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Retirement Improves Cognitive Performance

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Abstract

We analyze the effect of retirement and length of schooling on word recall at older ages using micro-data on 25,037 individuals and schooling and pension policy variation across 12 countries. Accounting for endogeneity of both schooling and retirement from the labour market, we show that they both have a positive effect on word recall. Mental and physical activities do not decrease due to retirement, and time use on non-passive activities significantly increases. Different levels of schooling across cohorts, ages and retirement states drive the spurious negative association between retirement and recall in raw data and in previous causal work that has ignored the role of schooling.

Keywords: cognitive ability, retirement, schooling

JEL Class: J26 (retirement; retirement policy), I21 (analysis of education), I12 (health production), C36 (instrumental variables)

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1 Introduction

In many countries people are living longer and retiring earlier than in previous decades. They are spending a larger proportion of their lifetime in retirement, depending on earlier savings or pension benefits to finance consumption. Populations are aging and the burden of risk and provision of old age income security is shifting from public collective to private individual. Cognitive ability is important for both decision making in general and financial planning(Christelis et al., 2010) and senior saving behavior (Banks et al., 2010) in particular. Differences in cognitive performance amongst the elderly will increasingly determine their future consumption possibilities and drive inequality.

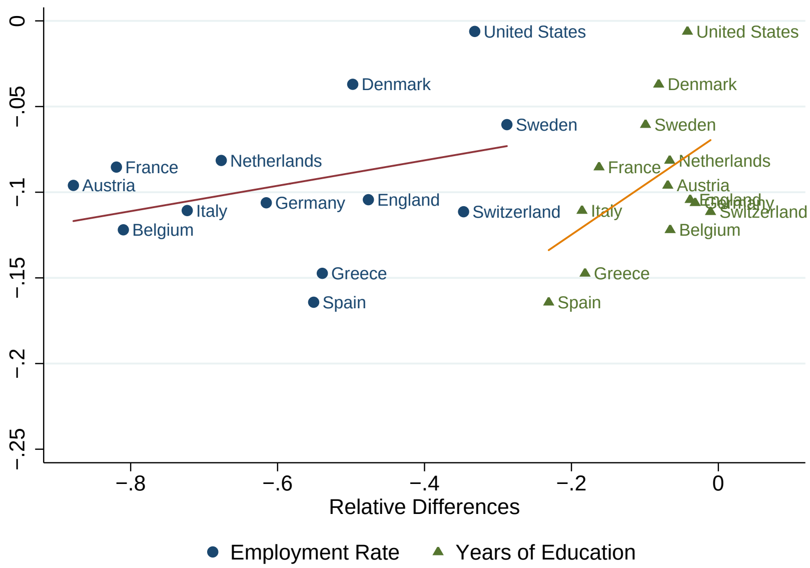
Although there is a great deal of heterogeneity in individual trajectories, cognitive ability usually increases at a declining rate until middle age and declines afterwards. It is becoming increasingly recognized (Hertzog et al., 2008) that different cognitive ability profiles in later life are associated with different behaviors from pre-school (Case et al., 2009), through compulsory school (Glymour et al., 2008), choice of leisure activities (Scarmeas and Stern, 2003) and age of retirement (Adam et al., 2007). If cognitive ability is malleable and some of these relationships are causal then cognitive ability can be usefully thought of as a form of human capital (Ben-Porath, 1967) or health capital (Grossman, 1972).

Cunha and Heckman (2007) develop a model of cognitive and non-cognitive skill acquisition through schooling investments, where the effect of schooling on cognitive ability is unambiguously positive. The relationship between retirement and cognitive functioning in a Grossman-like model is ambiguous. Bonsang et al. (2010) set up a standard Grossman model where individuals with higher cognitive functioning may perform work tasks and leisure activities more effectively. Work and leisure can involve different types of investment in cognitive functioning. Pension eligibility increases the cost of work relative to leisure investments. The net effect of retirement on cognitive functioning will depend on relative marginal productivities. Mazzonna and Peracchi (2010) further develop the role of retirement and cognitive performance. In their extended Grossman model, they include investment in cognitive functioning (reading, engaging in cultural and intellectual activities) directly in the utility function along with consumption. Although in the pure investment case cognitive functioning should fall on retirement, non-market incentives to invest in cognitive functioning work against this mechanism. In both models the effect of retirement on cognitive performance is of ambiguous sign.

This paper uses data from SHARELIFE release 1, as of November 24th 2010 or SHARE release 2.5.0, as of May 24th 2011. The SHARE data collection has been primarily funded by the European Commission through the 5th framework programme (project QLK6-CT-2001- 00360 in the thematic programme Quality of Life), through the 6th framework programme (projects SHARE-I3, RII-CT- 2006-062193, COMPARE, CIT5-CT-2005-028857, and SHARELIFE, CIT4-CT-2006-028812) and through the 7th framework programme (SHARE-PREP, 211909 and SHARE-LEAP, 227822). Additional funding from the U.S. National Institute on Aging (U01 AG09740-13S2, P01 AG005842, P01 AG08291, P30 AG12815, Y1-AG-4553-01 and OGHA 04-064, IAG BSR06-11, R21 AG025169) as well as from various national sources is gratefully acknowledged (see `http://www.share-project.org` for a full list of funding institutions).

The HRS (Health and Retirement Study) is sponsored by the National Institute on Aging (grant number NIA U01AG009740) and is conducted by the University of Michigan. The ELSA (English Longitudinal Study of Ageing) is funded by the US National Institute on Ageing and a consortium of UK government departments coordinated by the Office for National Statistics.

Figure 1: Relative drop in cognitive performance
50-54 vs 60-64 years old respondents



Human capital and health capital theory suggests that elderly cognitive functioning is affected by schooling in a positive way and by retirement in an ambiguous way. Banks and Mazzonna (2011) provide empirical support for a positive schooling effect using school leaving laws as an instrument. Rohwedder and Willis (2010), henceforth RW, provide empirical support for a negative retirement effect using pension eligibility ages as instruments. The causal schooling study ignores retirement and the causal retirement study ignores schooling. Theory suggests there may be a role for both which otherwise leads to omitted variable bias in empirical work. The schooling effect may be spuriously positive rather than zero and the retirement effect may even be incorrectly signed. In this paper we analyze the concurrent effect of schooling and retirement on word recall at older ages. We combine insights from studies exemplified by these two causal papers and use school leaving laws and early and old age pension eligibility as instruments.

In order to present the insight driving the contribution of our paper, figure 1 reproduces and extends the main descriptive figure of RW. We illustrate the correlation between word recall, schooling and employment differences around potential retirement age for a cross section of 12 countries in 2004. The vertical axis shows by country the relative difference between ages 60-64 and 50-54 in mean number of words recalled out of twenty in a test of memory. The figure comprises two parts. The scatter of blue circles to the left plots mean relative differences in employment rates, with a red linear regression line, following the insight in Bonsang et al. (2010). This first part reproduces the stylized fact that countries with the greatest fall in employment between these ages also have the greatest reduction in word recall. The scatter of green triangles to the right plots

mean differences in years of schooling, with an orange linear regression line. This second part shows a similar gradient in schooling and word recall: countries with the biggest increase in schooling have the greatest increase in word recall. While figure 1 plots simple correlations of differences in means between age groups for a cross section of countries and confounds cohort differences, it conveys an essential similarity: worse word recall is associated not only with less employment, but also with lower schooling for those around potential retirement age.

The remainder of the paper is organized as follows. Section 2 reviews the causal literature and specifies our identification strategy. Section 3 provides institutional background and describes the data to be used. Section 4.1 presents and discusses estimation results. Section 4.2 provides some robustness checks of the main findings. Section 5 interprets the results in the light of previous literature. Section 6 summarizes and concludes.

2 Literature review and identification strategy

We combine insights from two groups of papers. The seminal studies were Adam et al. (2007) for retirement and cognitive functioning and Glymour et al. (2008) for schooling effects on memory. Since our approach is essentially a combination of the methods employed in these groups of papers, describing them is informative in order to place our contribution in the literature.

The first group of papers studies the relationship between cognitive functioning and retirement. Adam et al. (2007) analyze how retirement mediates the relationship between aging and cognitive performance in Continental Europe using the Survey of Health and Retirement in Europe (SHARE) data. This descriptive analysis clearly indicates the relationship between differences in employment status and differences in cognitive performance of the elderly by age group across countries. RW extends the work of Adam et.al. by examining a causal role for retirement in determining word recall, using combined SHARE, US Health and Retirement Survey (HRS) and English Longitudinal Study of Ageing (ELSA) data. They motivate their analysis by appealing to Gruber and Wise (2004), who show the strong relationship between incentives provided by pension benefits and age of retirement in different datasets from 12 countries. Spikes in retirement hazard rates commonly correspond to ages of first eligibility for pension benefits. Therefore, RW characterize pension incentives as ages of eligibility to early pension benefits and to old age pensions, which correspond to jumps in incentives and spikes in retirement. They find retirement has a strong negative effect on word recall.

Bonsang et al. (2010) extends Adam et.al. to look at the effect of retirement on cognitive functioning. They use five waves of HRS using eligibility to Social Security benefits to instrument retirement, and two waves of SHARE using differences in country mean retirement ages as instruments for individual retirement status. The authors find a strong negative effect of retirement on cognitive functioning in both datasets. Mazzonna and Peracchi (2010) extend RW using two waves of SHARE and ages of early and old age pension eligibility as instruments for retirement. The paper presents an extended Grossman model of health capital and emphasizes the role of schooling, although treated as exogenous throughout. Once again retirement is found to reduce cognitive performance. The Mazzonna and Peracchi study is perhaps closest to our paper. Our contribution is to additionally consider schooling as an endogenous variable. Coe et al. (2011) use employer-

provided pension incentives which generate early retirement windows in HRS data to provide exogenous variation in retirement age to explain cognitive functioning. This is a nice complement to other papers using eligibility ages for public pensions. However, no clear causal relationship is found between retirement and cognitive functioning.

The second group of papers studies the relationship between cognitive functioning and schooling. Glymour et al. (2008) is a seminal paper considering the causal relationship between schooling and memory and mental status amongst the elderly. The authors use compulsory schooling laws across different States in the US as instruments, as they have been in several other contexts (see Lleras-Muney (2005) on the effect of schooling on mortality). Glymour finds schooling to affect memory but not mental status. Banks and Mazzonna (2011) use a change in the minimum school leaving age in ELSA to provide a forcing variable in a regression discontinuity design. They find large effects of schooling on memory and executive functioning (attention and problem solving).

An important limitation of these instrumental variables approaches is that in the case of treatment heterogeneity they identify a local average treatment effect (Imbens and Angrist, 1994) because the instrument affects only a subset of the population. The large causal schooling literature has long recognized this issue (Card, 2001), but there are fewer causal retirement papers, and instrumental variables techniques are less used in retirement studies (Coe and Zamarro, 2011). Compulsory schooling laws directly affect individuals at the bottom of the schooling distribution. Although spillovers to high school and beyond cannot be ruled out (Lange and Topel, 2006; Brunello et al., 2009), most of the impact will be for those who otherwise would have chosen the pre-reform lower level of compulsory schooling. Likewise, though less recognized, a local average treatment effect interpretation is also relevant for causal retirement studies using pension eligibility instruments. Those most likely affected will have higher replacement rates because of lower market wages or higher benefits.

In order to understand and interpret our findings on the effect of retirement on word recall we turn to the descriptive literatures from epidemiology and gerontology. Cognitive functioning is an important aspect of mental health and retirement from the labour market has important consequences for the allocation of time to different activities. Three association studies serve to illustrate the relationships that this literature found.

Mein et al. (2003) analyze health functioning around retirement for British civil servants from the Whitehall II study. They find mental health to improve on retirement, especially among the higher grades of this otherwise homogeneous sample. Warr et al. (2004) study the link between types of activity and psychological well-being of older British people. In their paper, overall activity level is positively correlated with life satisfaction and negatively with depression. Specific activities driving this result are family, religious activity and voluntary work. Gauthier and Smeeding (2003), in a large study of time use for older adults in 9 countries, shows that passive activities increase with age. Of the 6 hours on average allocated to market work when aged 45, 3.5 are reallocated to sleeping, bathing, dressing, eating and watching TV by age 75. The remainder is reallocated to active pursuits such as hobbies, leisure away from home and sport. However, the authors make no distinction between the respective contributions of aging versus retirement to this change in active time use.

Time spent on different activities changes on leaving the labour market, and so does mental health. None of these descriptive studies distinguishes aging from retirement or

suggests a causal interpretation of retirement on types of activity. However, activity outcomes are in principle as amenable to a causal approach as is word recall. Retirement from the labour market, as well as being associated with, may also lead to a redistribution of non-market activities. Any changes in activities and cognitive functioning due to retirement ought to provide another link in the causal chain of relationships.

In this paper we model elderly word recall as a function of schooling *and* retirement status. Furthermore we model types of activity similarly as a function of schooling and retirement status. We combine the insights of the groups of papers exemplified by RW on retirement and by Banks and Mazzonna (2011) on schooling. An instrumental variables approach with two endogenous variables and heterogeneous effects allows us to make inferences about local average treatment effects. Those directly affected by schooling laws and early pension ages are likely to be at the bottom of the schooling and market wage distributions. Given the strong positive relationship between schooling and wages these are likely to be the same individuals. Our inferences on the effect of schooling and retirement on elderly memory will be valid for those with short schooling and low wages rather than better paid college graduates.

3 Data Description

3.1 Data sources and variables

Identification of our empirical model of word recall requires exogenous variation in both schooling and retirement. This source of exogeneity comes from within and between country variation in compulsory schooling laws and pensionable ages. Within country variation in pension eligibility for RW is between gender. Within country differences in compulsory schooling laws are between cohorts. In order to provide sufficient variation in schooling laws within country, we chose a broader age range (55-70) than RW (60-64).

In order to use compulsory schooling laws as instruments, we further trim our sample in two ways. First we exclude immigrants (which we identify as individuals born outside the nation where they were interviewed) as they may not have been subject to the same compulsory schooling laws as the other respondents in the country. Second, we exclude individuals for whom we do not have information on the compulsory law to which they were subject. The SHARE data for Switzerland that is available to us does not have sufficient regional information to code compulsory schooling for our cohorts of interest. Furthermore, we drop US respondents who refused to provide information about their area of birth. This procedure leaves us with an overall sample of 25037 individuals who report non-missing values for years of education, retirement status and cognitive performance. Throughout we call the 55-70 age range our preferred “large sample”; for the sake of comparability with previous studies we estimate every specification in parallel for the “small sample” aged 60-64. We use 2004 data, which is the first cross section for which HRS, SHARE and ELSA are all available.

We use ELSA, HRS and SHARE data because of their quality, representativeness and high degree of comparability. Our variables of interest have all been used extensively, especially in the groups of studies outlined in section 2. Here we present the survey questions used, describe transformations made and indicate comparability issues between countries.

The measure of cognitive functioning we use is word recall and is of the same structure across countries. The interviewer reads out a list of 10 words at a fixed speed. Right afterwards the respondent repeats as many words as can be remembered (immediate recall). Other questions about cognitive functioning follow. Then the interviewer asks the respondent to repeat as many words from the original list as can still be remembered (delayed recall). The sum of words correctly recalled immediately and after the delay together gives the total word recall measure, our outcome of interest, ranging 0-20.

Even though the surveys are otherwise highly comparable, they code education in slightly different ways. While HRS asks directly the highest grade of school or year of college attended, in SHARE and ELSA respondents declare their highest completed level of education. As a consequence in ELSA and in each SHARE country years of schooling, derived as the minimum number of years required in order to achieve given educational qualifications, appear as discontinuous variables concentrated around key values. This bunching is typically at completion of primary, lower secondary, upper secondary and tertiary education. However, since the number of years to achieve a key educational attainment differs considerably among European countries, aggregating the data smooths out discontinuities and eliminates most of the bunching observed in single countries.

Figure 2 shows mean words recalled by years of schooling and retirement status for six selected countries. The recall-schooling relationship is positive everywhere but not monotonic, and workers have better recall than retirees for most of the time in most countries. The US has the smoothest positive relationship (and the largest sample size), while Denmark has the most erratic pattern (and the smallest sample size). Coding in ELSA does not allow us to discriminate individuals with less than nine years of schooling (the minimum compulsory schooling length in England). As a consequence, while we observe non-compliers with English schooling law reform, i.e. those born after July 1943 with nine years of schooling (see table 3), those born before are bottom-coded to nine. SHARE and HRS data have no such bottom-coding. Figure 3 pools all countries and shows a clearer positive relationship of more words recalled across most years of schooling. Dashed linear regressions illustrate the parallel trends, with workers recalling 0.8 more words than retirees on average throughout the schooling distribution.

We derive retirement status from response to a question which is almost identical across surveys: "Did you do any paid work during the last four weeks, either as an employee or self-employed, even if this was only for a few hours?". If the respondent answers in the negative they are defined as retired, regardless of prior work history.

Figure 4(a) presents the years of schooling distribution for workers and retirees. The proportion of workers increases for longer schooling. Those with up to 9 years of schooling are 3/4 retirees, those 10-13 2/3 are retirees and from 14 just less than half are retired. About 1/3 of observations are in the 4-10 years schooling range spanning the window of minimum schooling laws. Figure 4(b)(c)(d) shows the education distribution by retirement status according to age group. The pattern of a greater proportion of retirees lower down the schooling distribution is still apparent. Schooling is more evenly distributed for the oldest age group and shifts upwards for younger ages as schooling minima are higher for those later cohorts.

Figure 5 presents sample proportions more clearly than the previous figure. The proportion of retirees decreases by 0.5 across the range of schooling. The right pane shows

In HRS the time range is quantified as "one month

Figure 2: Cognitive functions, by years of education - sample of countries

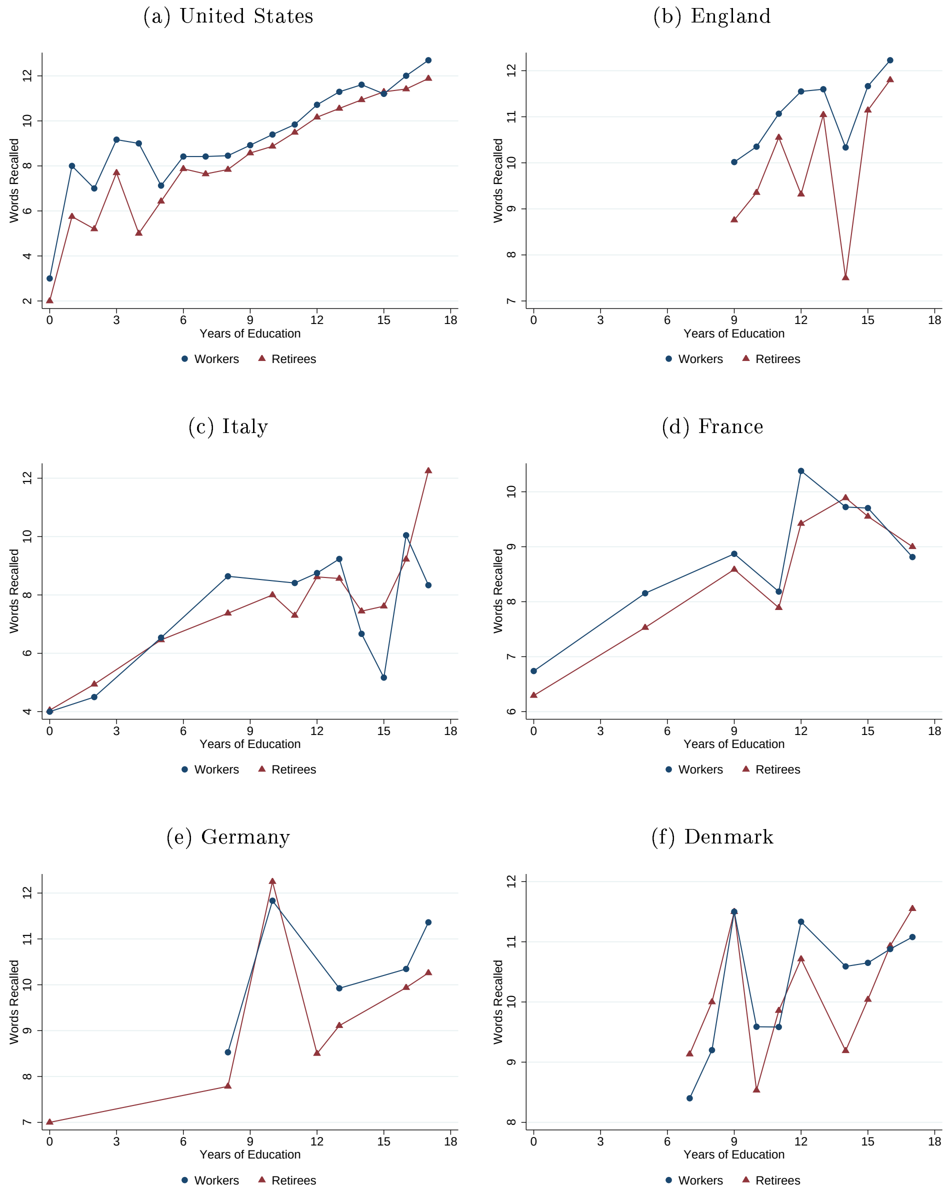


Figure 3: Cognitive functions, by years of education - all countries

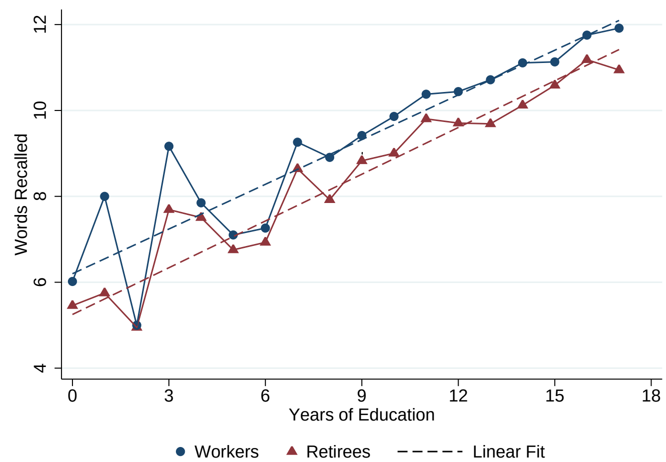
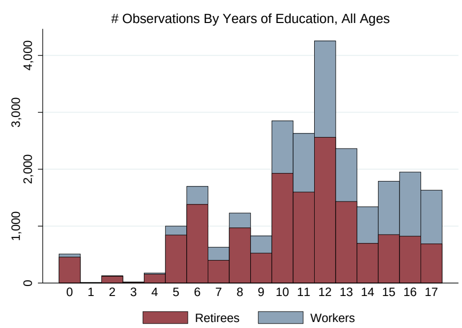
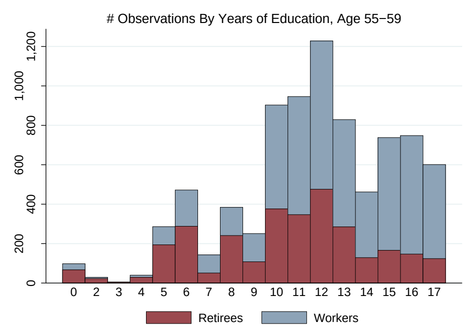


Figure 4: Years of education: distribution

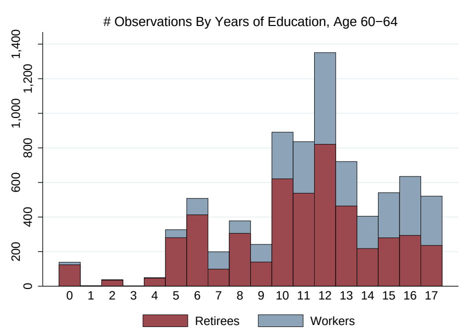
(a) All Ages



(b) Age 55-59



(c) Age 60-64



(d) Age 65+

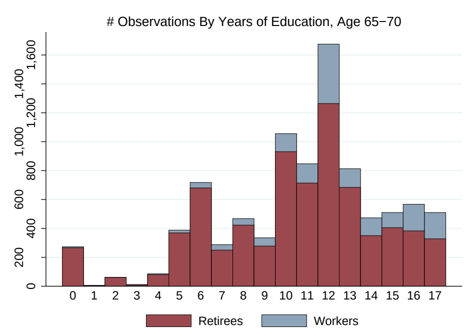


Figure 5: Proportion of retirees

(a) By Schooling (b) By Schooling and Age Groups

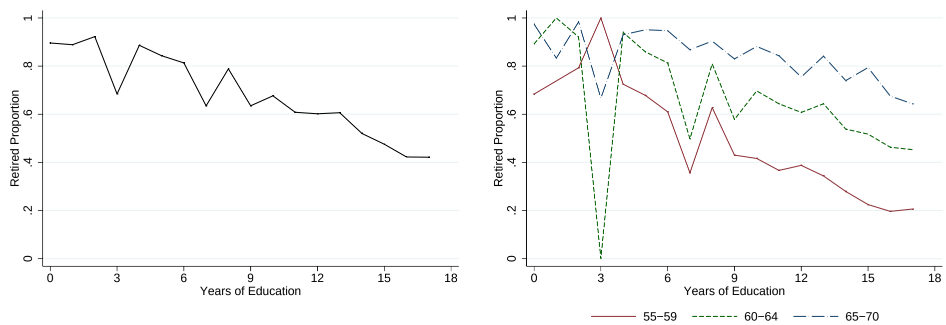


Table 1: SHARE activities: descriptives

Type of Activity	Workers	Retirees	T-stat.
Voluntary / charity	0.158	0.142	2.471
Cared for sick adult	0.076	0.066	2.108
Help to family / neighb.	0.315	0.249	7.830
Attended education / training	0.111	0.047	13.659
Sport or social club	0.239	0.186	6.834
Religious org.	0.097	0.129	-5.140
Political org.	0.065	0.039	6.502
Sum	1.056	0.852	9.637
Hyperbolic weighting	1.060	0.928	5.513
Linear weighting	0.920	0.806	5.556

SHARE sample only: 12859 observations.

the decline in retirement with increasing schooling is steeper for younger age groups, as more are still working.

As a final descriptive statistic, in table 1 we decompose the transition from market work to leisure in terms of the distribution of activities reported by workers and retirees . The three surveys record time use differently and we focus on SHARE because of sample size and the greater policy variation within that survey which can be exploited in subsequent regression analysis. SHARE respondents indicate for each of the activities listed in the upper pane of the table whether they did it or not in the month before the inteview. Entries in this pane are proportions of the sample engaging in the said activity according to retirement status. Workers are significantly more active than retirees in all areas apart from religious organization, where retirees are significantly more active.

For each activity indicated, there is a probe for frequency: daily, weekly or less often. The lower pane of table 1 treats this frequency information in different ways in order to

Table 2: Pensionable ages

Country	Women		Men	
	Early	Normal	Early	Normal
United States	62	65	62	65
England	60	60	65	65
Austria	56	60	61	65
Germany	60	65	60	65
Sweden	61	65	61	65
Netherlands	60	65	60	65
Spain	60	65	60	65
Italy	57	60	57	65
France	60	60	60	60
Denmark	60	65	60	65
Greece	55	57	60	62
Belgium	60	63	60	65

Source: Rohwedder and Willis (2010)

summarize total activity engagement. The first row is a simple sum of activities ignoring frequency. Hyperbolic weighting attributes daily 2, weekly 1, less often 2/3. Linear weighting attributes daily 1.5, weekly 1.0, less often 0.5. Frequency weighting narrows the aggregate difference and reflects that retirees perform fewer activities but engage in those they do more frequently. Regardless of weighting, workers remain significantly more active than retirees.

3.2 Institutional Background

This section places schooling, cognitive functioning and retirement described in the previous section in the context of education policy and pension policy variation.

Table 2 is a reproduction from the online appendix to RW, which shows early and old age pensionable ages by gender for our 12 countries. All countries but France have distinct early and old age pension programs. There are gender differences in early pensionable ages in three countries and in old age pension ages in five. Almost everywhere there is variation in pensionable ages within and between countries. The table refers to pensionable ages in year 2004 for those aged 60-64. Our “large sample” spans the broader age range 55-70. Arguably the pensionable ages which were in force when retirement decisions were made are most relevant for each cohort in each country. However, in the large sample 9% of observations were potentially subject to a different early pensionable age threshold than presented in the table and 20% have a potentially different old pensionable age threshold. The second percentage is largely driven by US and excluding HRS data, only 6% of the remaining observations have different pensionable ages to those presented. These differences would be especially important if we were modelling age of retirement and reforms would aid identification. However we are using single cross-sections of data with the more modest aim of instrumenting retirement *status* in year 2004 when word recall is

measured. Interpretation of first stage coefficients will depend on which pensionable age rules were chosen for each cohort, but for second stage instrumental variables coefficients of interest this is a matter of statistical precision rather than bias of estimates. For the sake of comparison with RW we use their pensionable ages throughout.

Between and especially within country variation in school leaving laws have been used extensively to instrument for education for several different outcomes of interest. Lleras-Muney (2001) describes compulsory schooling law variation within and between States of the US. In the HRS data that is available to us the US is split into 10 regions. For the U.S. we map schooling laws to individuals according to their region of birth, imputing the population-weighted average of state-level compulsory schooling to each HRS zone. This mapping is available on request from the authors. For SHARE countries we use compulsory schooling laws documented in Fort (2006) and Garrouste (2010), with the exception of Denmark, which is documented correctly in Arendt (2005). For England we use the school leaving ages as documented in Banks and Mazzonna (2011).

Table 3 shows years of compulsory schooling for the 11 European countries in the sample. The US has regional as well as between cohort variations and is not presented. While during the small sample period only England changes its school leaving law, across the large sample period law variations occur in six countries. As mentioned in section 2, introducing within-country schooling law variation is an important motivation for widening the range of birth cohorts covered. Table 4 presents descriptive statistics for all variables used in the analyses. Means and standard deviations of age and outcome and endogenous variables are remarkably similar for large and small samples. Policy instruments show a different pattern. While years of compulsory schooling are similar, early and old age pension eligibilities are quite different. Expanding age window of the sample from 60-64 to 55-70 reduces the proportion of individuals eligible to early pension benefits and increases the proportion of individuals eligible to old age benefits, making the large sample more evenly balanced according to pension eligibilities.

We further compare the two samples plotting words recalled and years of schooling by retirement status and country in figure 6, where the left column represents the large sample and the right column represents the small sample. In the upper panes, retirees recall about half a word less than workers in the small sample. This gap doubles to about one word in the larger sample, which includes younger workers as well as older retirees because of the wider age range. In the middle panes, years of schooling exhibit a similar pattern as workers (in younger cohorts) have on average longer schooling than retirees everywhere. The gap is one to two years and does not differ much between samples. In the lower pane we group schooling by pensionable (pension eligibility) status and country. The left pane for the large sample shows schooling decreasing by eligibility (none, early, old) within all countries, mainly because older ages and earlier cohorts have less schooling. While in the large sample there are only two countries without all three eligibility states observed, the smaller sample (with a narrower age range) is relatively sparse with only one country having observations of all three eligibility states.

We use the large sample to produce tables 5 and 6, which presents correlation matrices respectively for the variables of interest and for the policy instruments. Schooling has the strongest correlation with recall and this is positive. Retirement is negatively correlated with recall and schooling, with about half the magnitude of the schooling-recall correlation. Correlations in the large and small samples are similar. Years of

Table 3: Compulsory schooling

Country	**Birth Cohort** 1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
England	9	9	9	9	9	9	9	9	9	9	10	10	10	10	10	10
Austria	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	9
Germany	4	4	4	8	8	8	8	8	8	8	8	8	10	10	10	10
Sweden	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	9
Netherlands	7	7	7	8	8	8	8	8	8	8	8	8	8	8	8	8
Spain	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Italy	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
France	7	7	7	7	7	7	7	7	7	7	7	7	10	10	10	10
Denmark	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Greece	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Belgium	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8

Small sample (Rohwedder and Willis (2010)) bracketed

Table 4: Summary statistics

Variable	Large sample		Small sample	
	Mean	St. Deviation	Mean	St. Deviation
Cognitive Abilities	9.619	3.407	9.73	3.348
Education	11.249	3.734	11.308	3.692
Retirement	0.617	0.486	0.632	0.482
Age	62.331	4.616	62.035	1.429
Compulsory Ed.	8.061	1.451	7.98	1.323
Early Ret. Elig.	0.638	0.481	0.801	0.399
Old Age Ret. Elig.	0.452	0.498	0.256	0.436
Observations	25037		7787	

Table 5: Cross-correlations between variables of interest

Large Sample

Variables	Cognitive Abilities	Retirement	Education
Cognitive Abilities	1.000		
Retirement	-0.208	1.000	
Education	0.420	-0.253	1.000

Small Sample

Variables	Cognitive Abilities	Retirement	Education
Cognitive Abilities	1.000		
Retirement	-0.176	1.000	
Education	0.422	-0.224	1.000

Table 6: Cross-correlations between instruments

Large Sample

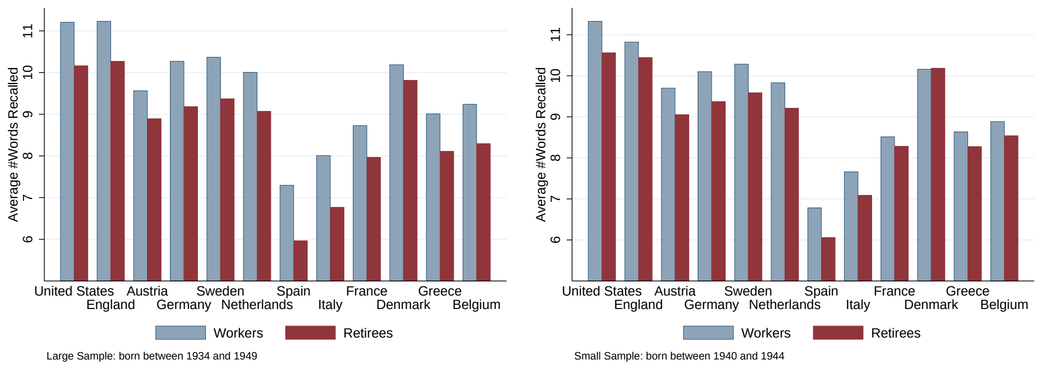
Variables	Early Ret. Elig.	Old Age Ret. Elig.	Compulsory Ed.
Early Ret. Elig.	1.000		
Old Age Ret. Elig.	0.685	1.000	
Compulsory Ed.	-0.288	-0.163	1.000

Small Sample

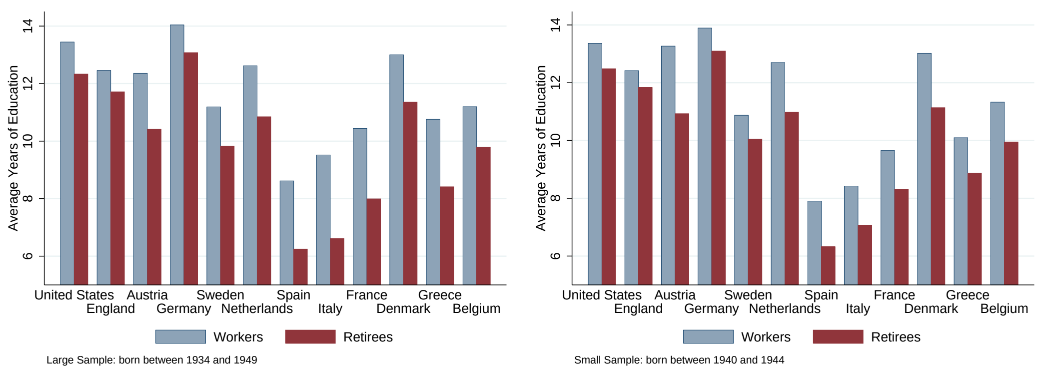
Variables	Early Ret. Elig.	Old Age Ret. Elig.	Compulsory Ed.
Early Ret. Elig.	1.000		
Old Age Ret. Elig.	0.292	1.000	
Compulsory Ed.	-0.332	-0.163	1.000

Figure 6: Word recall and schooling

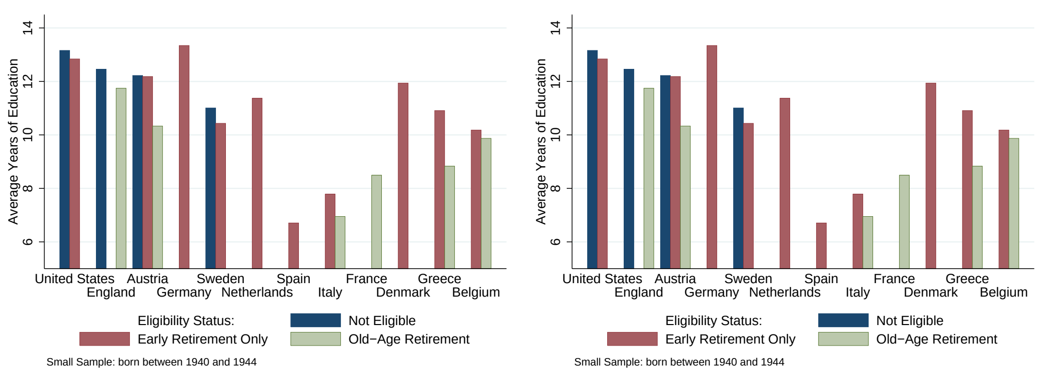
(a) Cognitive Functions



(b) Education



(c) Education, by Retirement Eligibility



compulsory schooling is negatively correlated with pension eligibility and this is twice as strong for early compared to old age pensions. Countries with more compulsory schooling tend to have later eligibility to early pension benefits and somewhat later eligibility to old age pensions. Not surprisingly, early and old age pension benefit eligibilities are highly correlated across countries.

In fact, we consider these two instrumental variables as separate components of a single piece of information, as they are consecutive steps of a hypothetical categorical variable representing the number of pension eligibilities. However, separating them allows both to estimate more precisely the effects of different retirement policies and to highlight the key difference between RW and our setting.

Figure 7 illustrates how ages of pension eligibilities confound the retirement coefficient from an instrumental variable estimation when schooling, which is strongly related to old age cognitive performance, does not enter the model. In the upper pane we group observations according to their early pensionable age; in the lower, to their old-age pensionable ages. The blue dots in the upper part of the panes represent the average values of residuals from a regression of years of schooling on a full set of age dummies for each of the groups that pension eligibilities define. The use of residuals allows us to filter the effects of age differentials across groups.

The graph shows a striking correlation between schooling and pensionable ages: the higher are minimal ages for pension benefits, the higher is the level of education of the population affected. Due to this correlation and given the relationship between schooling and old-age cognitive functioning, pensionable ages alone are correlated with our variable of interest, and are likely to bias inference.

At the same time, the blue dots generally move on the vertical axis accordingly to the brown bars in the lower part of the panes. The brown bars represent average compulsory years of schooling for each of the pension eligibility groups, and appear to explain most the positive relationship between ages of pension benefit eligibility and schooling. As a consequence, figure 7 is a strong motivation for taking an instrumental variables approach to both retirement and schooling, using compulsory schooling laws as an additional instrument.

4 Results

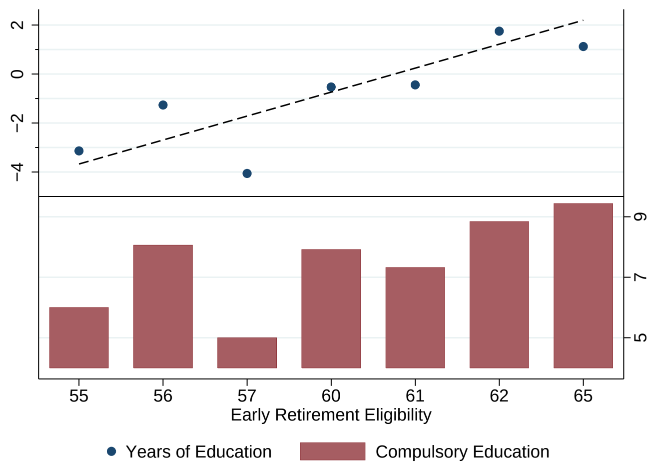
4.1 Main estimations

In this section we present and discuss our model estimates: baseline Ordinary Least Squares, which are comparable with various association studies, reduced forms followed by first stage regressions describing the explanatory power of the instruments and two stage least squares estimates of our main model of interest. We conclude with a simulation illustrating the schooling, retirement and word recall relationship found.

Table 7 shows baseline OLS estimates for our specifications of interest including schooling. The table is organized with panes according to gender and columns according to sample age range and whether age dummies are included as controls. Consider the specification with large sample and age control (column 3) for both genders (top pane). In retirement 0.55 fewer words are recalled, which is about the same as aging 10 years. One year of schooling increases recall by 0.35 words. Estimates are of similar magnitude and

Figure 7: Instrument validity for pension eligibility alone

(a) Early Retirement



(b) Old Age Retirement

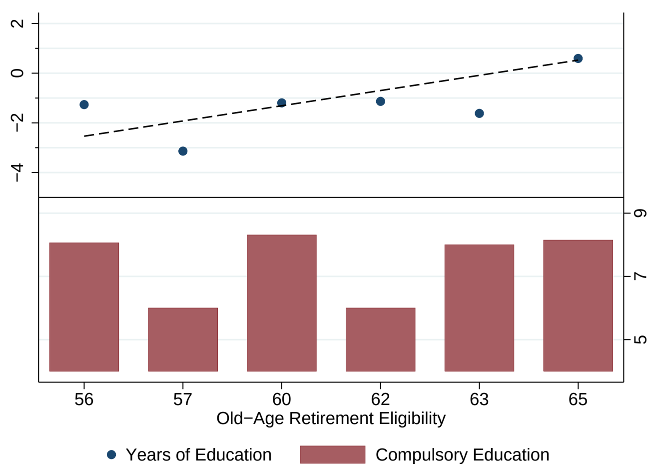


Table 7: Baseline estimates for word recall (OLS)

	Large Sample		Small Sample	
Corrected for Age	X	✓	X	✓
		Both Genders		
Retirement	-0.760***	-0.550***	-0.597***	-0.573***
	(0.0413)	(0.0444)	(0.0729)	(0.0732)
Education	0.358***	0.357***	0.365***	0.366***
	(0.00537)	(0.00536)	(0.00952)	(0.00952)
Age		-0.0571***		-0.0760***
		(0.00455)		(0.0241)
Constant	6.061***	9.500***	5.977***	10.67***
	(0.0739)	(0.284)	(0.131)	(1.495)
Observations	25037	25037	7787	7787
R^2	0.187	0.192	0.185	0.186
F-stat.	2883.9	1987.0	884.5	593.7
		Females Only		
Retirement	-0.825***	-0.643***	-0.724***	-0.700***
	(0.0576)	(0.0611)	(0.103)	(0.103)
Education	0.397***	0.396***	0.398***	0.398***
	(0.00741)	(0.00739)	(0.0131)	(0.0131)
Age		-0.0531***		-0.0799**
		(0.00607)		(0.0323)
Constant	6.190***	9.395***	6.223***	11.16***
	(0.102)	(0.380)	(0.181)	(2.005)
Observations	13775	13775	4364	4364
R^2	0.215	0.220	0.208	0.209
F.stat.	1891.2	1293.2	572.4	384.1
		Males Only		
Retirement	-0.910***	-0.736***	-0.780***	-0.763***
	(0.0573)	(0.0633)	(0.100)	(0.101)
Education	0.334***	0.334***	0.349***	0.350***
	(0.00752)	(0.00751)	(0.0133)	(0.0133)
Age		-0.0428***		-0.0482
		(0.00666)		(0.0345)
Constant	5.784***	8.366***	5.605***	8.583***
	(0.103)	(0.414)	(0.182)	(2.142)
Observations	11262	11262	3423	3423
R^2	0.191	0.194	0.200	0.200
F-stat.	1329.9	903.5	426.8	285.2

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Large sample: SHARE-HRS-ELSA, 1934-1949 birth cohorts. Small sample: SHARE-HRS-ELSA, 1940-1944 birth cohorts. Linear age correction. OLS estimation.

consistently signed across specifications and samples. The retirement coefficients become even more negative when splitting the sample by gender in the lower panes. Association studies and even causal studies have found similar positive correlations between schooling and cognitive functioning and negative correlations between retirement and cognitive functioning. This is re-assuring, but hardly surprising as several are based on data from the same sources.

In order to show the explanatory power of the instruments, table 8 presents reduced form regressions of the policy variables on word recall, organized in the same way as table 7. In the upper pane for both genders pooled, with the small sample only compulsory schooling is a significant determinant of word recall, whereas pensionable ages are insignificant. However, there is almost no variation in compulsory schooling within countries for the small sample cohorts, so this may be picking up country-specific factors. Moving to the large sample, all pension and schooling instruments become significant. The lower panes split the sample by gender. Compulsory schooling is always significant, as is at least one of the pension eligibility indicators. Since all within-country variation in pension eligibility is between genders, that these policies still have explanatory power is remarkable. However, as with compulsory schooling for the small sample, pension eligibility by gender may also be picking up country-specific factors. The significantly positive coefficient on early pension eligibility for both genders pooled, large sample with age controls would be consistent with this.

The strength of these reduced form relationships are presented in figure 8, which shows the mean number of words recalled and our instruments by country. Size of the brown circles represents sample size corresponding to each pair in figure 8a and to each country in figure 8b and 8c . Both figures refer to the sample including individuals born from 1934 to 1949 (our large sample). The dashed linear regression line shows a strongly positive relationship for compulsory schooling and a negative one for early and old-age retirement eligibility. The large circles in proportion to pension eligibility are for HRS (7300) and ELSA (4968). These are split among several smaller circles in the upper compulsory schooling pane due to region and cohort differences within country.

First stage schooling relationships are presented in figure 9 which graphs years of compulsory schooling and mean observed completed schooling by country. Both the small sample in the upper pane and the large sample in the lower pane exhibit a strong positive relationship with similar linear regression line slopes of 1.24 and 1.0 respectively. Figure 10 graphs first stage relationships between proportion pension eligibility and proportion retired by country. Panes to the left are for early pension eligibility, to the right are for old age pension eligibility, above are for the small sample and below are for the large sample. The upper pane is a reproduction of RW figure 6 for our sample (without Switzerland, US place of birth refusals and immigrants) and is indistinguishable. For this small sample aged 60-64 it is evident that early pension eligibility is almost complete for all but three countries and old age pension eligibility is zero for half of our countries. The relationship between proportion pension eligible and proportion retired is strongly positive, especially for early pensions. The lower pane for the large sample expands the age window such that proportions eligible for early pensions range 0.5 to 0.9 and for old age pensions 0.3 to 0.7. The early pension and retirement relationship is remarkably similar between the two samples whereas the old age pension and retirement relation is now much stronger than it was in the small sample.

Table 8: Reduced form estimates for word recall

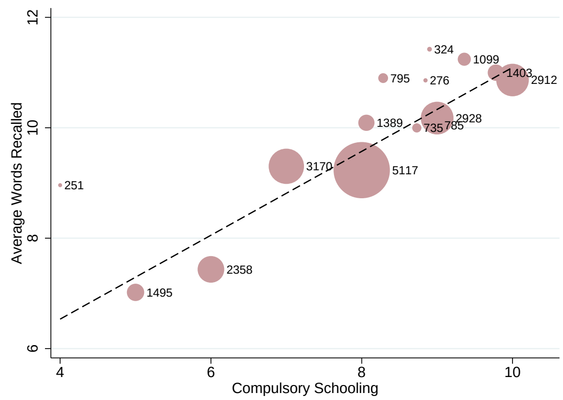
	Large Sample		Small Sample	
Corrected for Age	X	✓	X	✓
		Both Genders		
Early Ret. Elig.	-0.148**	0.215***	-0.0494	0.119
	(0.0597)	(0.0702)	(0.0979)	(0.105)
Old Age Ret. Elig.	-0.514***	-0.171***	-0.0919	-0.131
	(0.0560)	(0.0659)	(0.0856)	(0.0860)
Compulsory Ed.	0.716***	0.731***	0.853***	0.867***
	(0.0146)	(0.0147)	(0.0287)	(0.0288)
Age		-0.0801***		-0.119***
		(0.00818)		(0.0267)
Constant	4.169***	8.655***	2.989***	10.14***
	(0.130)	(0.476)	(0.266)	(1.625)
Observations	25130	25130	7809	7809
R^2	0.112	0.116	0.116	0.119
F-stat.	1060.2	822.1	342.7	262.6
		Females Only		
Early Ret. Elig.	-0.0891	0.175*	-0.569***	-0.399**
	(0.0840)	(0.0972)	(0.156)	(0.172)
Old Age Ret. Elig.	-0.656***	-0.443***	-0.406***	-0.445***
	(0.0773)	(0.0868)	(0.103)	(0.104)
Compulsory Ed.	0.783***	0.793***	0.903***	0.907***
	(0.0199)	(0.0200)	(0.0370)	(0.0371)
Age		-0.0559***		-0.0858**
		(0.0104)		(0.0370)
Constant	4.049***	7.159***	3.544***	8.698***
	(0.178)	(0.604)	(0.348)	(2.247)
Observations	13827	13827	4376	4376
R^2	0.129	0.131	0.143	0.144
F-stat.	683.7	521.1	243.0	183.8
		Males Only		
Early Ret. Elig.	-0.276***	-0.0973	-0.213	-0.126
	(0.0831)	(0.103)	(0.132)	(0.140)
Old Age Ret. Elig.	-0.512***	-0.305***	-0.616***	-0.597***
	(0.0801)	(0.107)	(0.211)	(0.211)
Compulsory Ed.	0.607***	0.616***	0.669***	0.685***
	(0.0211)	(0.0213)	(0.0467)	(0.0476)
Age		-0.0409***		-0.0701*
		(0.0140)		(0.0389)
Constant	4.650***	6.943***	4.138***	8.294***
	(0.187)	(0.808)	(0.430)	(2.345)
Observations	11303	11303	3433	3433
R^2	0.0987	0.0994	0.0970	0.0979
F-stat.	412.6	311.8	122.8	92.99

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

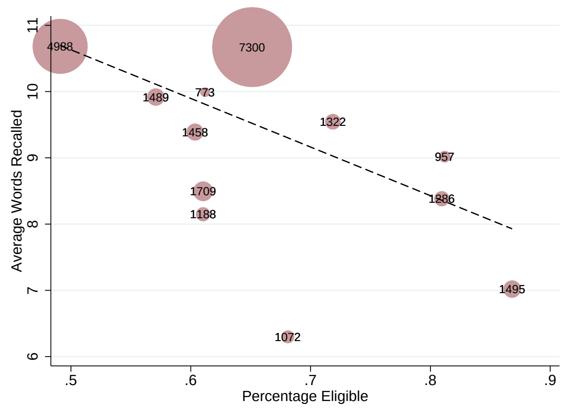
Large sample: SHARE-HRS-ELSA, 1934-1949 birth cohorts. Small sample: SHARE-HRS-ELSA, 1940-1944 birth cohorts. Linear age correction. OLS estimation.

Figure 8: Reduced form illustrations

(a) Compulsory Schooling



(b) Early Retirement Eligibility



(c) Old-Age Retirement Eligibility

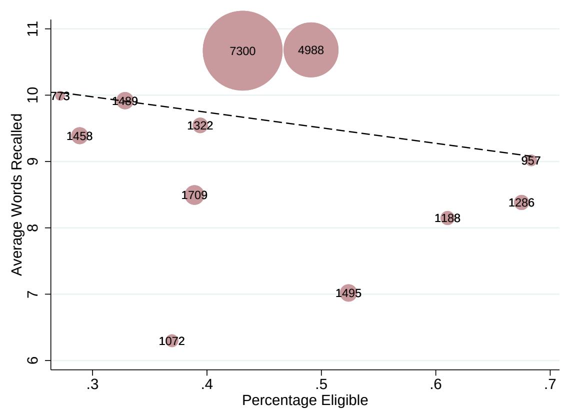
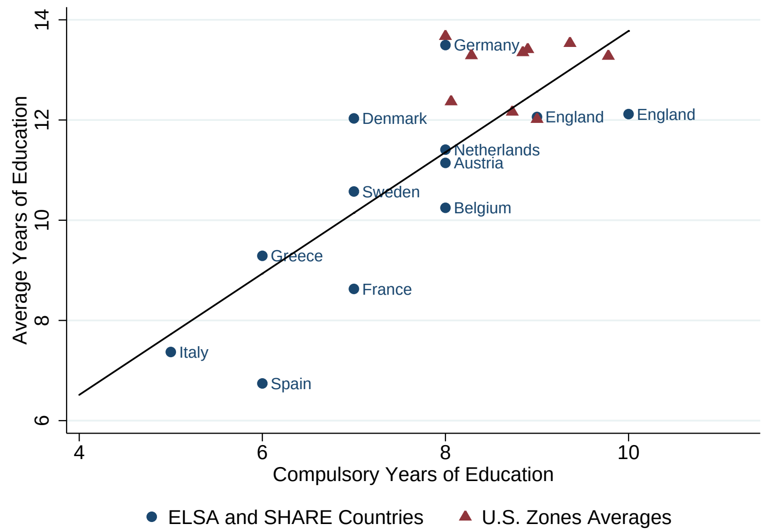


Figure 9: First stage schooling estimates

(a) Small Sample



(b) Large Sample

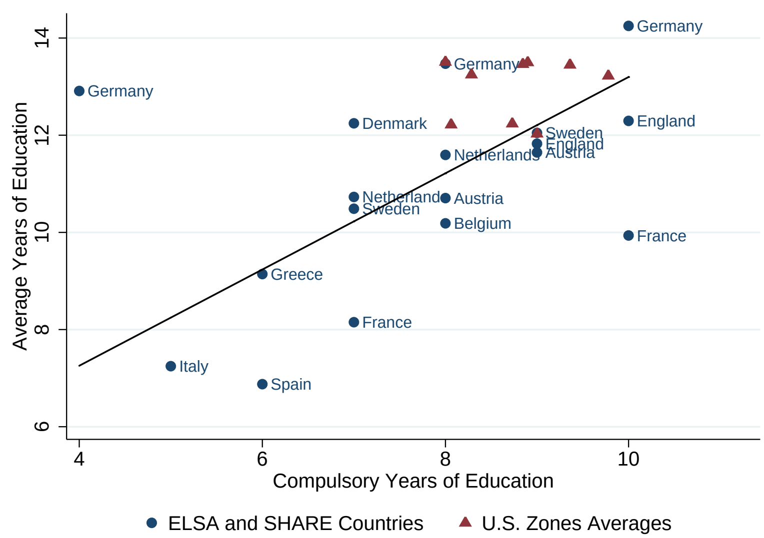
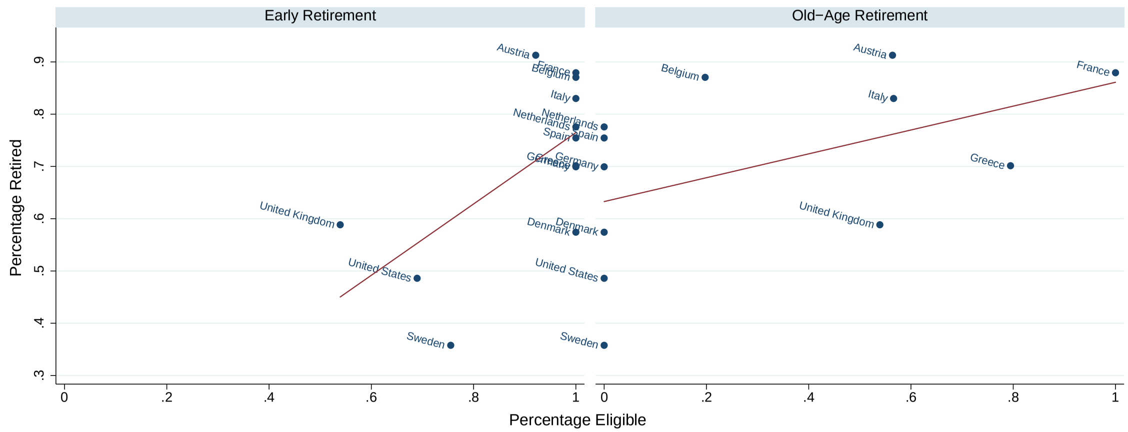


Figure 10: Reduced form retirement illustrations

(a) Small Sample



(b) Large Sample

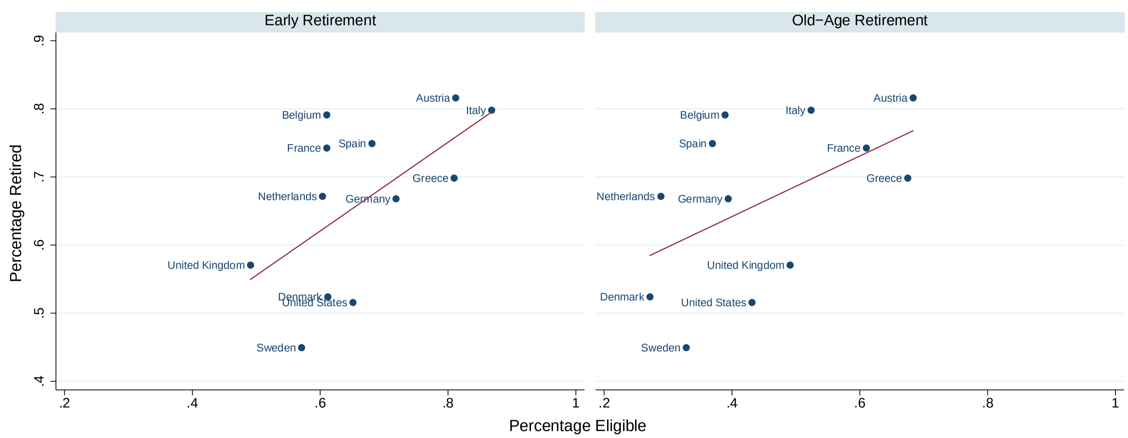
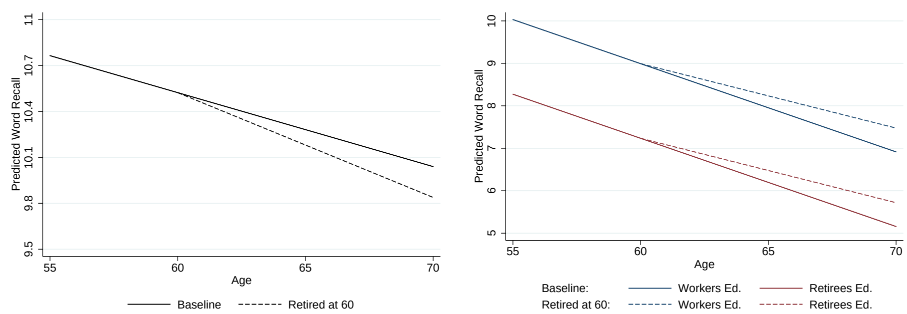


Figure 11: Simulating word recall by schooling and retirement status



Compulsory schooling and pension eligibility have strong reduced forms explaining cognitive functioning while being plausibly exogenous and strong first stages explaining schooling and retirement. Table 9 presents our main instrumental variables two stage least squares estimates. The upper pane is for the retirement first stage regression. Pension eligibilities and compulsory schooling have respectively positive and negative coefficients. The middle pane is for the years of schooling first stage regression. Old age pension eligibility and compulsory schooling have respectively negative and positive coefficients whereas early retirement eligibility is an insignificant determinant of schooling. F-tests show ample explanatory power throughout. The bottom pane shows second stage estimates for word recall. For the small sample retirement coefficients are now positive with opposite sign to the RW specification (which excludes schooling) but of similar magnitude. For the large sample without age control the retirement coefficient is small, negative and significant. However, given the large age variation between individuals in the large sample, our preferred estimate for the large sample includes age control. In this specification the retirement coefficient is positive with precisely three more words recalled on retirement. Schooling coefficients are similar across specifications with about 0.8 more words recalled per additional year of schooling. The coefficients are the same sign as the ones estimated in the baseline OLS specification, but of twice the magnitude.

For the sake of interpretation we illustrate the difference in the predicted relationship between age, retirement and word recall when schooling is considered. This simulation is presented in figure 11. The upper pane corresponds to the stylized figure 4 from RW. We obtain this by regressing word recall on age interacted with a retirement dummy, and therefore allowing no retirement effect other than on the slope of the age-related decline. The solid line represents declining recall when continuing to work until age 70. The dashed line shows an accelerated decline from retirement at age 60.

The lower pane of figure 11 shows the results from a regression of word recall on age, age interacted with a retirement dummy (instrumented) and schooling (instrumented). The different colors represent two hypothetical individuals retiring at 60: the red one has schooling set at the average for retirees and the blue one has schooling set to the average for workers. As in the upper panel the solid lines represent declining recall from

Table 9: Estimates for word recall (2SLS) instrumenting retirement and schooling

	Large Sample		Small Sample	
Corrected for Age	X	✓	X	✓
	First Stage: Retirement			
Early Ret. Elig.	0.242***	0.173***	0.176***	0.145***
	(0.00815)	(0.00957)	(0.0144)	(0.0154)
Old Age Ret. Elig.	0.188***	0.123***	0.165***	0.172***
	(0.00764)	(0.00899)	(0.0126)	(0.0127)
Compulsory Ed.	-0.0343***	-0.0372***	-0.0313***	-0.0339***
	(0.00199)	(0.00200)	(0.00423)	(0.00424)
Age		0.0153***		0.0218***
		(0.00112)		(0.00393)
Constant	0.655***	-0.200***	0.699***	-0.612**
	(0.0178)	(0.0649)	(0.0393)	(0.239)
R^2	0.188	0.194	0.0759	0.0795
F.stat.	1937.2	1510.5	213.1	168.1
	First Stage: Education			
Early Ret. Elig.	0.0873	-0.121	-0.0356	0.00906
	(0.0637)	(0.0751)	(0.101)	(0.109)
Old Age Ret. Elig.	-0.771***	-0.968***	-1.363***	-1.374***
	(0.0597)	(0.0704)	(0.0887)	(0.0891)
Compulsory Ed.	0.965***	0.956***	1.162***	1.166***
	(0.0156)	(0.0157)	(0.0297)	(0.0298)
Age		0.0459***		-0.0317
		(0.00875)		(0.0277)
Constant	3.765***	1.195**	2.409***	4.311**
	(0.139)	(0.509)	(0.276)	(1.684)
R^2	0.160	0.161	0.223	0.223
F-stat.	1588.0	1199.2	743.3	557.8
	Second Stage: Cognitive Functions			
Retirement	-0.394***	3.000***	2.648***	3.789***
	(0.130)	(0.412)	(0.478)	(0.581)
Education	0.729***	0.876***	0.781***	0.847***
	(0.0183)	(0.0284)	(0.0365)	(0.0422)
Age		-0.156***		-0.213***
		(0.0158)		(0.0363)
Constant	1.666***	7.649***	-0.779	10.95***
	(0.265)	(0.594)	(0.674)	(1.986)
Observations	25037	25037	7787	7787

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Large sample: SHARE-HRS-ELSA, 1934-1949 birth cohorts. Small sample: SHARE-HRS-ELSA, 1940-1944 birth cohorts. 2SLS estimation, instruments: minimal required age for old age and early retirement benefits, compulsory length of schooling

continuing to work throughout. Dashed lines show a slower decline from retirement at age 60. However, this change of sign of the retirement effect is dwarfed by the mean schooling deficit of the retired compared to those working. The schooling composition of retirees versus workers dominates the direct effect that retirement has of slowing the decline in recall. Schooling composition drives the spurious negative relationship between retirement and word recall found in raw correlations, OLS estimates and IV estimates that omit schooling.

4.2 Robustness Checks

In this section we conduct several robustness checks in order to help determine the origin of the difference in our estimates of a positive retirement effect compared to the negative finding elsewhere. Our specification is different to RW in that they omit schooling. Table 10 replicates the RW specification which instruments retirement with pensionable ages to explain word recall, but excludes schooling. The third column (without age controls for the small 60-64 year old sample) of the top pane (both genders) corresponds closest to RW table 1. Our sample is somewhat different, but nevertheless the coefficient of interest is similarly large (-3.1 compared to -4.6 in RW) and significant at the 1% level. RW find this magnitude robust to expanding their sample to ages 55-64 and including age quadratics. We confirm this with a larger sample extension to 55-70 (columns 1-2) and the inclusion of a linear age trend (columns 2 and 4). Middle and lower panes of the table split the samples by gender and a strong negative relationship persists, becoming even stronger for males. Omitting schooling from the analysis, RW findings are robust to changing the sample for our purposes. Any substantive differences in estimates when including schooling will be due to changes in specification rather than changes in the estimation sample.

Our preferred specification includes schooling, which is treated as endogenous. It may be simply including schooling rather than treating it as endogenous which is making the difference. Mazzonna and Peracchi (2010) have a specification with exogenous schooling and find negative retirement effects, so differences are unlikely. Nevertheless, table 11 develops RW specification with the inclusion of years of schooling as a control, i.e. considered as exogenous. The structure of the table is the same as that of table 9, with the two lower panes separating the analyses by gender. Coefficients on years of schooling are similar to the OLS coefficients estimated in table 7. However, the inclusion of schooling as a control has a strong impact on the estimated retirement coefficients. With respect to table 10, all retirement coefficients shifts towards positive values. In the main specification, which includes both genders, the inclusion of schooling as a control is enough for the retirement coefficients to become insignificant at the 10% confidence level, both in the large sample if we do not control for age and in the small one. Table 11 provides additional evidence against the finding of a negative causal effect of retirement on old-age cognitive functioning.

Another line of robustness checks is to note that our preferred instrumental variables specification from table 9 pools genders. Tables 12 and 13 present instrumental variables estimates for respectively women and men separately. As with the pooled sample, all of the first stage retirement explanatory variables are strongly significant. While schooling first stage regressions are similar to the pooled sample, early pension eligibility is signif-

Table 10: Estimates for word recall (2SLS) instrumenting retirement, ignoring schooling

	Large Sample		Small Sample	
Corrected for Age	X	✓	X	✓
		Both Genders		
Retirement	-2.732***	-2.799***	-3.155***	-3.095***
	(0.104)	(0.253)	(0.305)	(0.325)
Age		0.00319		-0.000134
		(0.0114)		(0.0294)
Constant	11.31***	11.15***	11.72***	11.69***
	(0.0678)	(0.573)	(0.197)	(1.755)
Observations	25037	25037	7787	7787
Sargan χ^2	4.863	4.782	11.28	12.38
		Females Only		
Retirement	-3.253***	-3.582***	-4.437***	-4.506***
	(0.156)	(0.333)	(0.441)	(0.472)
Age		0.0170		0.0178
		(0.0138)		(0.0412)
Constant	12.16***	11.32***	13.17***	12.12***
	(0.108)	(0.672)	(0.310)	(2.458)
Observations	13775	13775	4364	4364
Sargan χ^2	2.546	3.280	0.897	0.718
		Males Only		
Retirement	-2.695***	-6.204***	-7.076***	-7.929***
	(0.141)	(0.690)	(0.774)	(0.942)
Age		0.185***		0.237***
		(0.0334)		(0.0664)
Constant	10.66***	1.071	13.18***	-1.060
	(0.0846)	(1.713)	(0.435)	(3.845)
Observations	11262	11262	3423	3423

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Large sample: SHARE-HRS-ELSA, 1934-1949 birth cohorts. Small sample: SHARE-HRS-ELSA, 1940-1944 birth cohorts. Linear age correction. 2SLS estimation, instruments: minimal required age for old age and early retirement benefits

Table 11: Estimates for word recall (2SLS) instrumenting retirement, with exogenous schooling

	Large Sample		Small Sample	
Corrected for Age	X	✓	X	✓
		Both Genders		
Retirement	-1.681***	-0.408	-0.411	0.0114
	(0.105)	(0.277)	(0.334)	(0.365)
Education	0.328***	0.361***	0.371***	0.383***
	(0.00629)	(0.00926)	(0.0135)	(0.0141)
Age		-0.0625***		-0.0960***
		(0.0115)		(0.0271)
Constant	6.971***	9.709***	5.797***	11.35***
	(0.121)	(0.495)	(0.340)	(1.556)
Observations	25037	25037	7787	7787
Sargan χ^2	5.966	13.36	31.21	22.45
		Females Only		
Retirement	-1.957***	-1.211***	-1.608***	-1.337***
	(0.158)	(0.356)	(0.469)	(0.512)
Education	0.358***	0.379***	0.371***	0.379***
	(0.00911)	(0.0129)	(0.0192)	(0.0200)
Age		-0.0339**		-0.0607*
		(0.0133)		(0.0358)
Constant	7.380***	8.765***	7.131***	10.62***
	(0.186)	(0.544)	(0.505)	(2.057)
Observations	13775	13775	4364	4364
Sargan χ^2	0.300	0.000158	0.904	0.164
		Males Only		
Retirement	-1.900***	-4.047***	-5.001***	-5.623***
	(0.138)	(0.714)	(0.793)	(0.997)
Education	0.306***	0.259***	0.245***	0.230***
	(0.00842)	(0.0181)	(0.0254)	(0.0299)
Age		0.106***		0.146**
		(0.0329)		(0.0597)
Constant	6.664***	1.770	9.165***	0.626
	(0.153)	(1.489)	(0.697)	(3.212)
Observations	11262	11262	3423	3423

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Large sample: SHARE-HRS-ELSA, 1934-1949 birth cohorts. Small sample: SHARE-HRS-ELSA, 1940-1944 birth cohorts. Linear age correction. 2SLS estimation, instruments: minimal required age for old age and early retirement benefits

Table 12: Estimates for word recall (2SLS) instrumenting retirement and schooling for women only

	Large Sample		Small Sample	
Corrected for Age	X	✓	X	✓
	First Stage: Retirement			
Early Ret. Elig.	0.238***	0.180***	0.245***	0.220***
	(0.0111)	(0.0128)	(0.0217)	(0.0240)
Old Age Ret. Elig.	0.148***	0.101***	0.115***	0.120***
	(0.0102)	(0.0115)	(0.0143)	(0.0145)
Compulsory Ed.	-0.0464***	-0.0487***	-0.0504***	-0.0510***
	(0.00263)	(0.00264)	(0.00516)	(0.00516)
Age		0.0123***		0.0123**
		(0.00137)		(0.00515)
Constant	0.807***	0.123	0.835***	0.0958
	(0.0236)	(0.0798)	(0.0485)	(0.313)
R^2	0.179	0.184	0.0924	0.0936
F-stat.	999.5	774.0	148.0	112.5
	First Stage: Education			
Early Ret. Elig.	0.135	-0.00768	-0.789***	-0.832***
	(0.0861)	(0.0997)	(0.154)	(0.170)
Old Age Ret. Elig.	-0.842***	-0.956***	-1.125***	-1.115***
	(0.0792)	(0.0890)	(0.102)	(0.103)
Compulsory Ed.	1.032***	1.026***	1.209***	1.208***
	(0.0204)	(0.0205)	(0.0366)	(0.0367)
Age		0.0301***		0.0217
		(0.0106)		(0.0366)
Constant	2.941***	1.267**	2.474***	1.173
	(0.183)	(0.619)	(0.344)	(2.224)
R^2	0.187	0.187	0.259	0.259
F-stat.	1054.3	793.1	508.9	381.7
	Second Stage: Cognitive Functions			
Retirement	-0.610***	1.620***	1.425**	2.508***
	(0.196)	(0.504)	(0.694)	(0.842)
Education	0.731***	0.844***	0.783***	0.846***
	(0.0247)	(0.0369)	(0.0527)	(0.0609)
Age		-0.0936***		-0.155***
		(0.0169)		(0.0448)
Constant	2.393***	5.500***	0.492	8.690***
	(0.375)	(0.594)	(1.022)	(2.416)
Observations	13775	13775	4364	4364

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Large sample: SHARE-HRS-ELSA, 1934-1949 birth cohorts, females only. Small sample: SHARE-HRS-ELSA, 1940-1944 birth cohorts, females only. Linear age correction. 2SLS estimation, instruments: minimal required age for old age and early retirement benefits, compulsory length of schooling

Table 13: Estimates for word recall (2SLS) instrumenting retirement and schooling for men only

	Large Sample		Small Sample	
Corrected for Age	X	✓	X	✓
	First Stage: Retirement			
Early Ret. Elig.	0.248***	0.119***	0.135***	0.0994***
	(0.0119)	(0.0147)	(0.0211)	(0.0224)
Old Age Ret. Elig.	0.219***	0.0701***	0.184***	0.176***
	(0.0115)	(0.0152)	(0.0340)	(0.0339)
Compulsory Ed.	-0.0225***	-0.0287***	-0.0137*	-0.0206***
	(0.00302)	(0.00302)	(0.00749)	(0.00761)
Age		0.0295***		0.0291***
		(0.00199)		(0.00623)
Constant	0.504***	-1.150***	0.555***	-1.167***
	(0.0268)	(0.115)	(0.0689)	(0.375)
R^2	0.195	0.210	0.0368	0.0429
F-stat.	908.8	749.6	43.49	38.26
	First Stage: Education			
Early Ret. Elig.	0.0320	0.0294	0.570***	0.651***
	(0.0941)	(0.117)	(0.147)	(0.156)
Old Age Ret. Elig.	-0.515***	-0.518***	-0.995***	-0.977***
	(0.0907)	(0.121)	(0.236)	(0.236)
Compulsory Ed.	0.903***	0.903***	1.209***	1.224***
	(0.0239)	(0.0241)	(0.0520)	(0.0530)
Age		0.000609		-0.0659
		(0.0159)		(0.0433)
Constant	4.540***	4.506***	1.751***	5.654**
	(0.212)	(0.915)	(0.478)	(2.612)
R^2	0.133	0.133	0.179	0.179
F-stat.	576.5	432.3	247.8	186.5
	Second Stage: Cognitive Functions			
Retirement	-1.019***	-0.732	-2.697***	-2.804***
	(0.161)	(0.818)	(0.727)	(0.919)
Education	0.648***	0.658***	0.513***	0.507***
	(0.0257)	(0.0409)	(0.0439)	(0.0497)
Age		-0.0146		0.0347
		(0.0361)		(0.0524)
Constant	2.209***	2.847*	4.749***	2.727
	(0.355)	(1.473)	(0.833)	(2.714)
Observations	11262	11262	3423	3423

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Large sample: SHARE-HRS-ELSA, 1934-1949 birth cohorts, males only. Small sample: SHARE-HRS-ELSA, 1940-1944 birth cohorts, males only. Linear age correction. 2SLS estimation, instruments: minimal required age for old age and early retirement benefits, compulsory length of schooling

icant in the small sample. Compared to the pooled sample, second stage coefficients on schooling are similar for women but smaller for men. Retirement coefficients are quite different by gender. For women in the small sample without age control the retirement effect is more negative than in the pooled sample. Other retirement effects for women are less positive than corresponding pooled estimates. All coefficients are significant. For men, retirement coefficients are significantly negative with the exception of our preferred estimate of the large sample with age control which is insignificant.

A final robustness check includes country dummies and is presented in table 14. Within-country variation is all that remains for identification: gender differences in pensionable ages and regional and cohort differences in minimum schooling laws. This within-country variation is pooled but no between-country variation remains. First stage retirement estimates in the upper pane and schooling estimates in the middle pane are remarkably similar to our preferred estimates without country dummies in terms of significance and magnitude if not size. Second stage estimates of word recall are shown in the lower pane. The retirement effect is implausibly large and schooling is only significant at the 10% level for the small sample corrected for age in the final column. There is very little variation in compulsory schooling within country for the small sample. Indeed, our motivation for preferring estimates from the large sample is that it allows for more between-cohort schooling law variation to help identification. Of these country dummy specifications, our preferred estimates are for the large sample with age controls in the second column. These are very similar to our preferred estimates without country controls. Our estimates are robust to country-specific effects. Moreover, this finding suggests that compulsory schooling variation across countries explains most of the country-specific variation in our model and sample. We interpret this finding as additional evidence for a key role of compulsory schooling in the formation of cognitive abilities at older ages, and for its pertinence as an intrument for schooling.

In principle with two endogenous variables and three instruments we ought to be able to perform overidentification tests of instrument validity. However in our single cross-section of data we code pensionable ages as dummy variables for eligibility to early retirement benefits *or* old age retirement benefits at time of survey since an individual cannot be eligible to both at the same time. A Sargan test would assume that enough instruments are valid to identify the equations exactly Murray (2006), but because pensionable age instruments share the same rationale the test becomes biased and inconsistent. Hence our system of equations is effectively just identified and we are not able to perform valid overidentification tests.

In order to summarize our robustness check findings and contribution, figure 12 graphs the different estimated effects of retirement on word recall across specifications and samples. Instrumental variables retirement coefficients are presented for the large sample in the upper pane and for the small sample in the lower pane. Estimates are grouped into three sets. To the left schooling is omitted as with the RW specification of table 10, in the middle schooling is included as a control but treated as exogenous, and to the right schooling is instrumented. Each set contains six estimates according to sample gender (black for pooled at the centre of each group, blue for male at the left of each group, red for women at the right of each group) and age control (circles without, triangles with). The overall pattern is that moving from omitting schooling, to including schooling as a control and to instrumenting schooling changes the estimated retirement effect

Table 14: Estimates for word recall with country dummies (2SLS) instrumenting retirement and schooling

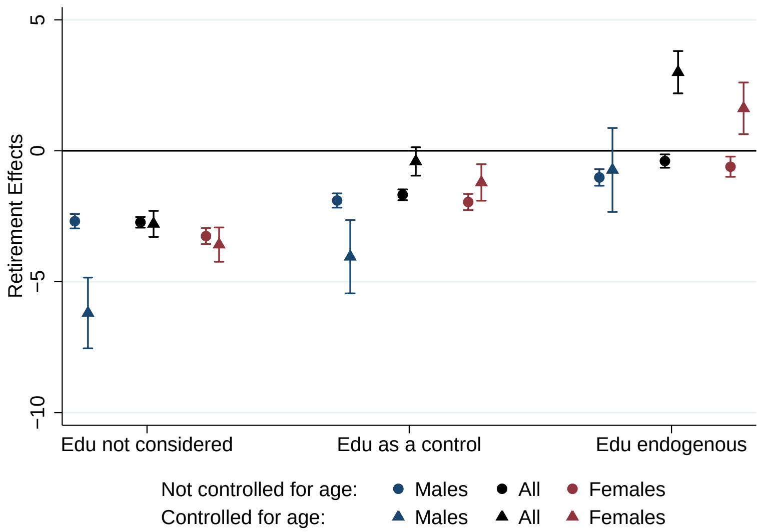
	Large Sample		Small Sample	
Corrected for Age	X	✓	X	✓
	First Stage: Retirement			
Early Ret. Elig.	0.255***	0.157***	0.120***	0.0627***
	(0.00818)	(0.00951)	(0.0162)	(0.0176)
Old Age Ret. Elig.	0.172***	0.0709***	0.130***	0.150***
	(0.00790)	(0.00937)	(0.0190)	(0.0191)
Compulsory Ed.	-0.0375***	-0.0248***	-0.0433***	-0.0267**
	(0.00412)	(0.00414)	(0.0127)	(0.0128)
Age		0.0230***		0.0318***
		(0.00117)		(0.00398)
Constant	0.607***	-0.853***	0.787***	-1.299***
	(0.0381)	(0.0833)	(0.114)	(0.285)
R^2	0.222	0.234	0.133	0.140
F-stat.	510.5	509.7	85.15	84.36
	First Stage: Education			
Early Ret. Elig.	-0.480***	-0.142**	-0.156	0.0281
	(0.0602)	(0.0704)	(0.112)	(0.123)
Old Age Ret. Elig.	-0.605***	-0.254***	-0.893***	-0.959***
	(0.0581)	(0.0694)	(0.132)	(0.133)
Compulsory Ed.	0.111***	0.0664**	0.251***	0.198**
	(0.0303)	(0.0306)	(0.0882)	(0.0893)
Age		-0.0798***		-0.102***
		(0.00867)		(0.0277)
Constant	12.53***	17.59***	10.90***	17.62***
	(0.281)	(0.617)	(0.787)	(1.981)
R^2	0.286	0.288	0.288	0.290
F-stat.	715.0	675.2	224.9	211.1
	Second Stage: Cognitive Functions			
Retirement	1.656	3.132***	0.825	7.677***
	(1.284)	(0.886)	(1.328)	(2.742)
Education	1.535***	0.954**	-0.137	1.005*
	(0.498)	(0.484)	(0.303)	(0.544)
Age		-0.150***		-0.353***
		(0.0301)		(0.0683)
Constant	-10.04	6.178	12.33***	16.11**
	(7.103)	(8.185)	(4.542)	(6.675)
Observations	25037	25037	7787	7787

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Large sample: SHARE-HRS-ELSA, 1934-1949 birth cohorts. Small sample: SHARE-HRS-ELSA, 1940-1944 birth cohorts. Linear age correction. Country dummies included. 2SLS estimation, instruments: minimal required age for old age and early retirement benefits, compulsory length of schooling

Figure 12: Summary of robustness checks

(a) Large Sample



(b) Small Sample

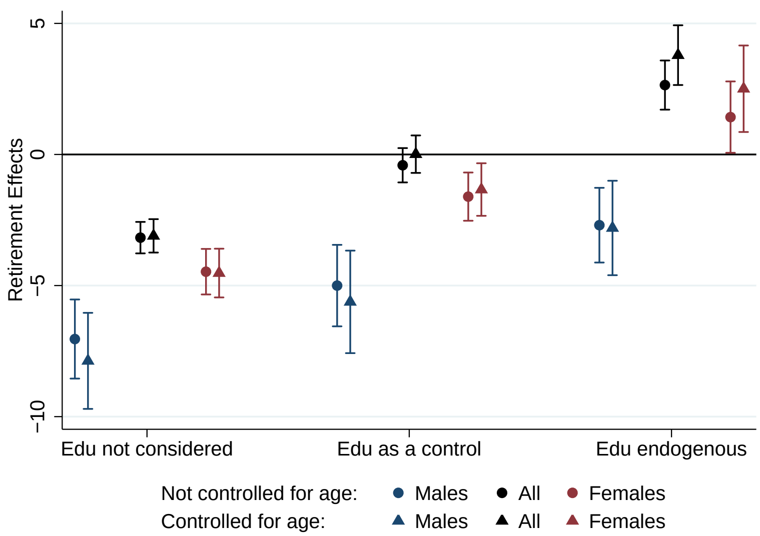


Table 15: Estimates for non-passive activities (2SLS) Instrumenting retirement and schooling

Corrected for Age	X	X	✓	✓
Country Dummies	X	✓	X	✓
	Activity Index: no weight			
Retirement	0.345***	0.138	0.494***	0.238
	(0.0612)	(0.257)	(0.127)	(0.210)
Education	0.193***	0.112	0.191***	-0.0412
	(0.0105)	(0.0827)	(0.0104)	(0.121)
Age			-0.00936	-0.0306**
			(0.00587)	(0.0132)
Observations	12859	12859	12859	12859
Ret. on word recall†	-0.532***	-0.246	1.467***	1.417**

† 2SLS retirement effect on word recall: same sample, intruments and controls
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses

from strongly negative to close to zero and to positive. For the large sample without age controls, estimates are negative throughout. Our preferred estimate is with schooling instrumented for the pooled large sample with age control and the effect of retirement on recall is strongly positive. Furthermore, whenever age is controlled and schooling is treated as endogenous, retirement coefficients are not significantly negative except for the small sample of males only.

5 Interpretation and discussion

None of the economics literature and only a few epidemiological studies find cognitive improvements due to retirement. The "use it or lose it" hypothesis may still be consistent with our findings if stimulating mental activity is pursued into retirement. Studies of time use at older ages show large shifts of time allocation at retirement, especially towards passive leisure such as watching television or leisure with low levels of physical activity such as time spent eating (Gauthier and Smeeding, 2003). Evidence from SHARE presented in table 1 corroborates this association in terms of retirees engaging in fewer non-passive leisure activities. However, these are raw correlations, in both cases without controls for age or the endogeneity of retirement status.

Table 15 present second stage estimates from instrumental variables regressions on SHARE data only explaining level of activity with retirement status and years of schooling instrumented by policy variation as before. In table 15 we use the unweighted sum of non-passive activities listed in table 1. Because descriptive analysis shows that although retirees perform less activities, they perform them more often than workers, this approach is most conservative. Separate analysis for weighted (either linearly or hyperbolically)

Table 16: Estimates for specific activities (2SLS) instrumenting retirement and schooling

Corrected for Age	X	X	✓	✓
Country Dummies	X	✓	X	✓
Voluntary/charity	0.122***	0.0982	0.103***	0.132*
	(0.0182)	(0.0831)	(0.0376)	(0.0677)
Cared for sick adult	0.0253	0.0118	0.0975***	0.0555
	(0.0155)	(0.0738)	(0.0320)	(0.0590)
Help to family/neighb.	-0.00303	0.143	0.0924*	0.163*
	(0.0245)	(0.130)	(0.0503)	(0.0912)
Attended education/training	-0.0324***	-0.0919*	-0.0359*	-0.0531
	(0.0102)	(0.0510)	(0.0211)	(0.0471)
Sport or social club	0.117***	0.0657	-0.0310	-0.00570
	(0.0217)	(0.0961)	(0.0452)	(0.0762)
Religious org.	0.126***	-0.0646	0.287***	-0.0135
	(0.0153)	(0.0830)	(0.0335)	(0.0845)
Political org.	0.0192**	0.0241	0.0109	-0.0106
	(0.00898)	(0.0432)	(0.0185)	(0.0347)

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Sample: SHARE, 1934-1949 birth cohorts. Linear age correction. Country dummies included where indicated. 2SLS estimation, instruments: minimal required age for old age and early retirement benefits, compulsory length of schooling

sum of activities, available from the authors upon request, fully confirms the result. Regressions in columns 2 and 4 include country dummies; in last two columns, a linear age trend. Because we use a different sample, in the last row we additionally report for each specification the estimated effect of retirement on word recall, following the procedure applied in the previous section: while the size of the coefficients changes with respect to our main sample, the signs and the significance levels do not. Without controlling for country, both retirement and longer schooling lead to more activity. When country is controlled for, retirement and schooling become insignificant. Here our first stage regressions using SHARE only rely on within country policy variation for Continental Europe. Nevertheless across all specifications retirement *never reduces* level of activity.

It is informative to re-run the analysis of table 15 activity-by-activity to establish whether retirement encourages some particular activities. Second stage instrumental variables estimates from this exercise are presented in table 16. Without country controls, voluntary work and religious activities are found to increase most due to retirement. Education and training are the only activities which fall at retirement, obviously because

of an important direct work-relationship. Consistently with this view, the significance level of the education and training coefficient decreases when controlling for age. When age and country are controlled for in the final column of table 16, voluntary work and help to family and neighbors are the activities which increase due to retirement. There are no significant reductions in other specific activities.

6 Conclusions

We show that the negative effect of retirement on word recall at older ages disappears or becomes positive when age and schooling are properly taken into account. We conclude that previous negative estimates of the effect of retirement originate from spurious correlations between pension eligibility ages and schooling, which in turn is a strong determinant of cognitive functioning at older ages. Higher schooling both delays retirement and improves cognitive functioning. The coefficient on schooling in a word recall equation increases once instrumented with compulsory schooling laws. This is due to the correlation between schooling laws and pension eligibility ages. The explanatory power of schooling is otherwise spuriously loaded on to the retirement coefficient. Schooling is the main determinant of cognitive functioning at old ages.

There are two important implications of the finding that retirement itself is not harmful for cognitive performance. First, if cognitive abilities influence financial decision making, retirement does not harm the ability of individuals to manage their wealth and assets. Therefore, the consequences of the ongoing shift from public to private individual management of retirement wealth and capital may not be as bad as otherwise expected. Second, if cognitive abilities enhance productivity according to a Ben-Porath human capital model, the productivity of retirees decreases at a lower than expected rate. This offers greater scope for reforms which encourage early retirees to return to the labor force.

However, there are also distributional issues at stake. While according to the conditions previously specified the burden of pension wealth management and the loss of productivity do not worsen after retirement, they will fall unequally across to the schooling distribution. Schooling differentials and especially low levels of schooling will affect the distribution of cognitive abilities and increase inequality at older ages, with money management difficulties and low productivity burdening especially those with least schooling.

We have established that although retirement from the labour market does not reduce cognitive performance, it does change time allocation. Mental and physical activity does not fall due to retirement. Hence our finding may still be consistent with a "use it or lose it" hypothesis if retirement does not simply increase passive leisure. Retirement *from the labour market* is the key here. It is important to distinguish between this and retirement from stimulating mental and physical activity altogether, which may well continue outside the labour market. Helping neighbors and friends as well as voluntary and charity work increase significantly due to retirement.

There are several limitations of our study which should motivate future work. Presently we model retirement status as a binary outcome. An obvious extension would be to analyze the effect of the length of retirement on cognitive functioning, and the pattern of cognitive change after pensionable age. While we estimate simple linear local average treatment effects, retirement could have non-linear and discontinuous effects, which can

be relevant for policy evaluation, both in work and retirement. This would require well-balanced, highly detailed longitudinal datasets. Moreover, while we acknowledge the endogeneity of schooling and we apply an instrumental variables method in order to address this, estimation of appropriate structural or semi-structural models would shed light on the behavioral mechanisms relating retirement and investments in cognitive functioning.

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