageing and rising levels of life expectancy, the proportion of older individuals has grown substantially in most developed countries in recent decades. In response to this demographic shift, researchers have increasingly focused on health in ageing populations, especially on the decline in mental health. The need for cognitive fitness is becoming more pressing and the analyses by Skirbekk et al. (2012) showed that macro-level factors, such as education or a higher age at retirement, are associated with an improvement in the relative cognitive performance of a population over the life cycle.

Understanding the determinants of poor mental health among the elderly allows us to identify potential risk groups. A large number of existing studies have shown that the environment during pregnancy and the first months of life may affect the development of vital organs and the immune system, with long-lasting effects on physical and mental health later in life.

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In our previous work, we showed that the business cycle at the time of birth influences cognitive functioning at ages 60+ (Doblhammer et al., 2013), and that individuals born during economic boom periods display signs of better cognition later in life. This current study analyses the influence of childhood conditions on late-life cognitive functioning and to what extent these mediate or moderate the effects of the business cycle at the time of birth. The aim was to find potential starting points for societal interventions that may counterbalance the negative long-term outcomes of adverse living conditions early in life.

We used data from 7935 elderly respondents from the first three waves of the Survey of Health, Ageing and Retirement in Europe (SHARE). We examined a summary score of cognitive functioning at ages 60+, linking this measure to the indicators of childhood and to the macro-economic deviations in the year of birth.

First, we describe pathways that link early-life conditions to late-life well-being and then present possible mediating and moderating effects of living conditions in childhood. We specify the data and describe the statistical method. Finally, we present the results of the regression models and discuss them in light of the literature overview.

1.1. Pathways linking early-life conditions and late-life well-being

The mechanisms underlying the effect of economic boom and recession periods on late-life cognition cannot be easily determined. However, several possible links exist that are closely related to the present knowledge about causal pathways from early-life conditions to late-life outcomes. Boom and recession periods differ plausibly in terms of the quality and quantity of nutrition as well as the psychological stress level in the household. Differences in the extent of types of housing and access to health care might also create differences in disease exposure. Studies on possible pathways linking early-life experiences and later-life outcomes, such as health or mortality, can be divided into those that focus on biology and those that focus on social aspects. While the SHARE data are not suitable for testing biological pathways, the survey did contain indicators that can be linked to biological pathways discussed in the literature. In addition, the third wave of SHARE includes a particularly large amount of life course information that can be linked to social pathways.

Biological pathways may act in different ways. Many conditions increase the risk of poor cognitive functioning and dementia late in life. Foetal malnutrition (Barker, 1994; Kuzawa, 1998), exposure to infectious diseases or other illnesses (Bengtsson and Lindstrom, 2000; Costa, 2000; Crimmins and Finch, 2006; Kuzawa, 1998), childhood adversity (Morozink et al., 2010), and distress during critical periods in utero or early in life (Brunson et al., 2005) have all been shown to affect health outcomes late in life, including mental outcomes. Those conditions directly increase the risk of cognitive functioning and dementia late in life by affecting brain development (Drury et al., 2012; Kuzawa, 1998; Landrigan et al., 2005; Stein et al., 2008) or indirectly by affecting known risk factors for cognitive impairment. Early-life circumstances may affect the hormone system and the inflammation level (Crimmins and Finch, 2006), which in turn leads to a chronic activation of inflammatory pathways and increases the risk of diabetes, cardiovascular diseases, and the metabolic syndrome.

In contrast, social pathways describe the short-term effects of economic conditions on the development of children's cognitive skills (see the overview in (Duncan, 2006)), which may then become persistent due to the level of educational achievement (Borghans et al., 2008). In general, education plays a crucial role in triggering indirect pathways which can lead to worse health outcomes later in life (see the overview in (Cutler and Lleras-Muney, 2008)).

1.2. Mediating or moderating effects of living conditions in childhood

The pathway from conditions at birth, indicated by the business cycle, to the cognitive status in late-life has been shown in our previous work. Now we turn to the conditions in childhood and explore whether they are able to mediate or moderate this pathway. The former considers whether the long-run effects of economic conditions at birth on late-life cognitive impairment run indirectly through childhood conditions. The latter considers whether childhood conditions mitigate or exacerbate adverse conditions at birth.

We investigated the impact of childhood conditions on the long-term consequences of economic fluctuations at the time of birth, thereby classifying five dimensions of childhood conditions: cognitive abilities in childhood, education, early-life social status, living arrangements, and health.

1.2.1. Cognitive abilities in childhood

Cognitive abilities in childhood may work as a mediator since it is known that deprivation in utero and around birth is associated with lower IQ (Shenkin et al., 2004), and cognitive ability influences late-life health, cognition and dementia. Higher childhood intelligence was shown to improve cognitive performance at old age, while people with low childhood intelligence tend to experience cognitive decline (Bourne et al., 2007). Fritsch et al. (2005) found that a high adolescent IQ and greater activity levels in youth reduce the risk of cognitive impairment at higher ages.

1.2.2. Education

Low education has been associated with a greater risk of cognitive impairment (van Hooren et al., 2007) and dementia (Sharp and Gatz, 2011). Within the pathway from early to later life education may act as a mediator by being a surrogate for cognitive abilities in childhood, which in turn are affected by conditions in utero and around birth. Levels of education attained may also work as a moderator without being influenced by conditions earlier in life. One possible explanation is the concept of cognitive reserve (Stern, 2002). The systematic review about the relationship between education and dementia by Sharp and Gatz (2011) stated that “it is important to think of education as a proxy or surrogate indicator.” Therefore, education might be a proxy for the cognitive reserve (Stern, 2002). People with high levels of education tend to process tasks in a more efficient manner and are able to sustain greater brain damage before displaying major functional deficits. Additionally, successful learning, and thus the final educational level, depends not only on intelligence but also on social class at school-going ages (Duncan, 2006) and other personal characteristics: persistence; interest in school; willingness to study; encouragement for academic achievement that is received from family, peers, and teachers; and general cultural factors (Neisser et al., 1996).

1.2.3. Early-life social status

Parental social class may capture determinants that buffer an individual against adverse conditions at birth. Indeed, individuals born into families of low social class may be less likely to reach higher levels of educational attainment (Duncan, 2006). Smith et al. (1998) showed that men whose fathers had manual occupations during a respondent's childhood were more likely to have manual jobs themselves as adults and to be living in deprived areas. Furthermore, they showed higher risks for respiratory diseases and increased cause mortality, and these risks increased with the lower social class of the father.

1.2.4. Living arrangements

Living arrangements in childhood may have mediating or moderating effects on the health pathway from birth to late life. Living as a child in a two-parent household lowers the risk of death at old age (Elo et al., 2010; Hayward and Gorman, 2004; Preston et al., 1998). Being born on a farm or in a rural area seems to have protective effects (Hayward and Gorman, 2004; Preston et al., 1998) on late-life mortality. Contrary to these positive findings on mortality, living in a rural area in childhood increases the risk of Alzheimer's disease later in life (Russ et al., 2012). Adverse socio-economic environments (Morozink et al., 2010) and a harsh family climate in childhood (Miller and Chen, 2010) are known to influence levels of inflammation markers in adolescence and adulthood, possibly through changes in gene expressions. Stress induced early in life may thus engender a pro-inflammatory phenotype. Over time, repeated or chronic inflammatory stress has negative physiological consequences on the body, resulting in a higher risk of chronic diseases later in life.

1.2.5. Health

Childhood health is a determinant of adult socio-economic status and adult health differentials (Palloni et al., 2009). Children born in recession periods are more likely to live in disadvantaged conditions, which can lead to adverse health early in life (Case et al., 2005). Early-life health and nutritional status have been shown to be associated with cognitive functioning late in life (Case and Paxson, 2008). In addition to health care, parental habits have an impact on the development of children. Alcohol exposure during pregnancy can cause permanent brain damage, retarded fetal growth (Nordberg et al., 1993), and deficits in intellectual functioning (Coles et al., 1991). Parental alcohol abuse has an impact on children during the formative ages of 13–27. The children suffer from long-term consequences, such as increased mortality or self-destructive behaviours (Christoffersen and Soothill, 2003).

According to the literature, childhood cognition as well as good childhood health are conceivable mediators in the pathway from early-life conditions to late-life. Education may either be a mediator or a moderator, depending on whether it is more closely linked to cognitive abilities in childhood or to an individual's cognitive reserve. Reasonable health care as well as living within a nurturing family environment may lead to a positive pathway that could mitigate or even compensate for the effects of adverse economic conditions at birth. The same is true for parental social standing, in that a high social status during childhood may amplify the positive or mitigate the negative effects of the conditions at the time of birth.

2. Methods

2.1. Data

We tested the above hypotheses by using the Survey of Health, Ageing and Retirement in Europe (SHARE), including data from all of the countries that participated in all three waves (Sweden, Denmark, Austria, Germany, the Netherlands, France, Switzerland, Belgium, Spain, Italy, and Greece). Our basic sample consisted of 21,273 respondents aged 60+ who were born between 1900 and 1945 and for whom information about cognitive status was available. We included respondents who participated in the first wave of SHARE (conducted in 2004), who participated for the first time in the second wave, or who were part of the refreshment sample of the second wave (2006/07). Over half (11,480) took part in the third wave, called SHARELIFE (2008/09). We excluded birth years 1900–1920 for Greece due to missing data about GDP (53 cases). Furthermore, to avoid possible biases, we excluded all cohorts born during war periods (2846 respondents). Thus, the final sample consisted of 7935 respondents (Table A in supplementary material).

2.2. Measures of cognitive functioning in SHARE

The first and second waves of SHARE included several questions for first-time participants that refer to the general domains of cognition. We used these questions to construct a summary score of cognitive functioning following the specifications of the DemTect scale. This measure falls back on similar questions and is proven for high validity and reliability (Kalbe et al., 2004). Orientation in time was measured by questions about the current date. Recall ability was tested twice. The respondent was asked to repeat a list of 10 words immediately and again at a later point in time following a set of questions. In the examination of numeracy abilities, the respondent had to solve some mathematical problems. Verbal fluency was measured by the ability of the respondent to name as many animals as possible within a specified time frame. Each of these five single items was constructed with a range of zero to four points (see Doblhammer et al., 2013) for more details). The summary score of cognitive functioning with a range of zero to 20 points was generated by adding up the points assigned in the single items, and the mean score was 13.4 (see Fig. 1). Finally, we divided the sample into two groups. All individuals with scores between zero and 14 points were combined in a group indicating “poor cognitive functioning” (4271), while individuals with scores between 15 and 20 points form a group indicating “good cognitive functioning” (3664). This distinction was made according to the DemTect scale, in which a performance of less than 13 of 18 points indicates at least some mild cognitive impairment. We did examine different cut-points, but the analyses reveal inconclusive results (not shown).

2.3. Economic conditions at the time of birth

We used the annual real gross domestic product per capita (GDP) for each country as a measure of aggregate economic conditions. From Maddison (2008) we obtained country-specific time series. For each series, the deviations around the trend reflect short periods in which average household conditions in the country are above or below their trend value. As such, their effects should capture effects of short-run pecuniary interventions.

We calculated the natural logarithm of the real GDP per capita to compute the cyclical component applying the Hodrick–Prescott Filter (Hodrick and Prescott, 1997) with a smoothing value of 500. We then converted the business cycle to an indicator of macro-economic conditions with three categories of quartiles. With

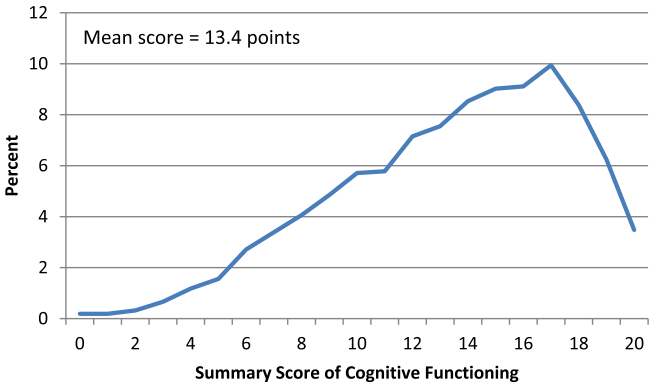

Fig. 1. Distribution of the summary score of cognitive functioning.
Data source: SHARE waves 1–3.

Table 1
Descriptive statistics of the sample ($N = 7935$).

Covariate	Category	%
Gender	Male	45.9
	Female	54.1
Age at 1st interview	60–64	7.2
	65–69	27.2
	70–74	29.8
	75–79	21.3
	80+	14.5
Business cycle	Recession	17.1
	Average	42.8
	Boom	40.1
Education	Low	61.8
	High	36.4
	No information	1.8
Childhood cognition	Worse	13.5
	About the same or better	80.1
	No information	6.4
Residence at time of birth	Urban	53.7
	Rural	45.3
	No information	0.9
Household composition when respondent was aged 10	Two parents	86.8
	Only mother/only father	7.3
	Other	5.8
Parity of respondent	Parity = 0	34.0
	Parity ≥ 1	66.0
Childhood health status	Excellent	35.0
	Good	55.8
	Fair/poor	9.2
Vaccinations during childhood	No vaccinations	9.5
	Had vaccinations	87.4
	No information	3.1
Infectious diseases during childhood	No	20.7
	Yes	79.3
Regular health care between ages 0–15?	No	7.1
	Yes	92.9
Parents/guardians drank heavily during respondent's childhood	No	92.7
	Yes	7.3
Social class of main breadwinner when respondent was aged 10	Managerial, professional, skilled non-manual	21.7
	Skilled manual	31.3
	Semi-skilled & unskilled manual	41.2
	Other	5.8
Number of books when respondent was aged	0–10	53.6
	11–100	35.5
	101+	9.2
	No information	1.8
Financial hardship between ages 0–18?	No	94.9
	Yes	5.1
Period of hunger between ages 0–18?	No	88.1
	Yes	11.9

Data source: SHARE waves 1–3.

some abuse of language, we called the years of the lowest quartile of the country-specific cycle “recession years”. Years of the second and third quartiles were assigned to the “average” category, and the category “boom” indicates years in the highest quartile (Table B in supplementary material). For each individual in our sample, we linked the year of birth with the cyclical component of the same year.

We should emphasize that these business cycle indicators do not capture differences between eras of affluence and eras of poverty. Rather, they capture *short-run* fluctuations. Indeed, an economic downturn in which GDP is below its trend for a prolonged time interval of say 10 years may be captured as a slowdown of the trend in economic well-being, instead of what we call a “recession”. This approach is common in the literature (see e.g. van den Berg et al., 2006).

Data on average household income, nutrition, or food intake were not systematically collected in the first half of the 20th century. Census data are typically uninformative on income and were not collected every year. However, the literature provides evidence on associations between business cycle fluctuations and other economic and demographic indicators in historical time series. (van den Berg and Gupta, 2014) have found a strong and significantly positive association between fluctuations in the mean real per capita wage and the concurrent business cycle in the Netherlands, implying that disposable income among employed workers moved in tune with the business cycle. Note that in our birth cohort years there was no welfare safety net, so that effects of changes in GDP on household income across the normal range should be stronger than in modern times. Lindeboom et al. (2010) found a strong negative correlation between the business cycle and fluctuations in real food prices (rye, potatoes, and wheat), suggesting that business cycle fluctuations do indeed coincide with fluctuations in nutritional intake. Woitek (2003) has listed extensive historical evidence relating the business cycle around birth to subsequent adult height.

The literature shows that birth rates and class-specific birth rates do not respond to business cycles in birth cohorts from before 1940, at least in data from North-West Europe (van den Berg et al., 2011). The same applies to the infant mortality rate (van den Berg et al., 2009).

2.4. Conditions during childhood

A variety of different measures were introduced to assess conditions early in life. We introduced education as based on the International Standard Classification of Education (ISCED), and we distinguish between highly educated people with at least upper secondary education and respondents with no more than lower secondary education. A third category comprised individuals whose responses were noted as “refusal”, “don't know”, “still in school”, and “other”. This information stemmed from the first or second wave of SHARE, depending on the time of the first interview of the respondent.

In their interviews during the third wave (SHARELIFE), the respondents described their early life circumstances. We specify four thematic dimensions: childhood cognition, living arrangements, health, and social status.

Childhood cognition was based on the relative position to others when the respondent was aged 10. This was established by asking how she/he performed in Maths compared to other children in class, then by differentiating between those who reported about the same or better performance to those who reported lower performance. A third group comprised those respondents who did not answer, who could not remember, or who did not go to school.

To analyse the mediating or moderating effects of living arrangements during childhood, we used three variables. Information on the residence at the time of birth allowed us to distinguish between urban and rural areas. The household composition when the respondent was aged 10 showed whether the child lived with two parents (biological or step-parents), only the father or only the mother, or in another arrangement. Parity indicated whether the respondent was a first-born or an only child ($=0$), or if there were one or more siblings (≥ 1).

The health variable included self-reported health during the respondent's childhood, categorised as excellent, good, and fair or poor. We also controlled for the presence of vaccinations, regular health care, and infectious diseases through the age of 15, and we used information about whether the parents or guardians drank heavily during the respondent's childhood.

The final variables contained various types of information about the respondent's early-life social status. The first group of the main breadwinner's occupation when the respondent was aged 10 encompassed such professions as legislators, senior officials and managers, professionals, technicians and associate professionals

(managerial and professional), and skilled non-manual workers, including clerks, service workers, shop workers, and market sales workers (skilled non-manual). The second group of skilled manual workers consisted of skilled agricultural or fishery workers. Craft or related trade workers, plant/machine operators and assemblers, and elementary occupations were assigned to a third group (semi-skilled and unskilled manual). A separate group was created for those with other or no occupations. The number of books in the household when the respondent was aged 10 was used with the categories being no or very few books (0–10), enough to fill one shelf or bookcase (11–100), or enough to fill two or more bookcases (101+). Financial hardship was controlled for the respondents between birth and age 18. The respondent was asked if he or she personally, or if the family as a whole, suffered from financial problems. Similarly, the respondent was asked if he or she suffered from periods of hunger between birth and age 18.

We adjusted for the age of the individual reported in five-year age groups up to age 80+, for gender, as well as for the country-specific dummy variables (Table 1).

2.5. Statistical analysis

Firstly, we examined associations between the business cycle at birth and the childhood conditions. Secondly, we examined direct associations between the business cycle at birth and cognitive functioning in models adjusted for age, gender, country, and with and without the intermediate childhood conditions. A childhood condition is defined as a mediator when the following three conditions are met: First, the business cycle at birth affects the childhood condition. Second, the childhood condition affects late-life cognition as an independent variable in a model that controls for the business cycle. Third, the coefficients of the business cycle indicators in the latter model loose significance, or the effect sizes become smaller, when controlled for childhood conditions. A moderating effect is explored by the interaction effect of the business cycle and the respective childhood condition.

We estimated country fixed-effects models, i.e. the observations are clustered within countries. Therefore, we used a robust cluster estimate of the variance. The first-step includes multinomial logistic regression models adjusted for age, gender, country, and the business cycle indicator, with the childhood conditions as outcomes. In the second-step, we estimated logistic regression models with cognitive functioning as the outcome. The basic model adjusted for age, gender, country, and the business cycle indicator, the further models additionally adjusted for the childhood conditions.

Note that we observed the area at birth not as a possible moderator, but instead we have used it as a control for the environment at birth on the individual level and as a control for a potential selection effect, which shall be discussed below.

3. Results

The models with the childhood conditions as outcomes and adjusted for age, sex, and country, revealed three potential mediators affected by the business cycle (Table 2). Childhood cognitive abilities depended on the business cycle: the odds of having about the same or better cognition in childhood than others were significantly higher for respondents born in boom periods (OR = 1.34; $p = 0.01$) than for those born in recession periods. Respondents born in boom years showed an increased risk of parents who drank heavily at respondent's age ten (OR = 1.33; $p = 0.03$). In addition, they had 1.14 times ($p = 0.05$) the odds of having had a skilled manual rather than an unskilled manual main breadwinner. We found no significant association between the business cycle and all other childhood conditions, indicating that those are no mediators but still potential moderator variables.

We now turn to the models exploring the effect of the business cycle on late-life cognitive functioning. The basic Model 1 shows the effect of the business cycle controlled for age, sex, and country only. Respondents who were born in a boom period were more likely to have good cognitive functioning than those born in a recession period (Table 3). Being born in a boom period produced an odds ratio of 1.41 ($p < 0.01$), which means that those respondents had 1.41 times the odds of good cognitive functioning than did those born in a recession period.

Table 2
Multinomial logistic regression analysis to identify the effect of the business cycle at birth on childhood conditions – separate models for each childhood condition.

Childhood condition as outcome (reference)	Category	Business cycle (ref.: Recession)	
		Average	Boom
		OR	OR
Education (Low)	High	0.950	1.101
Childhood cognition (Worse)	About the same or better	1.158**	1.344**
Residence at the time of birth (Rural)	Urban	1.047	1.140*
Household composition when respondent was aged 10 (Two parents)	Only mother/only father	1.065	0.880
	Other	0.796**	0.811
Parity of respondent (Parity = 0)	Parity ≥ 1	1.002	0.921
Childhood health status (Excellent)	Good	0.963	0.976
	Fair/poor	0.927	0.977
Vaccinations during childhood (No)	Yes	1.020	1.153
Infectious diseases during childhood (No)	Yes	0.979	1.003
Regular health care between ages 0–15? (No)	Yes	0.998	0.992
Parents/guardians drank heavily during respondent's childhood (No)	Yes	1.131	1.326**
Occupation of main breadwinner when respondent was aged 10 (Semi-skilled & unskilled manual)	Managerial, professional, skilled non-manual	1.058	1.148
	Skilled manual	1.220**	1.138**
	Other	0.884	0.851
Number of books when respondent was aged 10 (0–10)	11–100	0.906	0.980
	101+	0.828*	0.948
Financial hardship between ages 0–18? (No)	Yes	1.056	0.731
Period of hunger between ages 0–18? (No)	Yes	1.155	1.239

Source: SHARE waves 1–3; ***$p \leq 0.01$; **$p \leq 0.05$; *$p \leq 0.1$; "No information" categories not shown; each model adjusted for gender, age, and country; *Reading, e.g*: The estimated odds ratios represent the effects of the business cycle indicators on the risk of being high educated against the odds of being low educated.

Table 3
Logistic regression analysis to identify the effects of early life characteristics on good cognitive functioning late in life.

Covariate (reference)	Category	Model 1 basic model	Model 2 educ. & cogn.	Model 3 living arrange.	Model 4 health	Model 5 social status	Model 6 full model
		OR	OR	OR	OR	OR	OR
Gender (Male)	Female	0.745**	0.925	0.747**	0.743**	0.742**	0.888
Age at 1st interview (60–64)	65–69	0.480***	0.514***	0.499***	0.484***	0.523***	0.533***
	70–74	0.339***	0.383***	0.350***	0.345***	0.372***	0.394***
	75–79	0.202***	0.228***	0.207***	0.210***	0.219***	0.234***
	80+	0.111***	0.132***	0.113***	0.159***	0.121***	0.134***
Business cycle (Recession)	Average	1.159***	1.177***	1.151***	1.159***	1.202***	1.208***
	Boom	1.407***	1.380***	1.378***	1.414***	1.428***	1.398***
Education (Low)	High		3.451***				2.684***
Childhood cognition (Worse)	About the same or better		1.716***				1.706***
Residence at the time of birth (Rural)	Urban			1.619***			1.158**
Household composition when respondent was aged 10 (Two parents)	Only mother/only father			0.695***			0.766***
	Other			0.813			1.069
Parity of resp. (Parity = 0)	Parity ≥ 1			0.909**			0.953
Childhood health status (Excellent)	Good				0.887*		0.953
	Fair/poor				0.829*		0.814*
Vaccinations during childhood (No)	Yes				1.406***		1.233*
Infectious diseases during childhood (No)	Yes				1.181**		1.120
Regular health care between ages 0–15? (No)	Yes				1.292**		1.187
Parents/guardians drank heavily during respondent's childhood (No)	Yes				0.776***		0.968
Occupation of main breadwinner when respondent was aged 10 (Semi-skilled & unskilled manual)	Managerial, professional, skilled non-manual					1.263***	1.047
	Skilled manual					0.802***	0.927
	Other					0.980	0.946
Number of books when respondent was aged 10 (0–10)	11–100					2.094***	1.631***
	101+					3.667***	2.399***
Financial hardship between ages 0–18? (No)	Yes					1.000	1.191
Period of hunger between ages 0–18? (No)	Yes					1.014	1.123

Source: SHARE waves 1–3; ***$p \leq 0.01$; **$p \leq 0.05$; *$p \leq 0.1$; "No information" categories not shown.

Model 2 included the information about cognitive abilities in childhood and education. Good cognition (OR = 1.72; $p < 0.01$) and high education (OR = 3.45; $p < 0.01$) increased the odds of good late-life cognition, but only altered marginally the effect of the business cycle.

Table 4
Interaction effects of early life characteristics on good cognitive functioning late in life – separate models for each childhood condition with significant effects in Model 6 in Table 3.

Interaction effect between…	Value	OR
BC*Education	Average*High	1.074
	Boom*High	1.071
BC*Childhood cognition	Average*About the same or better	0.982
	Boom*About the same or better	1.111
BC*Residence at the time of birth	Average*Urban	0.994
	Boom*Urban	0.867
BC*Household composition when respondent was aged 10	Average*Only mother/only father	0.908
	Average*Other	1.214
	Boom*Only mother/only father	1.311
	Boom*Other	0.743
BC*Childhood health status	Average*Good	1.042
	Average*Fair/poor	0.821
	Boom*Good	0.994
	Boom*Fair/poor	1.017
BC*Vaccinations during childhood	Average*Had vaccinations	1.049
	Boom*Had vaccinations	1.041
BC*Number of books when respondent was aged 10	Average*11–100	0.994
	Average*101+	1.068
	Boom*11–100	0.984
	Boom*101+	0.936

Source: SHARE waves 1–3; ***$p \leq 0.01$; **$p \leq 0.05$; *$p \leq 0.1$; "No information" categories not shown; each model adjusted for all other information included in Model 6 in Table 3.

When we introduced early life living arrangements into the model (Model 3), we found that the odds of having good cognitive functioning were higher for respondents born in urban areas (OR = 1.62; $p < 0.01$) than for those born in rural areas. Having grown up in a two-parent family showed a protective effect; those who lived with only a mother or only a father (OR = 0.69; $p < 0.01$) revealed significantly lower odds of having good cognitive functioning. Respondents of a higher parity had slightly lower odds of gaining a good cognitive status (OR = 0.91; $p = 0.03$).

Individuals with worse self-reported childhood health in Model 4 had lower odds of having good cognitive functioning later in life. Individuals who had regular health care demonstrated higher odds (OR = 1.29; $p = 0.02$) of cognitive fitness than those who lacked regular care. We found a similar effect for respondents who received the recommended vaccinations during childhood (OR = 1.41; $p < 0.01$) in relation to respondents who did not. However, in contrast to the expected results, the presence of infectious diseases during childhood was associated with an odds ratio larger than one (OR = 1.18; $p = 0.04$). Cognitive functioning was negatively influenced by parental heavy drinking habits during the respondent's childhood, with 0.77 times the odds of good cognition ($p < 0.01$) relative to respondents with parents with normal drinking habits.

Model 5 included different indicators of early-life social status. The odds of good later life cognitive functioning were higher if the occupation of the main breadwinner in the household was highly skilled and specialized (OR = 1.26; $p < 0.01$) compared to those with semi-skilled and unskilled manual occupations. The odds were lower if the occupation was "skilled manual" (OR = 0.80; $p < 0.01$). Having a higher number of books in the household when the respondent was aged 10 was associated with increased odds.

Financial hardship or periods of hunger up through the age of 18 had no significant effects on later cognitive functioning.

Model 6 showed the effect of the business cycle, controlling for all of the information at the same time. The odds ratios for the boom (OR = 1.40; $p < 0.01$) and average (OR = 1.21; $p < 0.01$) periods varied only marginally relative to the previous models. Some of the early childhood characteristics partially lost effect size or even statistical significance (e.g. parity, health care, drinking habits of the parents).

With regards to the potential mediator variables, childhood cognition remained as the only variable with a significant effect on late-life cognition. There were no effects of parental drinking habits and the occupational status of the main breadwinner on late-life cognition. However, as mentioned before, childhood cognition changed the effect sizes of the business cycle indicators only marginally, thus yielding no sizeable indirect pathway running through childhood cognition. One can conclude that the effect of childhood cognition on late-life cognition is driven by other determinants than those captured by the business cycle.

While there have been no mediating effects, there was still the option of moderating effects on the long-run effects of the business cycle. In order to check this, we re-tested the full model with interactions between the business cycle and childhood conditions. We estimated seven models - one for each childhood condition (area at birth, childhood cognition, education, household composition, childhood health, vaccinations, number of books in household) - that showed a significant effect on late-life cognitive functioning. The results showed that none of the interaction effects were significant (Table 4).

4. Discussion

This study shows that the effects of boom and recession periods at birth are not simply mediated or moderated by living conditions during childhood. While being born in a boom or recession period influences cognitive abilities in childhood, and it is related to parental social status and parental life style during childhood, these characteristics do not form pathways that can explain the differences in late-life cognition by the business cycle. Our results may suggest that conditions at birth have direct long-run effects on late-life cognitive functioning, with good economic conditions being related to good cognition. As described earlier, the mechanisms underlying these effects cannot be easily determined. They may plausibly work through nutrition, disease environment, and psychological stress level around birth.

The effects of boom and recession periods are in line with our previous work (Doblhammer et al., 2013). In addition to the effect of the business cycle, we find evidence for a series of childhood conditions that in and of themselves influence late life cognition.

Childhood cognition and education affect late-life cognition. It should be noted that childhood cognition has a strong effect on education, but that the level of an individual's education also depends on other factors, as discussed above. An extended version of the multinomial logistic regression model with education as the outcome variable and all information on childhood conditions that are included as explanatory variables in Model 6 of Table 3 reveals that high education is related to childhood cognition but also to high social class, good childhood health, and birth in an urban area. Recall that the adverse effect of economic conditions at birth may primarily be a biological long-run effect that only kicks in at high ages, i.e. long after education is completed. After all, early-life conditions may affect the hormone system and the inflammation level (Crimmins and Finch, 2006). The chronic activation of inflammatory pathways increases the risk of diabetes, the metabolic syndrome, and cardiovascular diseases, may slowly affect the arteries and, at a later stage, may lead to impediments of the brain functioning at high ages. Alternatively, the brain development during the first stages of life may be compromised immediately by nutritional and infectious disease stress (Drury et al., 2012; Kuzawa, 1998; Landrigan et al., 2005; Stein et al., 2008) with long-lasting effects on cognitive functioning throughout life. Our results suggest that the first postulated biological pathway is dominant. In addition, the association between high education and high social class underlines the fact that the cohorts under observation were born in times where education was primarily driven by the over-all wealth of the parents and where the influence of social class on education was larger than nowadays (Jonsson, 1991). Moreover, it is still conceivable that education is a proxy for an individual's cognitive reserve which is a major concept in the context of cognitive functioning late in life. People with a high cognitive reserve are able to compensate for a decline in brain functions better than people with a low reserve (Stern, 2002). Our results support this theory.

An extensive collection of books during a respondent's childhood is generally associated with higher chances of good cognition later in life. Owning books may be an indicator of both the socio-economic status of the household and of the literacy levels of the family members, thus pertaining to the cognitive abilities of the respondent (Manly et al., 2005).

The positive long-term impact on cognition for those born in an urban area is supported by the findings of Russ et al. (2012). One explanation may be that living in a rural environment as a child is detrimental to developing cognitive reserve. In line with our expectations, we find that those who fare best lived in two-parent families. They are more likely to be cognitively and emotionally healthy during childhood and adulthood (Amato, 2005).

Having good health during childhood, including regular vaccinations, is a good indicator for later healthy cognitive functioning. The effects for the presence of infectious diseases, regular health care and parental drinking habits, disappears once we adjust for living arrangements, social status, childhood cognition, and education.

The relationship between the business cycle and late-life cognition may be driven by selection effects due to altered fertility and infant mortality during recession or boom periods. However, as mentioned earlier, infant mortality rates as well as birth rates do not respond to business cycles in birth cohorts before 1940. We will now examine whether there is evidence for a change in the composition of the birth cohort during a recession or boom period. In our analyses, variables such as the area at birth or the occupation of the main breadwinner not only control for the individual background characteristics of the environment in which the child grew up, but also for cohort composition effects. The results of the multinomial logistic regression models in Table 2 allow assessment of whether there is a relationship between the business cycle at birth and the socio-economic environment of the family the child is born into. We found that children born during a boom period are more likely to be born in an urban area and they are more likely to come from families in which the main breadwinner has a skilled rather than an unskilled manual occupation. Both the higher occupational status and birth in an urban area indicate a positive selection for those born in boom periods (and thus a negative selection for those born in recession periods). Further analysis of the relationship between the business cycle and cohort composition is required to fully understand the relationship between the business cycle and late-life cognition.

The strength of this study is that we were able to explore the long-term effects of early-life circumstances on an internationally harmonized measure of cognitive functioning. The SHARE dataset offered us the opportunity to analyse a transnational sample with

an extensive set of early life information. In addition, we used the business cycle as an exogenous indicator for macro living conditions which are independent of individual characteristics. Nevertheless, this study has some limitations. First, we only had data about the gross domestic product on an annual basis, which meant that we had no exact dates for the beginning and end of the boom and recession periods. As a consequence, we could not link precisely the pre-, peri- and postnatal periods to the business cycles.

One point worth noting is that there may have been a bias caused by an over-representation of less frail individuals for those birth cohorts born under adverse conditions. This may have led to an underestimation of the positive effects of beneficial conditions at birth on cognitive functioning at older ages. Indeed, several studies have found no systematic coherences of the size and social class composition of birth cohorts on the business cycle in European countries in the first half of the 20th century (see van den Berg et al., 2011 and references therein).

Attrition issues also exist in the SHARE sample. Ziegler (2011) showed that respondents who left the panel between the first and second wave due to death and other reasons were in worse health at the time of data collection. The mean age of those respondents participating in both waves was lower than in wave one. Thus, our results may be affected by an over-representation of healthy people. The SHARE survey deals with panel attrition by refreshing the sample to keep the initial sample size and to reduce potential selectivity. As described in the Methods section, we included respondents who participated in the first wave of SHARE, or who participated for the first time in the second wave, or who were part of the refreshment sample of the second wave.

The use of retrospective data may also result in a recall bias. Respondents may fail to name the exact occurrence and timing of events during their lives. This possibility has been comprehensively discussed in (Schröder, 2011) and therefore the SHARELIFE interview follows a Life History Calendar approach to help respondents remember past events more precisely. A recall bias is even more relevant among respondents with cognitive impairment. However, not everyone who is affected by cognitive impairment also suffers from memory impairment; they may have impairments in language, executive function, or visuo-spatial skills (Petersen, 2004). Furthermore, for patients with Alzheimer's disease it has been shown that they have difficulties in recalling recent events, whereas long-term memories remain more stable (Jelicic et al., 1995).

Exploring the distribution of individuals' characteristics by the business cycle indicators, we find that the composition of cohorts born in boom, recession, and average years differ only marginally (distribution not shown). We already discussed possible selection effects. Additionally, age groups do differ from each other. The mean age for respondents born during recessions (73.25) is higher than that of those born during boom periods (71.40). Yet our study design ensures that individuals from the same birth cohorts are observed at different ages. Hence the results are not driven by a simple age effect, in such that cognitive functioning deteriorates with age. In addition, if we include the war cohorts in the analysis, those born during boom years turn out to be younger, while the business-cycle effects remain largely unchanged. Thus our results are not driven by the possibility that respondents born in booms have benefited more from secular improvements in society than those born in recession periods.

In the context of our analyses, the use of a dichotomous dependent variable for cognitive functioning is more plausible than is a continuous indicator. Screening tests for cognitive impairment commonly used in medicine, such as the DemTect (Kalbe et al., 2004), use cut-points on their scales to define cognitive impairment or dementia. Our intention is to evaluate the dependence of the status of good cognitive functioning on early life factors. However, we performed sensitivity analyses using the continuous indicator of cognitive functioning as the dependent variable in a linear regression model framework and found similar results.

In conclusion, we find that the environment in early life shapes cognitive abilities and has long-term effects on cognitive functioning at old age. The results are helpful in identifying persons at risk of cognitive impairment. Our study thus underlines the need for societies to provide children with opportunities to develop their skills and abilities which can counteract disadvantages related to social background, family, or health. This may include better access to school, support programs to promote learning successes, better access to the health care system, promotion of healthy lifestyles, or measures to improve the economic and social situation of disadvantaged households.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.socscimed.2014.07.011.

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