The role of early-life conditions in the cognitive decline due to adverse events later in life

Gerard J. van den Berg
Dorly J.H. Deeg
Maarten Lindeboom
France Portrait

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Abstract: Serious life events, such as the loss of a relative or the onset of a chronic condition may influence cognitive functioning. We examine whether the cognitive impact of such events is stronger if conditions very early in life were adverse, using Dutch longitudinal data of older persons. We exploit exogenous variation in early-life conditions as generated by the business cycle.

Cognitive functioning of older individuals may be affected by events such as the loss of a (grand)child or partner or the onset of a serious chronic condition, and by negative economic shocks such as job loss or the reduction of pension benefits (see Orrell, Bebbington (1998); Clement, Darthout, Nubukpo 2003; Charles et al. 2006; Lindeboom, Portrait, and van den Berg, 2002; Van den Berg, Lindeboom and Portrait, 2006b, and references therein, for evidence). The death of the spouse and the concurrent changes in the lives of widowed persons have regularly been shown as most important sources of psychosocial stress - a factor associated with increased morbidity and mortality. Moreover, a small, but growing, body of evidence, suggests that adverse life events also may perpetuate poverty (Dercon, Hoddinott and Woldehanna, 2005, and references therein). As such, an indirect effect on health may be expected as well.

A recently emerging literature stresses the importance of a different set of causes of cognitive impairment at high ages. These causes originate earlier in life. Specifically, adverse conditions during the brain development early in life may affect cognitive development and cognitive functioning later in life. A number of studies strongly suggest a causal effect (see Factor-Litvak and Susser, 2004, for a recent overview).[1] The corresponding adverse early-life conditions that have been studied are mostly nutritional, but exposure to high levels of stress or illness could also partly explain the observed link. Much of this evidence concerns cognitive outcomes among prime-aged adults. Recent evidence also suggests that exposure early in life to hazardous chemicals may lead or contribute to old age neurological diseases, such as dementia, Alzheimer's disease or Parkinson's disease (see Landrigan et al. 2005 and Miller, O'Callaghan 2008 and references therein).

In the present paper we examine the role of economic conditions early in life on cognitive functioning at old ages. More specifically, we aim to detect whether favorable conditions early in life mitigate the effects of adverse events later in life on cognitive ability (see Fig. 1.1). It is conceivable that the impact of such events and shocks is weaker if conditions early in life were favorable. For instance, initial economic positions may influence the extent to which persons can cope with the stressful event of bereavement or conflicts with important persons throughout their lives. Possibly, conditions early in life may also influence the impact of health-related events, like the onset of chronic diseases, on mental health. The literature on the developmental origins

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[1] Schizophrenia is the most-studied severe cognitive disorder in this area of research (e.g. Susser and Lin 1992). Recent studies confirm the link between adverse conditions in utero and elevated risks of schizophrenia at adult ages for both genders (Saint-Clair, Xu and Wang, 2005, Brown and Susser, 2008, and references therein).

of diseases provides evidence that exposure to adverse (nutritional and pathogen) stimuli during the first stages of life may hinder the development of vital organs and immune system, with irreversible negative effects on health at high ages (see e.g. Barker, 1992). The "accumulation of risk" hypothesis in the literature on causal pathways in the life course states that health at old ages is the result of exposures to risk factors across the full elapsed lifetime (Kuh and Ben-Shlomo, 2004). Education and other intermediate outcomes may exacerbate long-run effects. Individuals born in poor families may be less likely to go to school and to learn appropriately (Black, Devereux and Salvanes, 2005; Case, Fertig and Paxson, 2005). This may affect the extent to which they can deal with negative life events later in life.

Our empirical analysis focuses on the interplay between early-life (economic) conditions, adverse life events later in life, and cognitive functioning at old ages (see Fig. 1.2). In a descriptive analysis, we inquire to which extent our indicators of early-life (economic) conditions are associated with cognitive status at old ages. Next, in our main analyses, we investigate the causal cognitive effects of adverse events later in life, and we assess whether the causal effect of such events is stronger if conditions early in life were adverse. We use a Dutch longitudinal database that follows older individuals for more than 15 years and that contains detailed information on demographics, socio-economic background, health, and mortality.

Knowledge on the determinants of cognitive decline among the elderly facilitates the identification of groups of elderly who are particularly at risk. This is of great societal importance. Cognitive decline of an elderly family member may have a strong impact on the functioning of the household. In particular, the person involved may have increasing difficulties in making financial decisions. A number of recent studies show that cognitive impairment adversely affects investment behavior among elderly individuals. Christelis, Jappelli and Padula (2010) show that low cognitive ability, as captured by indicators of mathematical, verbal, and recall skills, leads to a lower propensity to invest in stocks and other relatively risky assets. Banks and Oldfield (2007) show that a low numerical ability leads to low levels of retirement saving and investment portfolios. Banks, O'Dea and Oldfield (2010) show that lower numeracy is also related to different wealth trajectories pre and post retirement. Smith, McArdle and Willis (2010) find that numeracy is by far the most predictive of wealth among all cognition variables. They also find lower total household wealth and financial wealth when families choose the less numerate spouse as the financial decision maker in the family. These studies control for educational attainment and other personal characteristics. With the increasing individualization

of decisions on pensions and asset management, cognitive impairment may lead to substantial welfare loss for the household. Conversely, financial problems may enhance the cognitive decline, and we will address this in our study.

It is also important from a policy point of view to know the determinants of cognitive decline. The costs of care for cognitively impaired individuals are high and are expected to increase in the upcoming decades. Adverse events in the life of elderly individuals are readily observed by care professionals and are therefore a potentially informative red flag for an upcoming decline. If early-life conditions are found to affect the magnitude of the cognitive effects of major adverse events later in life, then it may be worthwhile to focus the monitoring on those who were subject to such events *and* who were born under adverse conditions.

The empirical analysis needs to address the potential endogeneity of early-life conditions as well as the potential endogeneity of the occurrence of adverse life events at higher ages. We deal with the latter by exploiting repetitive observations of cognitive ability measures. Specifically, we estimate fixed-effects panel data equations with cognitive ability measures as outcomes. This methodological approach is particularly suitable to study health effects of shocks and singular events that occur between successive individual observations (and their interaction with early-life conditions). We deal with the early-life conditions endogeneity problem by using contextual (aggregate) indicators of early-life conditions that are exogenous. Specifically, we use business cycle fluctuations in the birth year. This follows van den Berg, Lindeboom, and Portrait (2006a) and van den Berg, Doblhammer and Christensen (2010), who focus on the effects of the prevailing economic conditions at birth on individual mortality rates and cause-specific mortality rates later in life. The basic idea is that birth in a recession causes adverse economic conditions in many households. This may in turn lead to a low quality and/or quantity of nutrition, to adverse housing conditions, and to an enhanced stress level in the household. The business cycle is plausibly not affecting late-life health outcomes in other ways than through its effect on health and abilities around birth. An effect of the business cycle on late-life health outcomes is then evidence of a causal effect of early-life conditions on late-life health.[2]

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[2] Van den Berg, Lindeboom, and Portrait (2006a) and van den Berg, Doblhammer and Christensen (2010) find significant causal effects on mortality and on cardiovascular mortality, respectively. Similar methodological approaches are used by Doblhammer (2004), who demonstrates that survival at ages older than 50 is significantly affected by the season of birth, and by Bengtsson and Lindström (2000, 2003), who use variation in food prices and infant mortality early in life. These studies have in common that they exploit modest fluctuations in early-life conditions, and therefore the results are not driven by extreme events like severe famines or epidemics.

1. Data and measures

1.1 *The LASA data*

The Longitudinal Aging Study Amsterdam (LASA) is an ongoing study which follows a representative sample of Dutch older non-institutionalized and institutionalized individuals born in 1908-1937. The design and purposes of the LASA study are described in detail elsewhere (Deeg et al., 2002). Data from five waves are currently available (1992-93, 1995-96, 1998-99, 2002-03 and 2005-06). Table 1 describes the non-response at successive waves. Individuals can leave the sample for several reasons. About 75% of the respondents who leave the sample between two waves died. 14% of them refused to participate in the study anymore, 6% were too frail to participate, and 3% could not be contacted (Deeg et al., 2002).

1.2 *Health measures*

Table 2 provides summary measures on health and demographic measures. We measure cognitive status by the Mini Mental State Examination (MMSE) score (Folstein et al. 1975). The MMSE is a widely used method for assessing the general cognitive functioning of older individuals. It provides a total score that places the individual on a scale of cognitive functioning. The cognitive domains that are captured and combined by the MMSE are: orientation in time (5 questions; 5 points), orientation in place (5 questions, 5 points), registration of words (3 points), attention and calculation (5 points), recall of words (3 points), language (8 points) and visual construction (1 point). The lower the score, the higher the cognitive impairment. The variable ranges between 0 and 30 and usually a cut-off point of 23 or 24 is used to indicate cognitive impairment. Figure 2.1 provides the distribution of the MMSE scores in waves I-V. The MMSE score is positively associated with the level of education.

Apart from the MMSE, the data also contain a measure of fluid intelligence. Fluid intelligence is defined as the ability to deal with new information. Contrary to crystallized intelligence (or knowledge), fluid intelligence is particularly sensitive to decrements associated with ageing (Horn, 1985; Smits et al., 1997). Fluid intelligence is assessed with the Raven Coloured Progressive Matrices (RCPM, Raven, 1995). Both the MMSE variable and the Raven test score are relevant for financial decision making. Our analyses (to be discussed in section 3) will focus

on the results for the MMSE analyses. However, we also performed all analyses on the Raven test score variable. The results of these analyses (not reported here, but available upon request) are similar to those below, in the sense that the main qualitative findings about the interaction effects of early life conditions and shocks later in life on cognitive ability are the same.

Physical health is measured by indicators of functional limitations, disability, and the seven most important chronic diseases. Functional limitations are measured in the LASA study by self-reports on mobility activities in daily life. These self-reports include the extent of difficulty respondents experience to: (1) cut one's own toenails, (2) walk up and down a 15-steps staircase without stopping, and (3) make use of private or public transportation (McWhinnie, 1981; van Sonsbeek, 1988). The score takes on value 0 when all items are performed without any difficulty, and 1, 2, and 3, when 1, 2, or 3 items respectively are performed with difficulty. Disability is measured by asking the respondents whether he or she experiences difficulties in performing daily activities because of health problems. The variable takes the value "1" when health problems severely affect daily activities, the value "2" when health problems slightly affect daily activities, and the value "3" when the respondent does not experience any difficulties with daily activities because of health problems. Finally, the presence of chronic diseases is assessed by asking the participants whether they have or have had any of the following diseases: chronic obstructive pulmonary diseases (COPD), heart diseases, peripheral arterial diseases (PAD), diabetes, stroke, cancer, and arthritis (osteoarthritis and rheumatoid arthritis) (Kriegsman et al., 1996).

At wave I, 59% of the LASA respondents have no physical limitations, and about 4% of the respondents suffer from severe cognitive impairment and are clinically depressed.

1.3 *Demographic and socio-economic characteristics*

In addition to gender and age, the following individual characteristics are included in our analyses: marital status, urbanisation degree of the municipality where the respondent lives (categorical variable ranging from "1"= low to "5"= high), education (categorical variable ranging from "1"= elementary education not completed to "9"= university education), income, and the prestige code of the longest-held occupation. Income was ascertained by asking the respondents to assign their monthly net income to classes ranging from below €454 to above €1818. The total income of the respondent and his/her possible partner is asked, and a correction

factor equal to 0.7 is applied if the respondent has a partner (adult equivalent adjusted). Missing values for income were relatively frequent in wave I (about 16%). In later waves, reformulations of the income questions reduced this percentage to numbers much below 10%.The occupational prestige of the longest job is measured using the classification described in Sixma and Ultee (1983) (categorical variable ranging from 0 = ``never had job'' to 87 = ``high prestige'').

1.4 *Life events*

Table 3 presents frequencies of the life events occurring between successive waves. A substantial fraction of the respondents loses at least a parent, a brother, a sister, a child or a grand child during the observation period. 4% of the respondents on average lose their spouse between successive waves. A negligible number of respondents divorced during the observation window. Illness of partner and relatives is also a common phenomenon. Furthermore, with respect to chronic diseases, arthritis, and heart diseases are the most commonly observed chronic conditions and we also observe their onset most frequently. On average 10% of the respondents experience an admission to hospital during the six months prior to an interview. Finally, the onset of severe financial problems observed for about 10 percent of the cases in the first two waves, but this fraction declines slowly in the later waves.

1.5 *Macro indicators*

A Hodrick-Prescott filter with smoothing parameter 500 is used to decompose log annual per capita GDP into a trend and a cyclical component (Hodrick and Prescott 1997). The GDP data are from Maddison (2003). Fig. 2 shows the log(real annual per capita GDP) and the detrended series. The cyclical development is in line with important historical events. First, there is a severe recession around the end of World War I and at the arrival of the Influenza Pandemic (October – November 1918) (Vugs 2002). Second, the Dutch economy developed positively alongside a global economic upturn in the 1920s, which resulted in an increase of the average living standards. Third, there is a clear recession during the Great Depression, which reached the Netherlands at a relatively late moment in time (1931) compared to other countries, and which lasted relatively long (until about 1936). The latter was partially caused by a refusal of the Dutch government to abandon the gold standard. The recession had substantial impact on the daily life of civilians. For instance, the number of unemployed individuals rose from 50,000 to 414,500 between 1929 and 1936 (Beishuizen and Werkman 1968).

The birth cohorts that we consider cover the birth years 1908-1937. These cohorts did not experience widely different educational opportunities. Also, the Netherlands did not suffer as many casualties during the Second World War as many other European countries. The Hunger Winter in 1944 led to a high infant mortality and a strong reduction in fertility, but this period falls outside of our birth years interval. The latter interval does include the flu epidemic of 1918, which coincided with a recession. To some extent, therefore, the effect of birth in a recession may be exacerbated because of this.

We construct three measures for the state of the business cycle at birth. First, the value of a Boom dummy equals one when log GDP is above its trend level and zero otherwise. A second variable corresponds to the actual value of the cyclical component. In contrast to the boom dummy, this variable takes the severity of booms and recessions into account. Third, two dummy variables measuring the peak years (years belonging to the 4th quartile of the cyclical component) and trough years (years belonging to the 1st quartile of the cyclical component) of the boom and recession, respectively.

Table 4 presents results of some exploratory analyses at baseline. The maximum of the MMSE score is equal to 30. In Table 4 and elsewhere, we transform this cognition score into the logarithm of 31 minus the MMSE score, to assure that the results do not depend too much on extreme low values of the MMSE score. High values are therefore associated with impaired cognitive functioning, low values with good cognitive functioning.

Notice that there is a negative linear association in the sample between age in 1992 and birth year. Any restriction on birth years thus necessarily entails a restriction on the age window. For example, a restriction to early birth cohorts entails a restriction to older individuals. This complicates a direct comparison of favourable and unfavourable birth cohorts as in e.g. van den Berg, Lindeboom and Portrait (2006a). In fact, age was measured exact up to days at the date of the interview. This provides some additional variation in age over and above the birth year. We also ran the same regressions while including both age and birth year. The results (available upon request) were virtually identical to those reported in Table 4.

The results in Table 4 indicate that the state of the business cycle may have an effect on cognitive functioning at later ages. More specifically, those born in a boom have better cognitive health

and those born in recession years have worse cognitive health.

2. Empirical analyses and results

In this section we perform analyses based on the entire sample and the cognitive score for all waves. We start with simple regressions where we pool the panel information. Subsequently, we perform panel data analyses with fixed effects, where the outcome is the cognitive score, and the explanatory variables include the shocks since the previous wave of the panel, and their interactions with the early-life indicators.

Our range of empirical analyses is somewhat restricted by the fact that the sample is drawn from the stock of those alive in 1992 who were born in 1908-1937. This sample excludes those born in those years who died before 1992. The association of early-life effects and later events may then be weakened because of dynamic selection. However, if the dynamic selection is driven by the same unobservable as the fixed effect in the outcome of interest then panel data analysis deals with this selection issue.

Table 5 present the results of a model based on pooled data where the cognitive score is related to a range of observed demographic characteristics, the occurrence of life events and the cyclical components of the business cycle at the time of birth. Table 6 presents the results of the same model, but in this specification the cyclical component is replaced by the peak and trough values of the cyclical component (the values of the first quartile and the fourth quartile of the cyclical component). Both tables include three different specifications of the levels equation. The first specification (I) includes a base specification where the onset of new chronic conditions are aggregated into a single indicator. In the second column (specification II) we add the lagged dependent variable. In the third specification (III) we extend on specification II by making a distinction between the different kinds of health shocks. We start with a brief discussion of the results in Table 5. Note that the models are estimated with outcomes from wave II of the panel onwards.

We find strong effects of the demographic variables across all specifications and most of these effects are as expected. For instance, the age coefficients are such that cognitive functioning decreases with age. The negative education coefficient indicates that those with more years of

education have higher cognitive skills at later ages. Females also have higher cognitive skills. The effect of education and gender is reduced to about half when the lagged dependent variable is added to the specification, but these two variables remain strongly significant. The number of chronic conditions has a positive effect indicating that chronic conditions are associated with worse cognitive functioning.

Concerning the life event variables, no effects are found for the bereavement indicator. We do however find effects for experiencing the death of family members (parents, siblings and (grand)children) and illness of a family member or relative. The latter effect indicates that an illness of a family member or relative is associated with better cognitive outcomes. An illness of a close relative may involve the provision of care by the respondent and this in turn may have a (temporary) cognition-preserving effect. This somewhat surprising finding is supported by Resnick et al (2007) who find that individuals who experienced the injury or illness of a friend during the past year had better cognitive outcomes. Deeg at al (2005) find that the occurrence of disasters results in short term improvements of cognitive functioning. In earlier work (Lindeboom, Portrait, van den Berg, 2002) we found strong negative effect on the mental health of the illness of a family member or a relative. We find some effect for an indicator whether the individual experienced financial difficulties in the past period, but this effect is only significant at the 10% level in the "static" model (Model I). Finally, we find a significant effect of a stroke on cognition (specification III).

The coefficient of the cyclical component of the business cycle at birth has the expected sign, but it is not significant at the standard levels. We neither find significant additive effects for the peak and trough years in Table 6. The effects of the other demographic and life events variables in Table 6 are similar to those in Table 5.

Tables 7 and 8 report the results of a model in first differences of the transformed cognitive score and therefore allows for unobserved individual fixed effects. This also means that additive effects of the business cycle indicators cancel from the specification. The first column (specification I) of Table 7 reports the results for the full sample, the second and the third column are estimated on samples of individuals who are born in a period where the cyclical component of the GDP is negative ('Recession') and positive ('Boom'), respectively. The sample sizes did not permit us to estimate separate models for 'peak' and 'trough' years.

The results reported in column 1 are in line with the results of the life events variables presented in Tables 5 and 6. A stroke has a strong effect on the cognitive health score and the positive coefficient indicates that cognitive skills deteriorate after the onset of a stroke. The negative coefficient of the 'illness of a family member or a relative' also remains when we control for unobserved fixed effects and implies that cognitive skills improve after the onset of this life event.

We calculated the fixed effects of this model and regressed these on a set of time-constant variables. The results of this exercise are reported in Table 9. Of course it is difficult to give a pure causal interpretation to the coefficients. The results indicate that those born in peak years have better cognitive skills. The effect of the demographic variables is (as expected) very similar to those in Tables 5 and 6. The negative birth year variable indicates that those born later have better cognitive skills. Furthermore we find better cognitive skills for females, those who are married and those who have more years of education. Again the stroke indicator (defined here as whether or not one has experienced the event prior to the first wave) has a strong impact on the fixed effect.

The results of column 1 in Table 7 provide an aggregate effect of the life events variables. In column 2 and 3 of Table 7 and in Table 8 we estimated the model on separate sub-samples. With these analyses we aim to detect whether individuals exposed to different conditions early in life respond differently to life events later in life. Earlier work (e.g. Koupil et al., 2007) shows that adverse conditions earlier in life may have differential effects for males and females. This implies that the impact of life events may also differ with respect to gender. We therefore estimated different models for males and females. The results of columns 2 and 3 of Table 7 and the results of Table 8 show that the impact of shocks later in life may vary with respect to conditions that individuals have been exposed to earlier in life and that this differs for men and women. More specifically, column 2 and 3 of Table 7 reveal that the effect of a stroke is driven by those who are born in a recession. The stroke has no impact on the cognitive skills for those who are born under more favourable conditions at the time of birth. We furthermore learn from columns 2 and 3 of Table 7 that the positive effect of the 'illness of a family member or relative' variable is entirely driven by those born in a boom: the (temporary) cognition-preserving effect of an illness of a friend or relative is only present for those born in favourable economic conditions. The results of Table 7 also show that the 'death of parents, siblings and (grand)children' has a negative impact on cognitive skills. A further disaggregation with respect

to gender shows that the "stroke" effect and the effect of a death of a relative is primarily important for the development of the cognitive skills of women born in recessions. The cognition-preserving effect of an "illness of a family member or relative" is present for both men and women born in booms.

All analyses were repeated with a different measure of cognitive functioning, namely the Raven test score (see section 2). All analyses of Tables 4 to 9 were repeated with this variable. The results (available upon request) were very similar.

3. Conclusions

Individuals who experience a stroke at high ages witness a strong subsequent decline in cognitive abilities. We find that this decline is stronger if the individual experienced adverse economic conditions around his or her birth. Specifically, the cognitive abilities of individuals born in a recession suffer more strongly from a stroke than the cognitive abilities of individuals born in years with a favourable business cycle. This suggests that strokes are more devastating if the individual is born under adverse conditions or that the ability to recover from strokes is more limited if birth was under adverse conditions. This finding is consistent with the literature on the "developmental origins" of cardiovascular diseases. Lawlor, Ben-Shlomo and Leon (2004) survey the strong evidence on the negative association between birth size on the one hand, and cerebrovascular accidents (CVA) outcomes (i.e. strokes) later in life on the other hand. Basically, individuals with low birth weight experience strokes earlier than other individuals. What we find is that, for individuals born under adverse conditions, the cognitive effects of strokes are larger.

We also find significantly stronger negative cognition effects of surgery and illness or death of a family member if the individual was born under adverse conditions. At the same time, we do not observe an effect of the presence of financial problems on the rate of cognitive decline. Moreover, the latter applies to individuals born under favourable as well as unfavourable conditions. A major difference between bereavement and illness of family members on the one hand and financial shocks on the other hand is that the former are typically beyond the control of the individual. Apparently, adverse events that are hard to influence lead to larger cognitive declines and are harder to compensate through favourable early-life conditions. As a final conclusion we note that, in general, the effects that we find are stronger for women than for men.

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Table 1: SPECIFICATION OF THE NON-RESPONSE IN THE LASA DATA

	Wave I	Wave II	Wave III	Wave IV	Wave V
Data present:	3,107:	2,545:	2,076:	1,691:	1,257:
Normal	2,925	2,204	1,717	1,340	932
Short / Telephone interview	182	341	359	351	325
Deceased		417	344	290	355
Refusals / Ineligible / Not contacted		145	125	95	79

Table 2 – MEAN / FREQUENCY OF RELEVANT VARIABLES AT WAVE I

VARIABLES	SCORE	Mean / Frequency
HEALTH		
Cognition (MMSE)		26.8
Functional Limitations (in %)	no difficulty	58.6
	one with difficulty	19.1
	two with difficulty	11.7
	three with difficulty	10.7
Disability (in %)	no	68.0
	yes, slightly	19.1
	yes, severely	12.9
Chronic diseases (in %)	Respiratory (COPD)	11.6
	Heart diseases	19.6
	Peripher. arterial (PAD)	9.8
	Diabetes	7.9
	Stroke (CVA)	5.7
	Cancer	9.3
	Arthritis	34.8
Number of chronic diseases		0.98
DEMOGRAPHICS		
Mean age		70.8
Female (in %)		51.5
Marital status (in %)	never married	6.1
	married	62.5
	divorced	5.2
	widowed	26.2
Urbanisation level (Low)		48.5
Education (in %)	elementary or less	33.9
	intermediate	44.2
	high	11.4
Monthly net income (in %)	missing	16.1
	<€681	18.9
	€682-€1136	32.9
	€1137-€1818	21.0
	>1818	11.1
Mean prestige code Sixma & Ultee		36.1

Table 3 – FREQUENCY OF LIFE EVENTS

BETWEEN	WAVE I & II	WAVE II & III	WAVE III & IV	WAVE IV & V
Widowed (in %)	4.4	3.5	3.4	3.4
Divorced (in %)	0.1	0.1	0.1	0
Incidence or relapse chronic diseases (in %):				
Respiratory diseases	2.5	3.0	2.1	1.8
Heart diseases	5.6	4.8	4.8	5.7
PAD (arterial)	3.0	2.2	3.1	2.4
Diabetes	1.7	2.0	2.1	3.5
CVA (stroke)	2.8	2.2	2.6	3.3
Arthritis	11.1	8.9	7.5	8.7
Cancer	3.6	3.8	3.6	4.6
Surgery (in %)	9.4	10.1	9.2	12.7
Death parent, brother, sister, child & grand-child (in %)	22.1	8.6	18.5	16.0
Illness partner & relatives (in %)	36.4	35.4	26.6	24.9
Financial problems (in %)	10.1	7.5	6.7	5.7

Table 4 EFFECT OF THE BUSINESS CYCLE AT BIRTH ON COGNITION AT WAVE I

VARIABLES	Model I	Model II	Model III
Birth year	-0.026***	-0.026***	-0.027***
	(0.002)	(0.002)	(0.002)
Boom	-0.056**		
	(0.028)		
Cyclical component of the business cycle		-0.223	
		(0.181)	
Trough years (1st quartile of cyclical component)			0.075*
			(0.040)
Peak years (4th quartile of cyclical component)			0.014
			(0.034)
Constant	1.756***	1.708***	1.721***
	(0.047)	(0.040)	(0.041)
Observations	1937	1937	1937
R-squared	0.116	0.114	0.116

Cognition is measured by log(31- MMSE). High values are associated with worse cognition.
Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 5 LEVELS EQUATIONS MMSE CORRECTED FOR PEAK AND TROUGH YEARS (1ST AND 4TH QUARTILE OF THE CYCLICAL COMPONENT) AT BIRTH (POOLED DATA)

VARIABLES	Model I	Model II	Model III
Lagged log(31-MMSE)		0.468***	0.467***
		(0.014)	(0.014)
Age	-0.089***	-0.055***	-0.050***
	(0.019)	(0.014)	(0.014)
Age squared	0.001***	0.0005***	0.0005***
	(0.0001)	(0.0001)	(0.0001)
Education	-0.090***	-0.047***	-0.048***
	(0.005)	(0.004)	(0.004)
Married	0.030*	0.011	0.012
	(0.018)	(0.017)	(0.017)
Female	-0.099***	-0.057***	-0.060***
	(0.021)	(0.014)	(0.014)
Number of chronic conditions	0.017*	0.013*	0.010
	(0.010)	(0.007)	(0.007)
Life events (onset)			
Bereaved	-0.007	0.016	0.016
	(0.032)	(0.029)	(0.029)
Death of parent, sibling, (grand)child	0.032*	0.024*	0.025*
	(0.017)	(0.014)	(0.014)
Illness of partner or relatives	-0.116***	-0.085***	-0.083***
	(0.016)	(0.013)	(0.013)
Financial problems	0.104*	0.050	0.058
	(0.059)	(0.046)	(0.046)
Stroke (CVA)			0.109***
			(0.040)
Heart diseases			-0.004
			(0.025)
Respiratory diseases (COPD)			-0.029
			(0.035)
PAD (arterial)			-0.058*
			(0.034)
Diabetes			0.028
			(0.042)
Cancer			-0.024
			(0.071)
Arthritis			-0.009
			(0.019)
Surgery			-0.013
			(0.022)
Business cycle variables			
Trough years (1st quartile of cyclical component)	-0.039	-0.020	-0.017
	(0.028)	(0.018)	(0.018)
Peak years (4th quartile of cyclical component)	-0.037	-0.016	-0.015
	(0.026)	(0.017)	(0.017)
Constant	3.743***	2.147***	2.009***
	(0.678)	(0.491)	(0.491)
Observations	6523	6511	6478
R-squared	0.233	0.385	0.384

Cognition is measured by log(31-MMSE). High values are associated with worse cognition
*** $p<0.01$, ** $p<0.05$, * $p<0.1$ Robust clustered standard errors in parentheses

Table 6 LEVELS EQUATIONS MMSE CORRECTED FOR VALUE OF CYCLICAL INDICATOR GDP AT BIRTH (POOLED DATA)

VARIABLES	Model I	Model II	Model III
Lagged log(31-MMSE)		0.468***	0.467***
		(0.014)	(0.014)
Age	-0.093***	-0.056***	-0.051***
	(0.019)	(0.013)	(0.013)
Age squared	0.007***	0.0005***	0.0005***
	(0.0001)	(0.0001)	(0.0001)
Education	-0.090***	-0.047***	-0.048***
	(0.005)	(0.004)	(0.004)
Married	0.033*	0.013	0.013
	(0.017)	(0.017)	(0.017)
Female	-0.098***	-0.057***	-0.059***
	(0.021)	(0.014)	(0.014)
Number of chronic conditions	0.017*	0.013*	0.010
	(0.010)	(0.007)	(0.007)
Life events (onset)			
Bereaved	-0.008	0.016	0.015
	(0.032)	(0.029)	(0.029)
Death of parent, sibling, (grand)child	0.031*	0.023	0.024*
	(0.017)	(0.014)	(0.014)
Illness of partner or relatives	-0.116***	-0.085***	-0.083***
	(0.016)	(0.013)	(0.013)
Financial problems	0.103*	0.049	0.058
	(0.059)	(0.046)	(0.046)
CVA (stroke)			0.111***
			(0.040)
Heart diseases			-0.001
			(0.025)
Respiratory diseases			-0.028
			(0.035)
PAD (arterial)			-0.058*
			(0.034)
Diabetes			0.028
			(0.042)
Cancer			-0.024
			(0.033)
Arthritis			-0.009
			(0.019)
Surgery			-0.013
			(0.022)
Business cycle variable			
Cyclical component of the business cycle	-0.052	-0.010	-0.029
	(0.158)	(0.104)	(0.103)
Constant	3.812***	2.166***	2.025***
	(0.666)	(0.480)	(0.481)
Observations	6523	6511	6478
R-squared	0.232	0.384	0.383

Cognition is measured by log(31- MMSE). High values are associated with worse cognition
Robust clustered standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 7 FIRST DIFFERENCED EQUATION FOR MMSE (RESPONDENTS BORN IN RECESSIONS AND IN BOOMS)

	Model I	Model II	Model III
	All respondents	Only respondents born in recessions	Only respondents born in booms
VARIABLES			
Age	-0.161***	-0.168***	-0.152***
	(0.016)	(0.021)	(0.025)
Age squared	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)
Life event (onset)			
Stroke (CVA)	0.111***	0.150***	0.071
	(0.043)	(0.055)	(0.066)
PAD (arterial)	-0.075*	-0.090	-0.063
	(0.041)	(0.057)	(0.059)
Heart diseases	0.030	0.025	0.039
	(0.029)	(0.041)	(0.042)
Diabetes	-0.018	-0.006	-0.025
	(0.049)	(0.072)	(0.068)
Cancer	0.009	-0.062	0.084
	(0.037)	(0.052)	(0.053)
Respiratory diseases (COPD)	-0.011	-0.010	-0.003
	(0.041)	(0.058)	(0.059)
Arthritis	-0.003	-0.023	0.019
	(0.024)	(0.033)	(0.034)
Surgery	-0.015	0.026	-0.060*
	(0.024)	(0.032)	(0.035)
Illness of partner or relatives	-0.053***	-0.022	-0.087***
	(0.015)	(0.020)	(0.021)
Death of a parent, sibling, (grand)child	0.015	0.036*	-0.011
	(0.016)	(0.022)	(0.023)
Financial problems	0.001	-0.025	0.035
	(0.051)	(0.063)	(0.082)
Bereaved	0.031	0.034	0.031
	(0.034)	(0.049)	(0.048)
Observations	6482	3368	3114
R-squared	0.045	0.039	0.055

Cognition is measured by log(31-MMSE). High values are associated with worse cognition
*** $p<0.01$, ** $p<0.05$, * $p<0.1$ Robust clustered standard errors in parentheses

Table 8 FIRST DIFFERENCED EQUATION FOR MMSE (MALES AND FEMALES BORN IN RECESSIONS AND BOOMS)

	MALES		FEMALES	
	Only males born in recession	Only males born in boom	Only females born in recession	Only females born in boom
VARIABLES				
Age	-0.158***	-0.180***	-0.179***	-0.128***
	(0.031)	(0.038)	(0.030)	(0.035)
Age squared	0.001***	0.002***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Life event (onset)				
Stroke (CVA)	0.092	0.134	0.211***	-0.022
	(0.075)	(0.086)	(0.081)	(0.105)
PAD (arterial)	-0.136	-0.126	-0.027	-0.013
	(0.083)	(0.095)	(0.079)	(0.076)
Heart diseases	0.039	0.029	0.010	0.039
	(0.059)	(0.058)	(0.059)	(0.062)
Diabetes	-0.093	-0.020	0.055	-0.016
	(0.102)	(0.112)	(0.100)	(0.084)
Cancer	-0.085	0.128	-0.041	0.036
	(0.069)	(0.079)	(0.078)	(0.072)
Respiratory diseases	-0.054	0.002	0.029	-0.002
	(0.077)	(0.078)	(0.087)	(0.093)
Arthritis	-0.047	0.016	-0.006	0.022
	(0.050)	(0.059)	(0.043)	(0.042)
Surgery	0.001	-0.080	0.054	-0.046
	(0.046)	(0.052)	(0.046)	(0.050)
Illness of partner or relatives	-0.027	-0.124***	-0.017	-0.056*
	(0.031)	(0.031)	(0.026)	(0.029)
Death of a parent, sibling, (grand)child	-0.013	-0.023	0.081***	-0.002
	(0.031)	(0.036)	(0.031)	(0.029)
Financial problems	0.078	-0.125	-0.110	0.170
	(0.086)	(0.111)	(0.087)	(0.116)
Bereaved	0.017	0.065	0.050	0.008
	(0.089)	(0.082)	(0.059)	(0.060)
Observations	1520	1419	1848	1695
R-squared	0.040	0.071	0.045	0.047

Cognition is measured by log(31-MMSE). High values are associated with worse cognition

*** p<0.01, ** p<0.05, * p<0.1. Robust clustered standard errors in parentheses

Table 9 FIXED EFFECTS REGRESSED ON INDICATORS OF EARLY LIFE CONDITIONS AND OTHER TIME CONSTANT VARIABLES

VARIABLES	MODEL I	MODEL II
Year of birth	-0.014***	-0.014***
	(0.001)	(0.001)
Education	-0.091***	-0.091***
	(0.005)	(0.005)
Female	-0.103***	-0.104***
	(0.023)	(0.023)
Married	-0.069***	-0.070***
	(0.024)	(0.024)
Education	-0.091***	-0.091***
Presence of chronic conditions in wave I		
Respiratory diseases	-0.024	-0.024
	(0.034)	(0.034)
Heart diseases	0.027	0.027
	(0.028)	(0.028)
PAD (arterial)	0.041	0.042
	(0.039)	(0.039)
Stroke (CVA)	0.129**	0.127**
	(0.054)	(0.054)
Diabetes	0.022	0.024
	(0.047)	(0.047)
Cancer	0.004	0.008
	(0.039)	(0.039)
Arthritis	-0.009	-0.009
	(0.019)	(0.019)
Conditions at birth		
Cyclical component of business cycle	-0.201	
	(0.157)	
Trough years		-0.007
		(0.029)
Peak years		-0.051**
		(0.026)
Constant	1.807***	1.816***
	(0.042)	(0.042)
Observations	2264	2264
R-squared	0.189	0.190

*** p<0.01, ** p<0.05, * p<0.1 Robust standard errors in parentheses

Fig. 1.1 MITIGATING ROLE OF EARLY-LIFE CONDITIONS ON THE EFFECT OF ADVERSE EVENTS LATER IN LIFE ON COGNITIVE ABILITY.
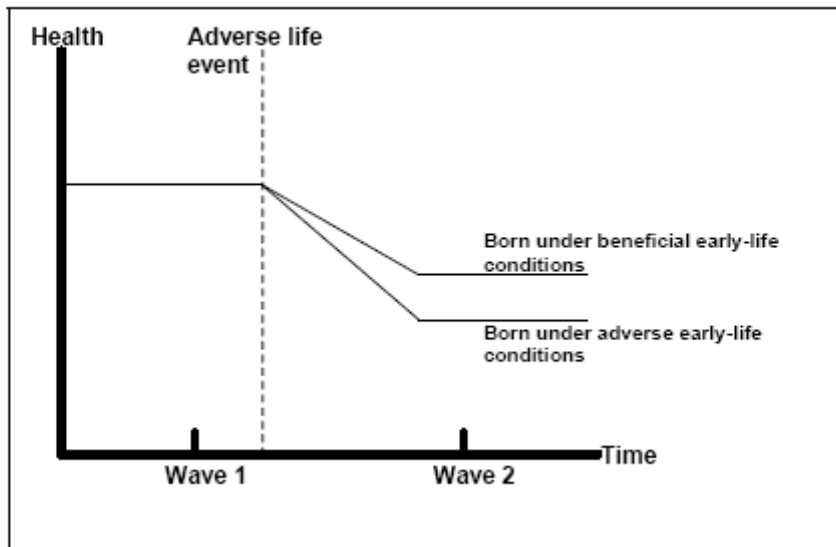

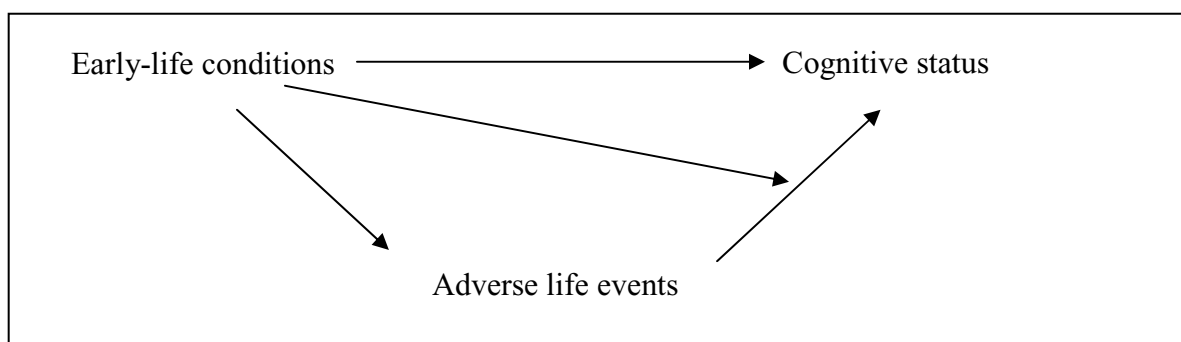Fig. 1.2 EARLY-LIFE CONDITIONS, ADVERSE LIFE EVENTS AND LATER-LIFE COGNITION
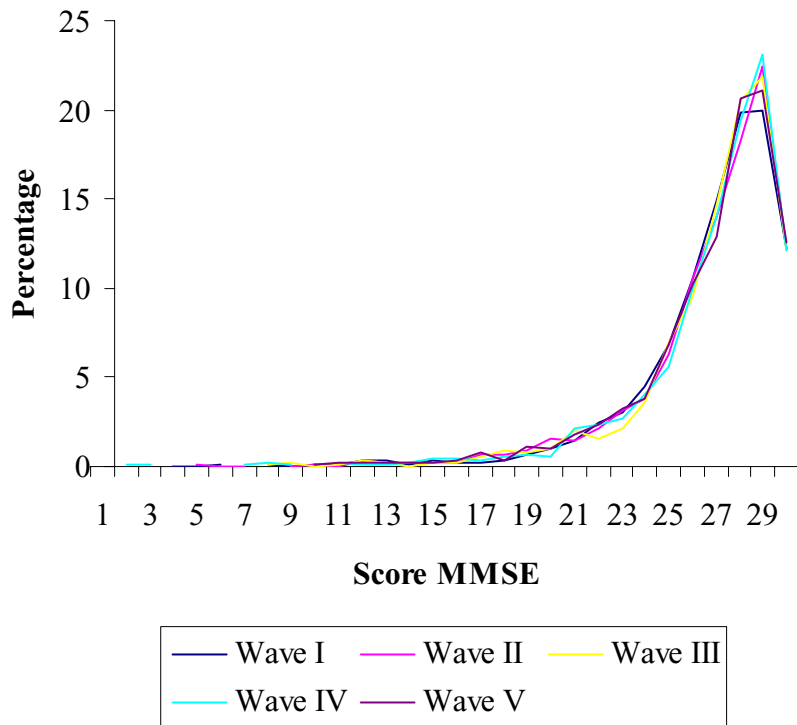
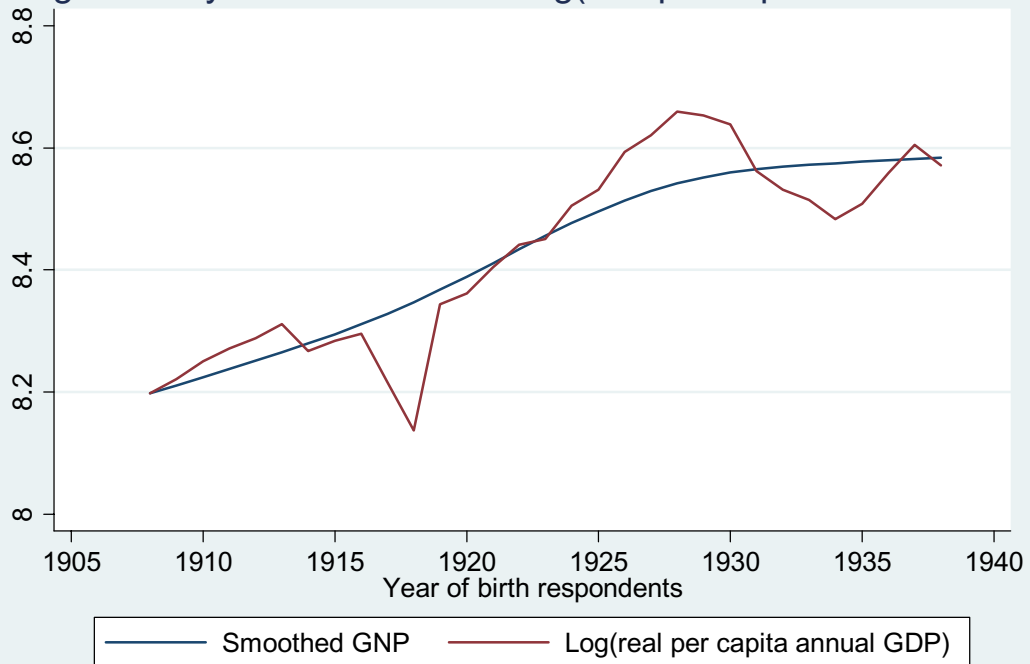Fig. 2.1 MMSE DISTRIBUTION AT WAVES I-V

Figure 2: Cyclical fluctuations Log(real per capita annual GDP)

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