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Does Retirement Affect Cognitive Functioning?[1]

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Abstract

This paper analyzes the effect of retirement on cognitive functioning using two large scale surveys. First, a longitudinal survey among older Americans allows controlling for individual heterogeneity and endogeneity of the retirement decision. Second, a cross-national European survey allows identifying the causal effect of retirement on cognition by using the cross-country differences in the age-pattern of retirement. The results highlight in both cases a significant negative and quantitatively comparable effect. It suggests that promoting labor force participation of older workers could delay cognitive decline, and thus the occurrence of associated impairments at older age.

JEL Classifications: *I12, J14, J24, J26*

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1. Introduction

In most developed countries, the proportion of older individuals has substantially increased over the last decades. This demographic shift has increased the focus on health in aging. At the same time, increased life expectancy combined with a decline in average retirement age have increased the proportion of an individual's life spent in retirement. This structural change imposes many challenges for the financial sustainability of social security systems. Moreover, this extended retirement spell raises questions about its potential consequences on the physical and mental health of the elderly, which may in turn affect long-term care expenditures (Dave et al., 2008).

Older individuals face many challenges associated with physical and mental deterioration. Among these, the decline in cognitive capacity with age has been well documented: a large amount of evidence suggests that aging is associated with a decline in the ability to perform several cognitive tasks (Dixon et al., 2004; Schaie, 1994). More particularly, aging has a salient effect on episodic memory tasks[2] (Petersen et al., 1992; Small, 2001), episodic memory deficits being also largely considered as a hallmark symptom of Alzheimer's disease (Adam et al., 2007; Dubois et al., 2007).

However, this decline is not homogenous across the population, with some people maintaining cognitive vitality even into extreme old age (Berkman et al., 1993; Silver et al., 1998; Silver et al., 2001). At the same time, age-related cerebral modifications that are at the root of Alzheimer's disease have been observed to have heterogeneous effects on cognitive functioning. For example, Katzman et al. (1989) described cases of cognitively normal elderly women who were discovered (by ways of post mortem analysis) to have advanced Alzheimer's disease pathology in their brains. Stern (2002, 2003) and Scarmeas and Stern (2003) propose the concept of cognitive reserve to explain this apparent absence of direct relationship between the severity of the factor that disrupts performance (such as the degree of brain modifications with age, or brain pathology associated with Alzheimer's disease) and the degree of disruption in performance or of dysfunction in daily life activities. This suggests that some individuals are able to more efficiently use their cognitive resources and thus are less susceptible to disruption. Individual heterogeneity may stem from innate or genetic differences, or different life experiences, such as occupational attainment or leisure activities.

[2] Episodic memory refers to memory of information about specific past events that involved the self (i.e. events personally lived) and occurred at a particular time and place (e.g., the last holidays).

The degree of resilience to these biological changes, i.e., the cognitive reserve, has been found to depend on several factors. Among these, education undoubtedly plays an important role (Evans et al., 1993; Le Carret et al., 2003). Moreover, differential susceptibility to age-related cognitive decline or to Alzheimer's disease has also been shown to be related to occupation (Evans et al., 1993; Letenneur et al., 1994; Schooler et al., 1999; Stern et al., 1994), professional or leisure activities (Carpuso et al., 2000; Scarmeas et al., 2001; Wilson et al., 2002; Newson and Kemps, 2005), and lifestyle (for a review, see: Fillit et al., 2002; and Fratiglioni et al., 2004).

In summary, this literature suggests that individual heterogeneity in the level of cognitive functioning and the rate of age-related change in cognitive functioning is associated with an individual's lifestyle, such as his engagement in mentally stimulating activities (Salthouse, 2006). This hypothesis is quite appealing, as it suggests that individuals have some control over the evolution of their cognitive functioning, and that there is scope for policy interventions to affect the pattern of cognitive aging.

However, the way the causality runs between activities and the brain remains an open issue in neuropsychology. Do activities improve cognitive functioning or are brighter people more often engaged in cognitively demanding activities? One argument favoring the first hypothesis can be found in the neurobiological literature, where several experimental studies on animals have shown that rats bred in an enriched environment present a greater dendritic density in the hippocampus and an increased number of glial cells than animals bred in standard conditions (Rosenzweig and Bennett, 1972). Moreover, Winocur (1998) showed that these brain modifications affect the cognitive abilities of older rats. A second argument in favor of the causal effect of activities on cognitive functioning can also be found in studies such as that of Maguire et al. (2000), which shows that taxi drivers in London, who had developed an intensive practice of orientation in the city, had significantly posterior hippocampi than control subjects, and above all, that the amount of occupational experience is correlated with the size of the hippocampus. Those studies suggest then that activities have a direct effect on cognitive functioning.

The aim of our study is to address the causal impact of lifestyle on cognitive functioning of older people by focusing on the relationship between cognitive functioning and retirement. Indeed, retirement implies major changes in individual lifestyle and is likely to affect involvement in activities that may contribute to maintaining, or improving, cognitive functioning at older age. If individuals have on average more cognitively

stimulating activities at work than during retirement, we would expect a decline in cognitive functioning during retirement due to the decrease in stimulating activities, as suggested by the neuropsychological literature. From an economic point of view, cognitive functioning can be interpreted as a form of human capital, in particular health capital (Grossman, 1972), and its evolution will emerge from deliberate choices based on the perceived costs and benefits of investing in cognitive functioning. In the Grossman model, health capital is benefical as it reduces the time lost due to illness or injury, and thereby increases the time available to allocate to work, leisure, and health investments. The same reasoning may apply to cognitive functioning. Individuals with higher cognitive functioning may be more efficient in performing leisure and work activities, resulting in more effective time available to allocate to market and non-market activities. Eligibility for social security benefits corresponds to a drop in the relative wage rate in the Grossman model. It thus affects the marginal benefits and costs of effective time, and thus the investment in cognitive functioning. The marginal benefit is unambiguously lower, while the marginal cost may increase or decrease. This will depend on the relative marginal productivity of leisure and work. Due to social security benefits, work, as an investment in cognitive functioning, is more expensive. On the other hand, it decreases the cost of leisure, which also constitutes an input for cognitive functioning. The net impact of retirement on cognitive functioning can be positive, negative, or null. If the marginal productivity of work activities is always higher than the marginal productivity of leisure time, the eligibility for social security benefits will induce a decrease in cognitive functioning. In the case where marginal productivity of work activities is always lower than marginal productivity of leisure time, the drop in the marginal cost may offset the decrease in marginal benefits and results in an increase in cognitive functioning when social security benefits become available.

In a recent study, Adam et al. (2007) found that retirees attain lower cognitive functioning than working individuals, using cross-sectional data from the United States and Europe.[3] Furthermore, they show that the longer the retirement spell, the lower the cognitive score, which suggests an acceleration of cognitive decline during retirement. However, the difference observed across workers and retirees may have explanations other than a causal effect between retirement and cognition. First, impairments in cognitive functioning may prevent people from working, may increase disutility from work, or may

[3] The Health and Retirement Study 2004 (United States); the English Longitudinal Study on Ageing 2004 (United Kingdom); the Survey of Health, Ageing, and Retirement in Europe 2004 (Austria, Belgium, Denmark, France, Germany, Greece, Italy, the Netherlands, Spain, and Sweden).

lower productivity. Moreover, unobservable factors associated with cognitive functioning and retirement may be interrelated with both. Individuals with higher innate ability (and thus cognitive functioning) may invest more in human capital and retire at a later age than individuals with low innate ability.

Inspired by the research of Adam et al (2007), Coe and Zamarro (2008) and Rohwedder and Willis (2010) have also investigated the relationship between retirement and cognitive functioning by using cross-national data, the Survey of Health, Ageing, and Retirement in Europe (SHARE), and the difference in the legal age of retirement across countries as an instrument for retirement decision to avoid potential endogeneity bias. The results are mixed: while Rohwedder and Willis (2010) find a significant and quantitatively important (close to a 40% drop) negative effect of retirement on cognitive functioning, Coe and Zamarro (2008) do not find a significant effect.

In this paper we estimate the causal impact of retirement on cognitive functioning using data from two large scale surveys and using novel identification strategies. First, we use panel data from the HRS, a longitudinal survey among individuals aged 50+ living in the United States, that allows us to control for individual heterogeneity and to circumvent the issue of endogenous retirement decision by using the eligibility age for Social Security as an instrument. Our identification approach follows that of Bound and Waidmann (2007), Charles (2002), and Neumann (2008), who analyze the effect of retirement on health. As a robustness check, we use workers' subjective beliefs about their retirement dates as an alternative instrumental variable for retirement. Second, we use cross-country data from SHARE, but unlike Coe and Zamarro (2008) and Rohwedder and Willis (2010) we identify the causal effect of retirement on cognitive functioning by using the cross-country differences in the age-pattern of retirement. The reason for that is that in European countries retirement eligibility depends not only on main Social security pension rules but also on eligibility rules, age is one among them, fixed by other social protection schemes, e.g. old-age unemployment, disability insurance, or early retirement schemes, in combination with labor market conditions (Gruber and Wise, 2004). The identification strategy will rely on the differences in the retirement age-patterns across countries and gender. Our results highlight in both cases a significant negative, and quantitatively comparable, effect of retirement on cognitive functioning, close to 9%.

The paper is organized as follows. Section 2 describes the econometric approach used to address the empirical issues and Section 3 presents the data, the measure of cognitive

functioning, and the explanatory variables included in the empirical model. Section 4 details the results from the longitudinal analysis using HRS and the results from the cross-national analysis using SHARE. Finally, Section 5 concludes and draws out implications from the analysis.

2. Empirical model

The aim of the empirical analysis is to test the hypothesis that retirement affects cognitive functioning. In our model, we assume cognitive functioning (c_{it}), measured by the score obtained at a cognitive test (described below), depends on retirement status (r_{it}), along with a vector of exogenous variables (x_{it}) including age, socio-demographic and health characteristics, and an unobserved error term (ε_{it}):

$$c_{it} = f(x_{it}, r_{it}, \varepsilon_{it}). \quad (1)$$

The error term can be decomposed into time-invariant individual heterogeneity (μ_i) and an idiosyncratic error term (ν_{it}):

$$\varepsilon_{it} = \mu_i + \nu_{it}. \quad (2)$$

Identification of the causal effect of retirement on cognitive functioning requires the error term and the retirement decision to be uncorrelated: $E(r_{it}\varepsilon_{it}|x_{it}) = 0$. This condition is unlikely to hold: first, retirement and cognitive functioning may be endogenous; low cognitive functioning may induce retirement. Second, unobserved individual heterogeneity may be correlated with both the retirement decision and cognitive functioning. Assuming linear separability, cognitive functioning and retirement are given by the following system of equations

$$c_{it} = x_{it}\beta_1 + r_{it}\beta_2 + \mu_i + \nu_{it}, \quad (3)$$

$$r_{it} = x_{it}\gamma_1 + c_{it}\gamma_2 + w_{it}\gamma_3 + \omega_i + \eta_{it}, \quad (4)$$

where equation (4) is the reduced-form equation of retirement decision, w_{it} is a vector of variables directly related to the retirement decision, but is assumed to have no direct effect on cognitive functioning, $E(w_{it}v_{it}|x_{it}) = 0$, and η_{it} is the idiosyncratic disturbance associated with retirement. From (3) and (4), the reduced-form model describing retirement decision is written as follows:

$$r_{it} = \frac{\gamma_1 + \gamma_2\beta_1}{1 - \beta_2\gamma_2} x_{it} + \frac{\gamma_3}{1 - \beta_2\gamma_2} w_{it} + \frac{\gamma_2}{1 - \beta_2\gamma_2}(\mu_i + \nu_{it}) + \frac{1}{1 - \beta_2\gamma_2}(\omega_i + \eta_{it}), \quad (5)$$

$$r_{it} = \Pi_1 x_{it} + \Pi_2 w_{it} + \Pi_3(\mu_i + \nu_{it}) + \Pi_4(\omega_i + \eta_{it}), \quad (6)$$

where Π_j represents the reduced-form parameters. If the retirement decision depends on cognitive functioning ($\gamma_2 \neq 0$), retirement will be correlated with the error term (ε_{it}) in equation (1) through μ_i and ν_{it}. Moreover, retirement and the error term (ε_{it}) in equation (1) are likely to be correlated if the unobserved fixed individual heterogeneity from retirement decision and cognitive functioning are correlated ($E(\mu_i \omega_i | x_{it}) \neq 0$).

The fixed effects (FE) estimator allows measurement of the parameters of interest, controlling for unobserved individual heterogeneity. The effect of retirement on cognitive functioning (β_2) will be consistently estimated unless ν_{it} is correlated to the retirement decision (i.e. $\gamma_2 \neq 0$). Moreover, the FE estimates are also susceptible to attenuation bias from measurement error in the retirement variable (Griliches and Hausman, 1986). We deal with those issues by using Instrumental Variable (IV) methods. The instruments correspond to the vector w_{it} in equation (4). To be valid instruments, the variables in the vector w_{it} must be related to retirement decision ($\gamma_3 \neq 0$) and correlated to cognitive functioning only through the effect of retirement ($E(w_{it} \nu_{it} | x_{it}, \mu_i) = 0$). Large spikes in the retirement hazard at ages 62 and 65 have been well noted in the literature, and Social Security has been found to play a significant role in explaining such spikes (Burtless and Moffit, 1984; Ruhm, 1995; Gruber and Wise, 1999; Coile and Gruber, 2000). We thus use these key retirement ages in the United States as identifying instruments for the retirement decision. Age 62 represents the earliest age at which Social Security benefits can be claimed, while age 65 is the normal retirement age in the US (i.e. the age at which individuals can receive full Social Security benefits if they retire at that age). Note that the normal retirement age is set to increase to age 67 over a 22-year period; this affects people born January 2, 1938, and later.[4] We thus compute two dummy variables equal to 1 if the individual belongs to the corresponding age-interval in the retirement equation, while the cognitive functioning equation includes age as a smooth function using low-order polynomials. While these specific age values are likely to have a direct effect on the decision to retire, it is less likely that they have a particular

[4] Table A1 in the Appendix shows the normal retirement age for the different cohorts that we use for our empirical analysis.

effect on cognitive functioning, except through retirement. The empirical strategy consists of estimating Equation (3) using the two-stage least-squares within estimator, with these age threshold dummies as instruments for retirement. As a robustness check, we also estimate the model by using an alternative instrument for retirement that corresponds to a dummy that is equal to one when the individual has reached her/his expected age of retirement.

This alternative instrument for retirement behaviour has some advantages and drawbacks. On one hand, contrary to the eligibility age for retirement, this variable is not totally fixed at one particular age. We are therefore able to use a more flexible functional form for age by including age dummies in order to check whether the results obtained with the Social Security instruments are not due to a misspecification of the age trend. On the other hand, the exclusion restriction of such an instrument might be questionable: first, individuals with lower cognitive functioning may expect to retire earlier, or cognitive functioning and expected age of retirement may be driven by a third unobserved factors. However, the within transformation of the data is likely to purge this correlation. Second, even when controlling for unobserved time-invariant heterogeneity, the exclusion restriction might be violated if expected age of retirement is related to the trend in the cognitive decline. As a check, we will investigate this possibility by allowing the age trend to depend on the expected age of retirement by including interaction effects between age and expected age of retirement in our model.

The second part of the empirical analysis will use the cross-national difference in the pattern of retirement across European countries, which are mainly due to differences in institutional settings across countries, in order to identify the causal effect of retirement on cognitive functioning. We argue that the difference in the aggregate retirement profile across countries cannot be explained by differences in the profile of cognitive decline and can thus be used as an instrument for retirement decision.

3. Data

3.1. The Health and Retirement Study

The empirical analysis uses six waves (1998–2008) from the Health and Retirement Study (HRS).[5] The HRS has been following a sample of Americans born between 1931 and 1941

[5] The HRS is sponsored by the National Institute of Aging (grant number NIA U01AG009740) and is conducted by the University of Michigan.

and their partners since 1992. Since 1998, this survey has also included respondents from the Asset and Health Dynamics Among the Oldest Old (AHEAD) study (cohorts born between 1890 and 1923), and a representative sample of individuals born between 1924 and 1930 (the Children of the Depression Age) and between 1942 and 1947 (War Babies). An additional sample of individuals born between 1948 and 1953 (Early Baby Boomers) was added in 2004. Most interviews were done by telephone, although exceptions are made when the individual has health limitations or when the household has no telephone. The data contain a wide range of information about mental and physical health, labor status, financial situation, the family, and activities of the respondents.

In our study, we restrict the sample to respondents aged 50 or over.[6] We exclude from the sample individuals reporting having never worked and those having definitely left the labor force before the age of 50. Moreover, all individuals are dropped from the study who report returning to work during the sampling period. Including thoese individuals in the sample would require the assumption that the effect of leaving the labour force or going back to labor force on cognitive functioning would be symmetric. Moreover, we may argue that individuals going back to work are more likely to remain active on the labor market (e.g. looking for a job) during their non-working period. Finally, all observations are dropped where there are missing or unreliable values for the variables included in the model. The final sample corresponds to an unbalanced panel including 74,894 observations for 18,704 individuals.

3.2. The Survey of Health, Ageing and Retirement in Europe

The cross-national analysis uses data from the Survey of Health, Ageing and Retirement in Europe (SHARE). SHARE is a European multi-disciplinary survey including more than 30,000 persons born in or before 1954, and coming from 14 European countries ranging from Scandinavia to the Mediterranean.[7] In this paper, we use release 2 of the first two waves of the survey, which were conducted in 2004 and 2006. The data were collected using a computer assisted personal interviewing (CAPI) program, supplemented by a self-completion paper and pencil questionnaire. For more details on the sampling procedure,

[6] As a check, we have also restricted the analysis to individuals being between 50 and 75 year-old and we obtained similar results. Tables A3 and A4 in Appendix present the results of our model that excludes individuals being older than 75.

[7] SHARE data includes fourteen European countries: Austria, Belgium, Czech Republic, Germany, Denmark, France, Greece, Ireland, Italy, the Netherlands, Poland, Spain, Sweden, and Switzerland.

questionnaire content and fieldwork methodology, we refer readers to Börsch-Supan and Jürges (2005).[8]

We restrict the sample to respondents aged between 50 and 65 years because it is during this age window that there are important differences in the employment rate across countries. All observations where there are missing or unreliable values for the variables included in the model are discarded from the analysis. The final sample includes 32,624 observations.

3.3. The measure of cognitive functioning

The HRS contains measures of cognitive functioning based on simple tests. The empirical analysis using the HRS focuses on one key cognitive domain: episodic memory, which is assessed through a test of verbal learning and recall. The motivation for analyzing this particular cognitive domain is twofold: first, this cognitive aspect is particularly affected by aging; some studies even argue that this cognitive function is among the first to decline with aging (Souchay et al., 2000; Anderson and Craik, 2000; Prull et al., 2000). Second, the related measure used to assess episodic memory, i.e., the score obtained in a test of word learning and recall, does not suffer from floor or ceiling effects (excess of maximum or minimum values), which thus provides a more sensitive measure than other measures of cognitive functioning that only allow for limited variability in scores. In the HRS, the episodic memory task consists of learning a list of ten common words.[9] The interviewer reads a list of 10 words (e.g., book, child, hotel, etc.) to the respondent, and asks the respondent to recall as many words as possible from the list in any order. Then, immediate and delayed recall phases are carried out. Immediate recall follows directly, while a short interval is inserted before the delayed recall. Memory score for this task is calculated by the sum of the number of target words recalled at the immediate recall phase and the number of target words recalled at the delayed recall phase (score ranging from 0 to 20). The memory score has a distribution close to the normal distribution with a sample mean of 9.8 and a standard deviation of 3.65.

[8] More information can be found on the SHARE website: http://www.share-project.org/.

[9] Note that the HRS in fact uses four different lists of common words and that respondents are asked a different list of words from the lists that they, and their spouse, had to answer during the previous wave. This is done in order to avoid the respondent remembering the words from that previous list. There is, in fact, evidence of such a learning effect with the first two waves of the HRS, where individuals were asked the same list of words.

In the SHARE data, cognitive functioning is measured using a similar test of verbal learning and recall of ten common words, as for the HRS. The sample mean is 9.4 with a standard deviation of 3.3. Figure 1a and 1b display the distirbution of the memory score for HRS and SHARE, respectively.

[Figure 1a and 1b about here]

Moreover, SHARE data also include a word fluency test score based on the task of naming as many animals as possible in 60 seconds. This task is aimed at measuring the executive functioning of the individual. The fluency score has a sample mean of 20.5 with standard deviation of 7.2.

To ease the interpretation of our results, we use standardized measures of the test scores as dependent variable in our analysis.

3.4. The retirement variable

There are many definitions of retirement. For the purpose of our analysis, we follow Lazear (1986) and define an individual as being retired if he is definitively out of the labor force with the intention of staying out permanently. In the model assuming exogeneity of retirement (i.e., without using IV techniques), we use a categorical variable describing retirement status and time spent in retirement for retired individuals. Retirement duration is measured using information about the month and year of interview and the month and year when the individual left his/her last job. The reference categories include "Working", "Retired for 0 to 4 years", "Retired for 5 to 9 years", and "Retired for 10 years or more".

For the model using IV methods with eligibility rules as instruments, we use a dummy variable related to retirement status: an individual is defined as "Working" if he claims to be currently working for pay and "Retired" if he reports not working. The analysis using SHARE data uses the same definition.

3.5. The explanatory variables

In addition to the retirement variable, we include several other explanatory variables that are likely to be related to cognitive functioning. The effect of education is measured using a second-order polynomial of years of education.[10] Second-order polynomials of age are included in order to account for the "normal" cognitive aging process. The effect of age is assumed to be quadratic, allowing cognitive functioning to decline at an increasing rate with

[10] Note that this variable is truncated at 17 years of education in the HRS.

aging. [11] We control for health by including a variable equal to 1 if a doctor has ever told the respondent that he has had a stroke (or a transient ischemic attack), a heart related disease[12], or high blood pressure. Finally, we include a dummy variable for single-living households, and a categorical variable for ethnicity (White/Caucasian, Black/African American, or Other) for HRS data. The cross-national analysis using SHARE includes a dummy variable equal to one if the individual is interviewed for the second time to account for the test-retest effect (contrary to the HRS, the list of words used for the word recall test is the same for both waves; it is thus possible that individuals who do the test for the second time attain a better score than those doing the test for the first time).

4. Results

4.1. Evidence from the United States

4.1.1. Descriptive results

Column (i) of Table 1 presents the parameters of Equation (3) estimated by Ordinary Least Squares (OLS).[13] Almost all coefficients are highly significant. These results are in accordance with the results obtained by Adam et al. (2007), who use data from Europe (SHARE and ELSA) and the United States (HRS). The coefficients on education and age have the expected signs and are highly significant.

Education is positively related to cognitive functioning, while age has a negative effect. Living in a single household may have two opposite effects on cognitive functioning. First, it may induce lower cognitive functioning due to the lack of social interaction (Ybarra et al., 2008). Second, it may stimulate cognitive functioning, as single-living individuals must deal alone with all tasks associated with management of the household. The empirical results show that individuals living alone have a lower cognitive score. Consistent with the findings of Patel et al. (2002), suffering from a stroke has a large and significant negative impact on the dependent variable. The coefficients of the other health-related variables, i.e.

[11] To test for the functional form of the age trend, we have also included the cubic of age in our models but the related coefficient has been found to be not significant when using the within estimator. It is significant for the OLS but the coefficients of interest (i.e. the retirement coefficients) remain almost unchanged by the inclusion of this explanatory variable.

[12] Heart-related diseases include heart attack, coronary heart disease, angina, congestive heart failure, and other heart problems.

[13] The standard errors of the estimates are corrected for autocorrelation among the observations corresponding to the same individuals over time.

having high blood pressure or a heart-related disease, are also negative and significant. All the coefficients related to retirement spell are negative and highly significant and show that, conditional on age, individuals retired for a longer time reach lower cognitive scores. On average, an individual retired within 5 years obtains a cognitive score that is lower by about 0.13 standard deviations than for workers. This difference increases to about 0.19 standard deviations when individuals are retired by more than 10 years.

[Table 1 about here]

4.1.2. The within estimator

The OLS estimator does not take into account the unobserved individual heterogeneity that might be correlated to the explanatory variables in the equation, and it thus may lead to inconsistent estimates of the effects of the covariates on cognitive functioning. Column (ii) of Table 1 displays the parameters of Equation (3) estimated with the fixed effects model.

The effect of aging is more pronounced when we control for individual heterogeneity. This suggests that older individuals have unobserved characteristics that are positively related to their cognitive functioning. This may be due to cohort effects or a selection process where individuals with higher endowment in health, and cognitive ability, live longer than individuals with lower endowments.[14] Regarding the health related variables, only the coefficients related to stroke and to heart-related disease remain negative and highly significant.

The parameters associated with retirement and retirement spell remain negative and highly significant, but their magnitude is lower as compared to the OLS estimates. This is what we can expect from the within estimator, as this controls for unobserved individual heterogeneity, which is likely to be negatively correlated to retirement. Moreover, the within estimator is more prone to attenuation bias due to measurement error in the retirement variable (Griliches and Hausman, 1986). However, as for the OLS estimates, we still observe that the length of exposure to retirement also affect cognitive functioning.

4.1.3. The IV estimator

The previous section showed that the negative effect of retirement on cognitive score remains, even when individual heterogeneity is controlled for. However, the transitory

[14] This result might also be due to attrition where individuals with lower cognitive functioning are more likely to leave the panel.

shocks in cognitive functioning may induce older workers to leave the labor force. Moreover, the within estimator exacerbates measurement error and is likely to suffer from attenuation bias. To solve those potential issues, we employ IV methods, using the eligibility rules as instruments for retirement in the same spirit of Bound and Waidmann (2007), Charles (2002), and Neumann (2008). We use age-threshold dummy variables for reaching the minimum age for being eligible for Social Security benefits (62 years) and the normal retirement age, as defined in Table A1 in the Appendix, as instruments for retirement. While these specific age values are likely to have a direct effect on the decision to retire, it is unlikely that they have a particular effect on cognitive functioning.[15] The IV estimator uses only work/retirement status as an endogenous variable and thus does not take into account retirement duration. So the coefficient related to the retirement variable in the (IV) fixed effect model has to be interpreted as the average short term effect of retirement on cognitive functioning that roughly corresponds in our data to an average effect about 5 years post retirement.

Before turning to the IV estimation, we first describe the profile of cognitive functioning around the key age of retirement in the United States. Figure 2 presents the estimated cognitive test score by age from 55 to 70 years, controlling for fixed effects. This figure highlights a significant decline in cognitive scores after the age of 62, which corresponds to the minimum age at which Social Security benefits can be claimed. There is no biological reason for changes in the process of cognitive decline at those particular ages. Aging is a long-term process and is not homogeneous across individuals. The evolution of average cognitive functioning should thus be a continuous function of age. This graph suggests, however, that there is a significant decrease in cognitive functioning at the minimum age of eligibility for receiving Social Security benefits, which also corresponds to the peak age of retirement in the United States. This first descriptive result supports our hypothesis that retirement is accompanied by a decline in cognitive functioning.

[Figure 2 about here]

We now turn to the IV estimates. Table 2 presents the parameter estimates of the model estimated by the two-stage least-squares within estimator. The coefficients of the first-stage equation describing the retirement decision are displayed in column (i). The instruments,

[15] It should be noted that age 65 also corresponds to the age from which individuals become eligible for Medicare and may affect health, and thus cognitive functioning. As a check, we have estimated the model by using only the 62 year old threshold as an instrument for retirement and obtained similar results. Those results are available upon request.

i.e., the eligibility ages for Social Security, have large and highly significant effects on the probability of retirement. The probability of retirement increases by about nine percentage points at age 62. The F-test of joint significance of the instruments proposed by Bound et al. (1995) confirms that they are significant predictors of retirement (*F(2, 16164) = 185.27*). The Sargan-Hansen test of overidentifying restrictions does not reject the hypothesis that our instruments are valid. [16]

The effect of retirement on memory score is negative and significant. It suggests that individuals retiring experience a drop in cognitive score by about 0.24 of a standard deviation (95% confidence interval -.42 to -.05). It corresponds to about a 9% decrease in cognitive score (compared to the sample average score). The estimate is larger than in the model that assumes exogeneity of retirement (See column (ii)), possibly due to measurement errors in the retirement variables that are likely to bias downward the within estimates. The Durbin-Wu-Hausman test rejects the null hypothesis of exogeneity of retirement. This result suggests that the endogeneity bias, if any, tends to underestimate the impact of retirement on cognitive score when not taken into account. Nevertheless, these results reinforce our previous findings showing the negative relationship between retirement and cognitive functioning.

[Table 2 about here]

4.1.4. Alternative instruments: expected age of retirement

This section presents results of the IV model using an alternative instrument for retirement: expected age of retirement. This measure has been found to be a good predictor of actual date of retirement (Bernheim, 1989; Disney and Tanner, 1999; Benitez-Silva and Dwyer, 2005; Haider and Stephens, 2007). The HRS includes questions on whether and when the respondent plans to retire, and if there is currently no planned retirement date, when he thinks he will stop work or retire.[17] For this purpose, we select all individuals who are working at the first interview year and who have reported the year they expect to retire. The instrument is defined as a dummy variable equal to 1 when the respondent has reached her/his expected retirement age. Table 3 displays the results of the model estimated by two-stage least-squares within estimator. The first stage equation shows that this instrument has a large and significant impact on the retirement decision. The probability of retirement

[16] As a check, we have also estimate the model by using only age and age square as explanatory variables and obtained similar results than those presented in Table 2. Those results are available upon request.
[17] We use the measure available in the RAND HRS Data File (See Saint Clair et al., 2007).

increases by about 19 percentage points when individuals reach their expected retirement age. The F-test on the instrument shows that it has strong predictive power on actual retirement (*F(1, 6229) = 513.73*). The estimated effect of retirement on memory score is again negative and significant and almost the same as the previous within-IV estimate. The magnitude of the effect is estimated to be -0.24 of a standard deviation of the memory score (95% confidence interval -0.39 to -0.09).

[Table 3 about here]

One advantage of this instrument with respect to the age thresholds used in the previous section is that this instrument is not fixed at a particular age for all individuals and thus allows us to use more flexible age specifications in order to check whether the previous results might be driven by a functional misspecification of the effect of aging on cognitive functioning. In order to allow for a fully flexible age specification, we include age dummies in the model. Results are presented in Table A5 in the Appendix and show that the coefficient estimate related to retirement obtained from the two-stage within estimator is unaffected by this more flexible age - cognitive functioning relationship and suggests that the second-degree polynomial is a good approximation of the age trend of cognitive functioning.

As discussed earlier, this instrument may not satisfy the exclusion restriction assumption. However, the use of the fixed effect model ensures us to get rid of the possible correlation between cognitive functioning and expected retirement age that may arise from the fact that individuals with intrinsincly lower cognitive functioning are also more likely to expect to retire earlier (it might be due to a third unobserved factors affecting both the level of cognitive functioning and expected age of retirement, such as unobserved health). However, we may argue that the exclusion restriction is still violated if expected age of retirement is related to the age trend in cognitive functioning. In order to check whether this may drive our results, we include in the model interaction terms between age and age square and the expected age of retirement. Results are presented in Table A6 in Appendix and show that the coefficients related to the interaction terms are not significant while the coefficient of interest is not significantly different from the estimate presented in Table 3.

4.1.5. Does cognitive functioning affect retirement expectations?

Further evidence that causality runs from retirement to cognitive functioning comes from an analysis of the effect of cognitive functioning on retirement expectations. We estimate a

model of retirement decision that includes cognitive score as an explanatory variable to check whether a drop in cognitive capacity may affect the propensity to work of older workers. For this purpose, we estimate Equation (4) and test the hypothesis that the coefficient of cognitive functioning (γ_2) is equal to zero. To avoid the issue of simultaneity, we use retirement expectations of older workers as a proxy for labor force attachment, rather than actual labor force status. Our test analyzes whether cognitive functioning affects expectation of retirement at age 65. The validity of subjective expectation measures has been shown to provide strong predictive power of actual behavior (Manski, 2004; Disney and Tanner, 1999; Benitez-Silva and Dwyer, 2005). This proxy for labor force attachment allows measurement of the effect of a change in cognitive functioning on retirement expectations of older individuals, while avoiding the issue of simultaneity of cognitive functioning and labor force status. Table 4 presents the results of the fixed effects model on workers less than 65 years old. The coefficient of memory score is not significant, suggesting that changes in cognitive functioning do not affect the retirement expectations of older workers. Note that this results is also likely to be driven by the presence of measurement error in the measure of cognitive functioning that drives the coefficient estimate towards zero. Nevertheless, these results are in accordance with Haardt (2008), who found no evidence that changes in cognition affect retirement decision, using the English Longitudinal Survey on Ageing (ELSA). These findings support our previous results that the negative relationship between cognitive functioning and retirement is unlikely to be due to reverse causality.

[Table 4 about here]

4.2. Evidence based on cross-country comparison

In this section, we provide further evidence on the relationship between retirement and cognitive functioning from an international perspective. Gruber and Wise (1999, 2004) have highlighted the strong relationship between financial disincentives to work and the participation rate of older individuals across countries. As a result, a suitable instrument for retirement to analyze the causal effect of retirement on cognitive functioning would be the differences in financial incentives that older workers face across countries. However, those incentives are quite difficult to calculate in practice due to the complexity and the multitude

of social security programs that exist across European countries.[18] Contrary to the United States, where the major pathway to retirement is Social Security, many European countries have different pathways to retirement, including old-age unemployment, disability, early retirement schemes, and of course, legal retirement schemes.

Since our data set lack information that allows us to correctly calculate financial incentives for retirement (e.g. due to the absence of information on life-cycle contributions to retirement schemes), we use the differences in the aggregate employment rate by country, gender and age, which capture financial incentives and institutional rules, but are unlikely to be caused by differences in cognitive decline across countries. Conditional on the country of residence, gender and age, the heterogeneity in the age-profile of retirement across countries can thus be used as an instrument to analyze the causal effect of retirement on cognitive functioning.

The micro-analysis includes the same controls as for the empirical analysis on HRS data: a second-order polynomial in age, gender, country dummies, years of education[19], three dummies equal to 1 if a doctor has ever told the respondent that he has had a stroke (or a transient ischemic attack), a heart related disease, or high blood pressure.

4.2.1. Country-level analysis

Adam et al. (2007) found a relationship between the differences in cognitive scores between 50-54 and 60-64 year-old men relative to the score of the 50-54 year-old men across European countries and the US. They found that the relative decrease in cognitive score was higher in countries where the drop in employment was also higher. Figure 4a replicates the figure of Adam et al. (2007) with the updated data of SHARE using the pooled sample from the two first waves and HRS 2004 where cognitive functioning is measured by the word recall test, while Figure 4b uses the fluency score as a measure of cognitive functioning (where the United States is missing since we do not have the fluency test in the HRS). As in Adam et al. (2007), these figures highlight a strong relationship between the relative decrease in cognitive score and the relative decrease in employment rate across those two age categories. If we compare those figures with Figure 3 from Gruber and Wise (1999), which highlight the strong relationship between the tax force to retire and the unused labor

[18] Other than the complexity of computations, the main limitation is unavailability of complete data on professional life, to perform retirement incentives' computations.

[19] Years of education are constructed for the different SHARE-participating countries according to the 1997 International Standard Classification of Education (OECD, 1999).

force capacity among older workers, we see that the greatest drops in the employment rate occur in countries where financial disincentives to work are the highest. The coefficient of the regression line fitting the relationship between the relative drop in employment rate and the relative drop in cognitive functioning suggests that retirement decreases cognitive functioning by about 7% for the memory score and by about 11% for the fluency score. Those estimates are consistent with those obtained by the individual-level analysis that uses the longitudinal dimension of the HRS and the eligibility age for Social Security, or the expected age of retirement, as instruments for retirement.

[Figure 3, Figure 4a and Figure 4b about here]

4.2.2. Individual-level analysis

SHARE also allows the estimation of the causal effect of retirement on cognitive functioning at the individual level. We use the aggregate employment rate by country, gender and age as an instrument for retirement to estimate the causal effect of retirement on cognitive functioning. The aggregate employment rates are directly calculated from SHARE data as the average employment rate by country, gender and age.[20] This measure is then used as an instrument for individual retirement.

[Table 5 about here]

Table 5 presents the results of the OLS and the IV model using the normalized fluency score and the normalized word recall test score as the dependent variable.[21] The results for both cognitive tests are very similar, especially regarding the retirement status. Moreover, the effect of being retired on cognitive score estimated by OLS is also similar to the OLS estimates obtained using the HRS data. By construction, the instrument in the first-stage equation is highly significant. The IV estimates of the effect of being retired on both cognitive scores are also very similar and close to the results using the HRS data. The magnitude of the effect is estimated to be -0.2 of a standard deviation of the memory score (95% confidence interval -0.28 to -0.09) and -0.18 of a standard deviation of the fluency score (95% confidence interval -0.28 to -0.09). As for the model using longitudinal data from the HRS, the IV estimator confirms the negative effect of retirement on cognitive

[20] As a robustness check, we also calculated those aggregate employment rates by using data from the Labour Force Survey and obtained similar results.

[21] Table A7 in Appendix presents the results of the estimations made on the sample including both SHARE and HRS data (from 2004) for the word recall test. Results do not differ significantly from those presented in Table 5.

functioning for both cognitive tests.[22] The magnitude of effect of retirement on cognitive functioning is lower than the estimates obtained by Rohwedder and Willis (2010). This may be due to the fact that, contrary to their specification, our model also controls for country differences and important individual characteristics, such as age and gender, that are both related to eligibility rules for retirement and cognitive functioning. Omitting those variables is likely to violate the independence assumption between the instruments and the error term. Indeed, we observe large differences in memory score across countries; even among workers in their fifties (the observed gaps before retirement cannot be explained by differences in retirement pattern across countries).[23] For instance, we observe a clear North-South gradient in memory score across European countries. At the same time, the eligibility age for retirement benefits tends to be higher in Northern countries than in Southern countries. We thus argue that the larger impact they find is mainly due to the omission of country dummies, as well as gender and age, that leads to overestimate the parameter of interest. As a check, we also use the instruments proposed by Rohwedder and Willis (2010) instead of the aggregate employment rate, by country gender and age. Furthermore, we take into account for the fact that the incentives at those eligibility ages might differ across countries and gender.[24] For this purpose, we use those eligibility age thresholds fully interacted with country and gender dummies. The results are presented in Table A9 in the Appendix and are consistent with the results we obtained when using the aggregate employment rate by age, country and gender.

5. Conclusion

This paper has analyzed the effects of retirement on cognitive functioning, measured by a test of word learning and recall, using longitudinal data on older Americans from 1998 to 2008 (HRS) and a cross-national survey on older individuals from 14 European countries (SHARE).[25] The empirical results highlight a significant negative causal impact of

[22] As a robustness check, we have also estimated the model that includes interaction terms between country dummies and age (age and age square) to allow for country-specific age trend and we found the similar results. See Table A8 in Appendix.

[23] As previously mentioned, note also that HRS does not use the same list of words as SHARE.

[24] The eligibility age for retirement benefits by country and gender are presented in Table A2 in the Appendix.

[25] It is worth noting that our results rely mainly on one single cognitive task (ie, a task of word recall), which calls into question the generalizability of our results on the whole cognitive functioning. Nevertheless, several elements can be put forward to justify the generalization of our results: it is widely recognized that word recall tests involve a broad network of brain regions (i.e., frontal regions, hippocampus, etc.; Desgranges, Baron, and Eustache, 1998; Tulving, 2002) and that this kind of task is multidetermined, i.e. it implies a variety of other cognitive functions such as language, attention, executive functioning, etc. (Tulving, 2002). In that sense, it is

retirement on cognitive functioning. This negative effect remains even when controlling for individual heterogeneity and the endogeneity of the retirement decision. We show that this relationship is unlikely to be due to reverse causality by using eligibility for Social Security and expected age of retirement as instruments for retirement. Furthermore, we find no evidence that changes in cognitive functioning affect retirement expectations. This is in accordance with results from Haardt (2008), who found no significant effect of cognitive decline on the labor force supply of older workers in England using data from the English Longitudinal Study on Ageing. The empirical analysis using the cross-national differences in age-pattern of retirement (as a result of differences in institutional settings and labor market conditions) as an instrument for retirement provides results that are in accordance with those found using the longitudinal American data. In both cases we found a significant negative, and comparable, effect of retirement on cognitive functioning, close to 9%.

Those results demonstrate a causal effect of activity (here professional activity) on cognition using different large survey data and different identification strategies. Before that, arguments in favor of an effect of activities on cognition were relatively indirect coming from: (1) several experimental studies on animals (Rosenzweig and Bennett, 1972; Winocur, 1998); and (2) studies showing the presence of brain plasticity even in adults (Nudo, 1996), and that the stimulation of the environment can modulate this brain plasticity (Döbrössy and Dunnett, 2001).

On a theoretical point of view, all these results support the disuse perspective (Salthouse, 1991), which assumes that decreases in activity patterns result in atrophy of cognitive skills, while stimulating mental activities increase them (the "use-it or lose it" hypothesis), and suggest that retirement plays a significant role in explaining cognitive decline at older age. However, further studies will be necessary to specify the role of professional activities on cognition (and more particularly on the memory functioning). Indeed, a first question is to investigate whether the impact of the retirement on cognitive functioning depends on the type of professional activity: physical versus intellectual work; weak versus important workload; stressful work or not... For example, some studies have shown that intellectually demanding jobs during adulthood are associated with better cognitive functioning in later life, whereas manual labor are associated with worse cognitive functioning (Jorm et al., 1998; Potter, Helms, and Plassman, 2008). A second important

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important to underline that our results obtained with this memory task are consistent with those observed with the semantic fluency task for the European data.

question is to determine whether the relation between retirement and cognition is direct and/or whether there are some intermediate variables between retirement and cognition. Indeed, work is known to increase social interactions and a sense of self-efficacy, both variables being considered as important factors contributing to the maintenance of the cognitive reserve (Rowe and Kahn, 1998).

Finally, it can be underlined that memory loss and dementia among the elderly represent a major public health burden, especially in the current context of population aging. Cognitive impairments, even those not reaching the threshold of dementia diagnosis, are associated with a loss of quality of life, increased disability, and higher health-related expenditures (Albert et al., 2002; Ernst and Hay, 1997; Lyketsos et al., 2002; Tabert et al., 2002). Our findings suggest that reforms aimed at promoting labor force participation at an older age may not only insure the sustainability of social security systems but may also create positive health externalities that may in turn affect expenditures on long-term care.

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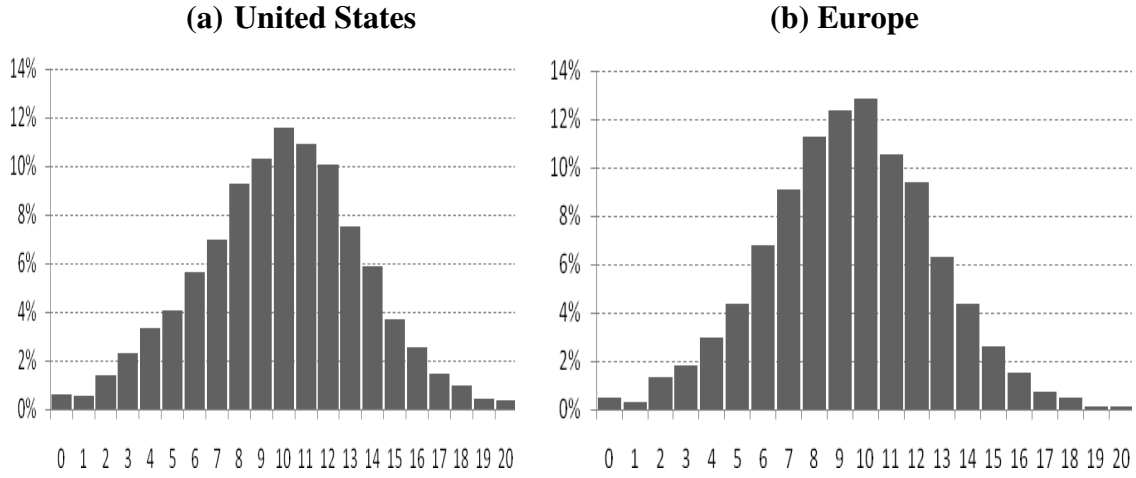
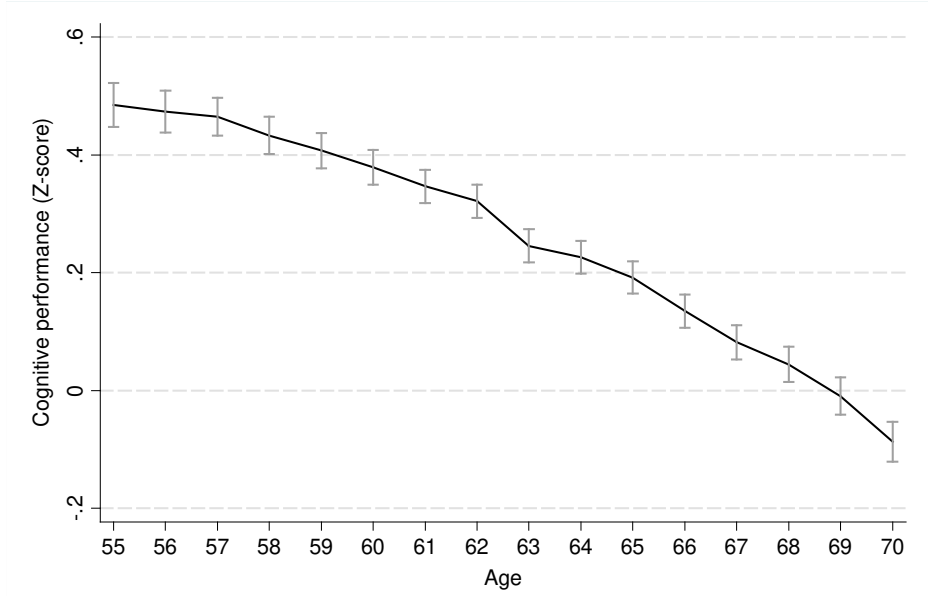
Tables and Figures

Figure 1: Distribution of memory score



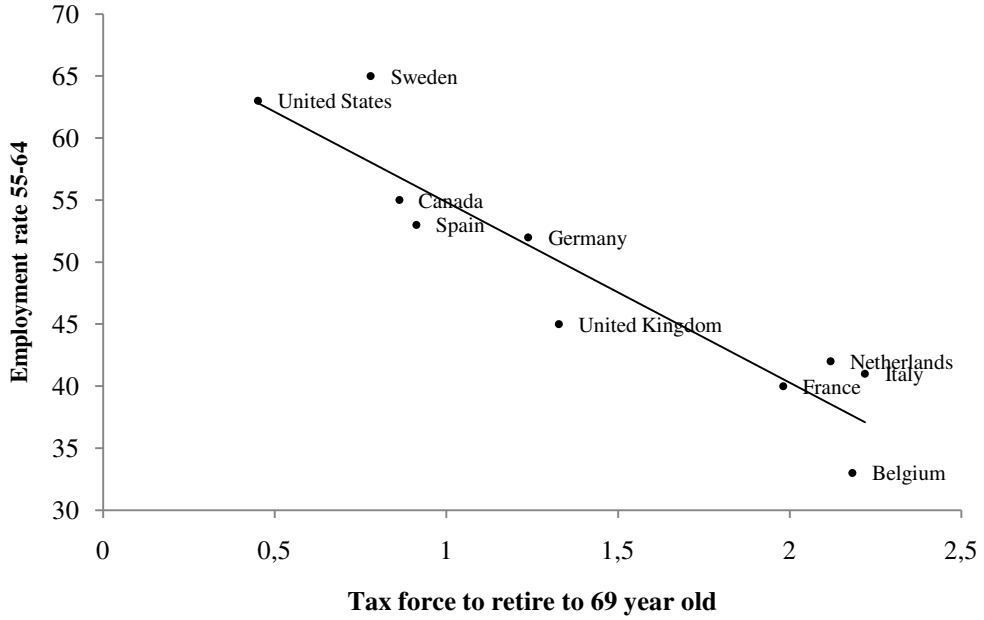
Note: Health and Retirement Study 1998-2008 (50+ individuals) and The Survey of Health, Ageing, and Retirement in Europe 2004-2006 (50-65 year-old). The memory score is the sum of the number of words recalled from a list of ten words during immediate and delayed recall tasks.

Figure 2: Cognitive score and age



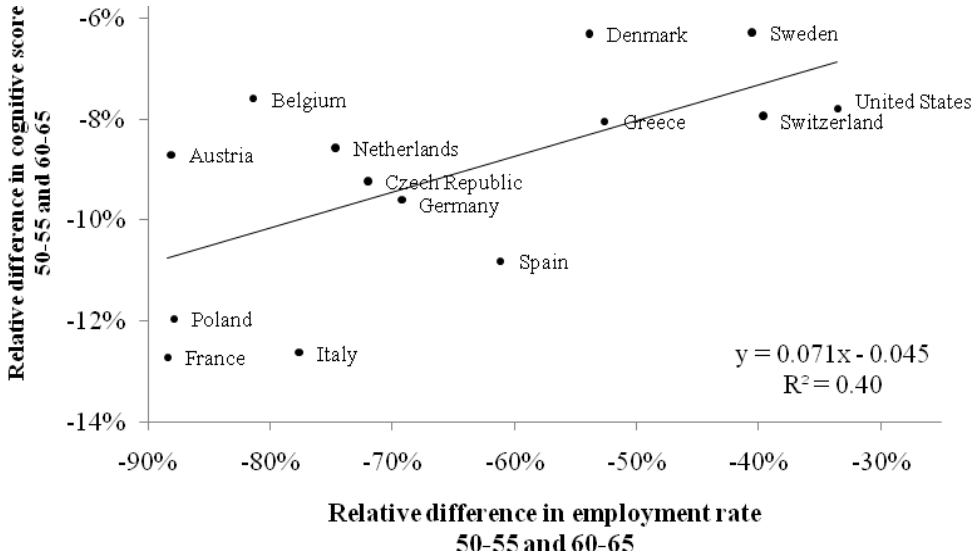
Note: Health and Retirement Study 1998-2008. The memory score is the standardized sum of the number of words recalled from a list of ten words during the immediate and delayed recall tasks. The estimates are based on a fixed-effect model including age dummies as explanatory variables.

Figure 3: Unused labor force capacity versus tax force to retire



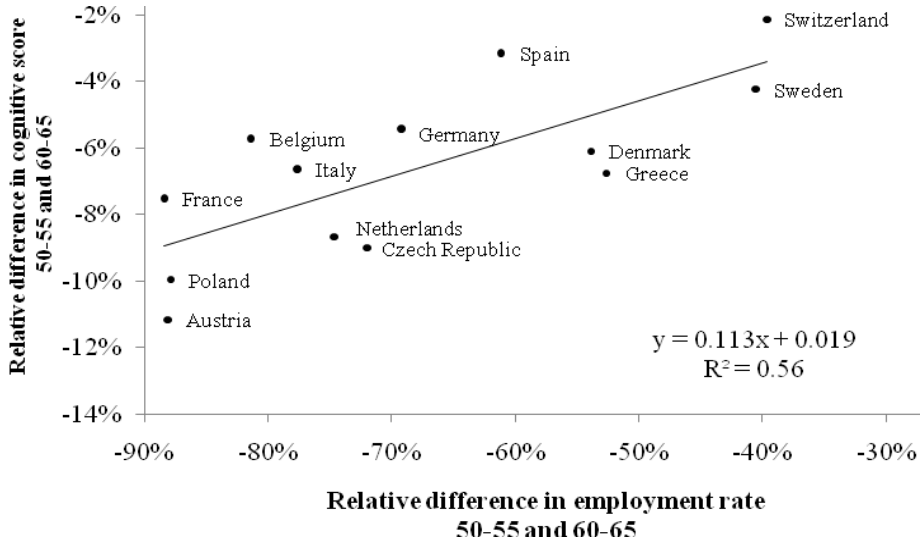
Source: Adapted from *"Social Security and Retirement Around the World,"* Jonathan Gruber and David A. Wise, eds., Chicago: University of Chicago Press, 1999. The tax force to retire is the log of the sum of the implicit tax rates over the period from the early retirement age (when a person is first eligible for social security benefits) to age 69.

Figure 4a: Employment rate and memory score. Relative difference between 60-65 and 50-55 year-old men



Note: Survey of Health, Ageing and Retirement in Europe 2004-2006. Health Retirement Study 2004 for the US. The relative difference in employment rate/cognitive score is defined as $(Y_{60\text{-}65} - Y_{50\text{-}55}) / Y_{50\text{-}55}$ for Y_i= the average employment rate/cognitive score for the age category i.

Figure 4b: Employment rate and fluency score. Relative difference between 60-65 and 50-55 year-old men



Note: Survey of Health, Ageing and Retirement in Europe 2004-2006. The relative difference in employment rate/cognitive score is defined as $(Y_{60\text{-}65} - Y_{50\text{-}55}) / Y_{50\text{-}55}$ for Y_i= the average employment rate/cognitive score for the age category i.

Table 1: Determinants of cognitive functioning at older age

Dependent variable:	Memory score	
	OLS	FE model
	(i)	(ii)
Work and Retirement:		
Working	-	-
Retired for 0 to 4 years	-0.135***	-0.041***
	(0.011)	(0.012)
Retired for 5 to 9 years	-0.160***	-0.062***
	(0.014)	(0.017)
Retired for 10 years or more	-0.190***	-0.103***
	(0.016)	(0.022)
Age	-0.027***	-0.042***
	(0.001)	(0.001)
$(Age^2)/10$	-0.009***	-0.011***
	(0.000)	(0.000)
Single household	-0.011	0.014
	(0.011)	(0.013)
High blood pressure	-0.032***	0.000
	(0.009)	(0.013)
Heart-related disease	-0.036***	-0.058***
	(0.011)	(0.016)
Stroke	-0.210***	-0.189***
	(0.019)	(0.025)
Years of education	0.089***	-
	(0.002)	
(Years of education^2)/10	0.010***	-
	(0.003)	
Woman	0.340***	-
	(0.010)	
Ethnicity:		
Caucasian	-	-
African American	-0.335***	-
	(0.014)	
Other	-0.259***	-
	(0.025)	
Constant	0.094***	-
	(0.013)	
(Within-)R^2	0.313	0.078
Number of observations	74,894	74,894
Number of individuals	18,704	18,704

Note: Health and Retirement Study 1998-2008. All respondents were 50 years of age or older. The dependent variable is the Z-score of the word recall test. Age and years of education are expressed in deviation from the sample mean. Robust standard errors are in parentheses. (*), (**), (***) mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively.

Table 2: Determinants of cognitive functioning at older age: IV-FE estimators

Dependent variable:	Retired	Memory score	
	LPM	FE model	IV-FE model
	(i)	(ii)	(iii)
Work and Retirement:			
Working	-	-	-
Retired	-	-0.034***	-0.240**
		(0.012)	(0.094)
Instruments:			
Eligibility I (62+)	0.094***	-	-
	(0.007)		
Eligibility II (Normal retirement age+)	0.171***	-	-
	(0.009)		
Age	0.025***	-0.044***	-0.038***
	(0.001)	(0.001)	(0.003)
$(Age^2)/10$	-0.004***	-0.011***	-0.012***
	(0.000)	(0.000)	(0.001)
Single household	-0.012**	0.014	0.011
	(0.005)	(0.013)	(0.013)
High blood pressure	0.018***	0.000	0.004
	(0.006)	(0.013)	(0.013)
Heart-related disease	0.039***	-0.059***	-0.051***
	(0.008)	(0.016)	(0.016)
Stroke	0.065***	-0.190***	-0.177***
	(0.012)	(0.025)	(0.025)
Within-R^2	0.224	0.078	
Test of overidentifying restriction (*p*-value)			0.703
Durbin-Wu-Hausman test (*p*-value)			0.026
Number of observations	74,894	74,894	74,894
Number of individuals	18,704	18,704	18,704

Note: Health and Retirement Study 1998-2008. All respondents were 50 years of age or older. The dependent variable is the Z-score of the word recall test. Robust standard errors are in parentheses. Age is expressed in deviation from the sample mean. (*), (**), (***) mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively.

Table 3: Determinants of cognitive functioning at older age: IV-FE estimator

Dependent variable:	Retired	Memory score
	LPM	IV-FE model
	(i)	(ii)
Work and Retirement:		
Working	-	-
Retired	-	-0.243***
		(0.077)
Instrument:		
Reaching the expected age of retirement	0.194***	-
	(0.009)	
Age	0.051***	-0.026***
	(0.001)	(0.005)
$(Age^2)/10$	0.009***	-0.007***
	(0.001)	(0.001)
Single household	-0.014	-0.002
	(0.011)	(0.021)
High blood pressure	0.016	0.007
	(0.011)	(0.020)
Heart-related disease	0.066***	-0.040
	(0.015)	(0.025)
Stroke	0.145***	-0.139***
	(0.028)	(0.051)
Within-R^2	0.377	
Durbin-Wu-Hausman test (p-value)		0.008
Number of observations	29,076	29,076
Number of individuals	6,670	6,670

Note: Health and Retirement Study 1998-2008. All respondents were 50 years of age or older, were working during the first wave of interview and had reported their expected age of retirement. The dependent variable is the Z-score of the word recall test. Age is expressed in deviation from the sample mean. Robust standard errors are in parentheses. (*), (**), (***) mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively.

Table 4: Determinants of expectation about working at 65 years old. FE model

Dependent variable:	Self-reported probability of working at 65 years old
	FE model
Cognitive Z-score	0.003
	(0.003)
Age	0.009***
	(0.001)
$(Age^2)/10$	0.004***
	(0.002)
Single household	0.019*
	(0.011)
High blood pressure	0.014
	(0.011)
Heart-related disease	-0.031*
	(0.017)
Stroke	-0.141***
	(0.034)
Within-R^2	0.013
Number of observations	21,908
Number of individuals	7,750

Note: Health and Retirement Study 1998-2008. All workers were aged between 50 and 64 years. Age is expressed in deviation from the sample mean. Robust standard errors are in parentheses. (*), (**), (***) mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively.

Table 5: Determinants of memory/fluency score at older age. IV estimator

	Retired	Memory score		Fluency score	
	LPM	OLS	IV	OLS	IV
	(i)	(ii)	(iii)	(iv)	(v)
Work and Retirement:					
Working	-	-	-	-	-
Retired	-	-0.133***	-0.198***	-0.147***	-0.186***
		(0.013)	(0.050)	(0.013)	(0.049)
Instrument:					
Country/gender-specific employment rate by age	-0.992***	-	-	-	-
	(0.023)				
Age	-0.002*	-0.012***	-0.009***	-0.005***	-0.003
	(0.001)	(0.001)	(0.003)	(0.001)	(0.003)
$(Age^2)/10$	-0.001	0.005	0.006*	0.006**	0.006**
	(0.001)	(0.003)	(0.003)	(0.003)	(0.003)
Single household	0.011	-0.107***	-0.107***	-0.070***	-0.069***
	(0.008)	(0.016)	(0.016)	(0.016)	(0.016)
High blood pressure	0.019***	-0.031**	-0.030**	-0.028**	-0.028**
	(0.006)	(0.012)	(0.012)	(0.012)	(0.012)
Heart-related disease	0.105***	-0.087***	-0.080***	-0.083***	-0.079***
	(0.009)	(0.021)	(0.022)	(0.019)	(0.020)
Stroke	0.187***	-0.307***	-0.294***	-0.280***	-0.273***
	(0.016)	(0.042)	(0.043)	(0.038)	(0.039)
Years of education	-0.019***	0.064***	0.063***	0.062***	0.061***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)
Years of education^2/10	-0.006***	-0.010***	-0.011***	-0.005*	-0.005**
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Woman	-0.008	0.284***	0.295***	0.046***	0.053***
	(0.006)	(0.011)	(0.014)	(0.011)	(0.014)
Second time interview	-0.019***	0.137***	0.136***	0.064***	0.063***
	(0.004)	(0.010)	(0.010)	(0.010)	(0.010)
Constant	0.991***	0.136***	0.169***	0.445***	0.464***
	(0.016)	(0.032)	(0.040)	(0.032)	(0.040)
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Durbin-Wu-Hausman test (*p*-value)			0.181		0.404
R^2	0.359	0.192	0.192	0.258	
Number of observations	32,624	32,624	32,624	32,624	32,624

Note: Survey of Health, Ageing, and Retirement in Europe 2004-2006. All respondents were aged between 50 and 65 years. The dependent variables are the Z-score of the score obtained at the word recall test and the fluency test. Age and years of education are expressed in deviation from the sample mean. Robust standard errors are in parentheses. (*), (**), (***) mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively.

Appendix

Table A1: Normal retirement age in the US

Cohorts: Birth date	Normal age of retirement
Before 1/2/1938	65
1/2/1938 - 1/1/1939	65 and 2 months
1/2/1939 - 1/1/1940	65 and 4 months
1/2/1940 - 1/1/1941	65 and 6 months
1/2/1941 - 1/1/1942	65 and 8 months
1/2/1942 - 1/1/1943	65 and 10 months
1/2/1943 - 1/1/1955	66
1/2/1955 - 1/1/1956	66 and 2 months
1/2/1956 - 1/1/1957	66 and 4 months
1/2/1957 - 1/1/1958	66 and 6 months
1/2/1958 - 1/1/1959	66 and 8 months
1/2/1959 - 1/1/1960	66 and 10 months
1/2/1960 and later	67

Table A2: Eligibility age of (early) retirement.

	Men		Woman	
	Early retirement age	Normal retirement age	Early retirement age	Normal retirement age
Austria	61	65	56	60
Belgium	60	65	60	63
Czech Republic	59	62	56	59
Denmark	60	65	60	65
France	60	60	60	60
Germany	60	65	60	65
Greece	60	62	55	57
Italy	57	65	57	60
Netherlands	60	65	60	65
Poland	60	65	55	60
Spain	60	65	60	65
Sweden	61	65	61	65
Switzerland	63	65	62	63
United States	62	65	62	65

Source: Social Security Administration (2006). *Social Security Programs throughout the World: Europe*.

Table A3: Determinants of cognitive functioning at older age (50-75 year-old)

Dependent variable:	Memory score	
	OLS	FE model
	(i)	(ii)
Work and Retirement:		
Working	-	-
Retired for 0 to 4 years	-0.126***	-0.035**
	(0.013)	(0.014)
Retired for 5 to 9 years	-0.165***	-0.067***
	(0.016)	(0.020)
Retired for 10 years or more	-0.222***	-0.111***
	(0.020)	(0.028)
Age	-0.019***	-0.035***
	(0.001)	(0.002)
$(Age^2)/10$	-0.014***	-0.012***
	(0.001)	(0.001)
Single household	-0.031**	0.007
	(0.014)	(0.016)
High blood pressure	-0.049***	-0.016
	(0.011)	(0.016)
Heart-related disease	-0.040***	-0.051**
	(0.014)	(0.020)
Stroke	-0.241***	-0.219***
	(0.026)	(0.034)
Years of education	0.102***	-
	(0.002)	
(Years of education^2)/10	0.011***	-
	(0.003)	
Woman	0.390***	-
	(0.012)	
Ethnicity:		
Caucasian	-	-
African American	-0.383***	-
	(0.017)	
Other	-0.269***	-
	(0.028)	
Constant	0.035***	-
	(0.013)	
(Within-)R^2	0.225	0.047
Number of observations	56,882	56,882
Number of individuals	15,387	15,387

Note: Health and Retirement Study 1998-2008. All respondents were between 50 and 75 years of age. The dependent variable is the Z-score of the word recall test. Age and years of education are expressed in deviation from the sample mean. Robust standard errors are in parentheses. (*), (**), (***) mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively.

Table A4: Determinants of cognitive functioning at older age: IV-FE estimators (50-75 year-old)

Dependent variable:	Retired	Memory score	
	LPM	FE model	IV-FE model
	(i)	(ii)	(iii)
Work and Retirement:			
Working	-	-	-
Retired	-	-0.026*	-0.216**
		(0.014)	(0.109)
Instruments:			
Eligibility I (62+)	0.095***	-	-
	(0.007)		
Eligibility II (Normal retirement age+)	0.161***	-	-
	(0.009)		
Age	0.030***	-0.038***	-0.031***
	(0.001)	(0.001)	(0.004)
$(Age^2)/10$	-0.002***	-0.013***	-0.014***
	(0.000)	(0.001)	(0.001)
Single household	-0.015**	0.006	0.003
	(0.007)	(0.016)	(0.017)
High blood pressure	0.018**	-0.016	-0.012
	(0.008)	(0.016)	(0.016)
Heart-related disease	0.049***	-0.051**	-0.042**
	(0.010)	(0.020)	(0.021)
Stroke	0.093***	-0.220***	-0.203***
	(0.018)	(0.034)	(0.036)
Within-R^2	0.242	0.046	
Test of overidentifying restriction (*p*-value)			0.925
Durbin-Wu-Hausman test (*p*-value)			0.079
Number of observations	56,882		56,882
Number of individuals	15,387		15,387

Note: Health and Retirement Study 1998-2008. All respondents were between 50 and 75 years of age. The dependent variable is the Z-score of the word recall test. Robust standard errors are in parentheses. Age is expressed in deviation from the sample mean. (*), (**), (***) mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively.

Table A5: Determinants of cognitive functioning at older age: IV-FE estimator

Dependent variable:	Retired	Memory score
	LPM	IV-FE model
	(i)	(ii)
Work and Retirement:		
Working	-	-
Retired	-	-0.222***
		(0.085)
Instrument:		
Reaching the expected age of retirement	0.181***	-
	(0.006)	
Single household	-0.013	-0.002
	(0.009)	(0.021)
High blood pressure	0.016*	0.006
	(0.008)	(0.020)
Heart-related disease	0.068***	-0.042*
	(0.011)	(0.025)
Stroke	0.149***	-0.149***
	(0.019)	(0.052)
Age dummies	Yes	Yes
Within-R^2	0.381	0.034
Durbin-Wu-Hausman test (*p*-value)		0.029
Number of observations	29,076	29,076
Number of individuals	6,670	6,670

Note: Health and Retirement Study 1998-2008. All respondents were 50 years of age or older, were working during the first wave of interview and had reported their expected age of retirement. The dependent variable is the Z-score of the word recall test. Robust standard errors are in parentheses. (*), (**), (***) mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively.

Table A6: Determinants of cognitive functioning at older age: IV-FE estimator

Dependent variable:	Retired	Memory score
	LPM	IV-FE model
	(i)	(ii)
Work and Retirement:		
Working	-	-
Retired	-	-0.298***
		(0.110)
Instrument:		
Reaching the expected age of retirement	0.144***	-
	(0.009)	
Age	0.062***	-0.022**
	(0.001)	(0.009)
$(Age^2)/10$	0.017***	-0.005**
	(0.001)	(0.003)
Expected age of retirement x Age	-0.002***	-0.000
	(0.000)	(0.000)
Expected age of retirement x $(Age^2)/10$	0.000	0.000
	(0.000)	(0.000)
Single household	-0.015	-0.004
	(0.010)	(0.021)
High blood pressure	0.017	0.008
	(0.010)	(0.020)
Heart-related disease	0.065***	-0.037
	(0.014)	(0.026)
Stroke	0.149***	-0.130**
	(0.027)	(0.053)
Within-R^2	0.392	
Durbin-Wu-Hausman test (p-value)		0.017
Number of observations	29,076	29,076
Number of individuals	6,670	6,670

Note: Health and Retirement Study 1998-2008. All respondents were 50 years of age or older, were working during the first wave of interview and had reported their expected age of retirement. The dependent variable is the Z-score of the word recall test. Age is expressed in deviation from the sample mean. Robust standard errors are in parentheses. (*), (**), (***) mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively.

Table A7: Determinants of memory/fluency score at older age. IV estimator

	Retired	Memory score	
	LPM	OLS	IV
	(i)	(ii)	(iii)
Work and Retirement:			
Working	-	-	-
Retired	-	-0.152***	-0.274***
		(0.011)	(0.045)
Instrument:			
Country/gender-specific employment rate by age	-1.000***	-	-
	(0.020)		
Age	-0.003***	-0.007***	-0.002
	(0.001)	(0.001)	(0.002)
$(Age^2)/10$	-0.002	0.000	0.002
	(0.001)	(0.003)	(0.003)
Single household	0.010	-0.100***	-0.099***
	(0.007)	(0.014)	(0.014)
High blood pressure	0.025***	-0.052***	-0.049***
	(0.005)	(0.010)	(0.010)
Heart-related disease	0.116***	-0.067***	-0.053***
	(0.008)	(0.017)	(0.018)
Stroke	0.201***	-0.308***	-0.284***
	(0.014)	(0.033)	(0.034)
Years of education	-0.020***	0.070***	0.068***
	(0.001)	(0.001)	(0.002)
Years of $education^2/10$	-0.007***	-0.006***	-0.007***
	(0.001)	(0.002)	(0.002)
Woman	-0.011*	0.297***	0.316***
	(0.006)	(0.010)	(0.012)
Second time interview	-0.018***	0.126***	0.124***
	(0.004)	(0.010)	(0.010)
Constant	0.985***	0.088***	0.150***
	(0.014)	(0.031)	(0.038)
Country fixed effects	Yes	Yes	Yes
Durbin-Wu-Hausman test (*p*-value)			0.005
R^2	0.327	0.210	
Number of observations	40,744	40,744	40,744

Note: Survey of Health, Ageing, and Retirement in Europe 2004-2006 and Health and Retirement Study 2004. All respondents were aged between 50 and 65 years. The dependent variables are the Z-score of the score obtained at the word recall test. Age and years of education are expressed in deviation from the sample mean. Robust standard errors are in parentheses. (*), (**), (***) mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively.

Table A8: Determinants of memory/fluency score at older age. IV estimator

	Retired	Memory score		Fluency score	
	LPM	OLS	IV	OLS	IV
	(i)	(ii)	(iii)	(iv)	(v)
Retired	-	-0.136***	-0.284***	-0.144***	-0.128**
		(0.013)	(0.060)	(0.013)	(0.058)
Instrument:					
Country/gender-specific employment rate by age	-0.988***	-	-	-	-
	(0.027)				
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Age and age square interacted with country dummies	Yes	Yes	Yes	Yes	Yes
Durbin-Wu-Hausman test (*p*-value)			0.009		0.795
R^2	0.359	0.193		0.259	
Number of observations	32,624	32,624	32,624	32,624	32,624

Note: Survey of Health, Ageing, and Retirement in Europe 2004-2006. All respondents were aged between 50 and 65 years. The dependent variables are the Z-score of the score obtained at the word recall test and the fluency test. The model also includes the control variables used in Table 5 with interaction terms between age, age squared and country dummies. Age and years of education are expressed in deviation from the country-specific mean. Robust standard errors are in parentheses. (*), (**), (***) mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively.

Table A9: Determinants of memory/fluency score at older age. IV estimator

	Memory score		Fluency score	
	OLS	IV	OLS	IV
	(ii)	(iii)	(iv)	(v)
Work and Retirement:				
Working	-	-	-	-
Retired	-0.133***	-0.201***	-0.148***	-0.215***
	(0.013)	(0.072)	(0.013)	(0.071)
Age	-0.012***	-0.009**	-0.005***	-0.001
	(0.001)	(0.004)	(0.001)	(0.003)
$(Age^2)/10$	0.005	0.006*	0.006**	0.007**
	(0.003)	(0.003)	(0.003)	(0.003)
Single household	-0.108***	-0.107***	-0.069***	-0.069***
	(0.016)	(0.016)	(0.016)	(0.016)
High blood pressure	-0.030**	-0.029**	-0.026**	-0.025**
	(0.012)	(0.012)	(0.012)	(0.012)
Heart-related disease	-0.082***	-0.075***	-0.076***	-0.069***
	(0.021)	(0.023)	(0.019)	(0.021)
Stroke	-0.290***	-0.278***	-0.254***	-0.242***
	(0.041)	(0.043)	(0.037)	(0.039)
Years of education	0.284***	0.296***	0.047***	0.059***
	(0.011)	(0.017)	(0.011)	(0.017)
Years of $education^2/10$	0.064***	0.063***	0.062***	0.061***
	(0.002)	(0.002)	(0.001)	(0.002)
Woman	-0.011***	-0.011***	-0.005**	-0.005**
	(0.002)	(0.002)	(0.002)	(0.002)
Second time interview	0.137***	0.135***	0.064***	0.062***
	(0.010)	(0.010)	(0.010)	(0.010)
Constant	0.137***	0.171***	0.446***	0.479***
	(0.032)	(0.048)	(0.032)	(0.048)
Country fixed effects	Yes	Yes	Yes	Yes
Durbin-Wu-Hausman test (*p*-value)		0.388		0.409
F-statistic (excluded instruments)		23.74		23.74
Partial-R^2 of excluded instruments		0.028		0.028
R^2	0.192	0.191	0.258	0.257
Number of observations	32,641	32,641	32,641	32,641

Note: Survey of Health, Ageing, and Retirement in Europe 2004-2006. All respondents were aged between 50 and 65 years. The dependent variables are the Z-score of the score obtained at the word recall test and the fluency test. The excluded instruments are the age eligibility thresholds dummies interacted with country and gender dummies (50 instruments). Age and years of education are expressed in deviation from the sample mean. Robust standard errors are in parentheses. (*), (**), (***) mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively.