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Does retirement affect cognitive functioning?

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ABSTRACT

This paper analyses the effect of retirement on cognitive functioning using a longitudinal survey among older Americans, which allows controlling for individual heterogeneity and endogeneity of the retirement decision by using the eligibility age for social security as an instrument. The results highlight a significant negative effect of retirement on cognitive functioning. Our findings suggest that reforms aimed at promoting labour force participation at an older age may not only ensure the sustainability of social security systems but may also create positive health externalities for older individuals.
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1. Introduction

In most developed countries, the proportion of older individuals has substantially increased over the last few decades. This demographic shift has increased the focus on health in ageing. At the same time, increased life expectancy combined with a decline in average retirement age has 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 period 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).

In a recent study using cross-sectional data from the United States and Europe,[1] Adam et al. (2007a) found that retirees attained lower cognitive functioning than working individuals. Furthermore, using a stochastic frontier methodology, the authors showed that the longer the retirement period, the lower the cognitive test score, and this suggests an acceleration of cognitive decline during retirement. However, the difference observed between 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 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.

Based on the descriptive evidence from Adam et al. (2007a), Coe and Zamarro (2011), Mazzonna and Peracchi (2010), and Rohwedder and Willis (2010) have also investigated the relationship between retirement and cognitive functioning. In order to address potential endogeneity bias, they used cross-national data[2] and the differences in the legal age of retirement across countries as

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

[2] Coe and Zamarro (2011) use the first wave of SHARE and Mazzonna and Peracchi (2010) the first two waves of SHARE. Rohwedder and Willis (2010) complement SHARE data with comparable data from the ELSA and the HRS.

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instruments for the retirement decision. The results were mixed: while Rohwedder and Willis (2010), and Mazzonna and Peracchi (2010) found a significant and quantitatively important negative effect of retirement on cognitive functioning,[3] Coe and Zamarro (2011) did not find a significant effect.

Although using cross-country differences in the eligibility age for retirement benefits as instruments can provide a powerful empirical strategy in order to identify the causal effect of retirement, it is not without its limitations. Individuals from different countries face different institutional settings, constraints and cultural differences beyond retirement schemes. This heterogeneity is likely to partly shape the level and the age-related profile of cognitive functioning, and to be correlated with the institutional settings of retirement schemes. For instance, there is a clear North-South gradient for many health outcomes beyond cognitive test scores, with Northern countries usually performing better than Southern countries (Börsch-Supan et al., 2005). At the same time, eligibility age for retirement tends to be higher in Northern than in Southern European countries. It is unlikely that the cross-country differences in retirement rules fully explain this pattern across European countries. Those differences might thus invalidate the exclusion restrictions and result in an over-estimation of the effect of retirement on cognitive functioning.

In this paper we estimate the causal impact of retirement on cognitive functioning using panel data from the Health and Retirement Study (HRS), a longitudinal survey among individuals aged 50+ living in the United States. These data allow us to control for individual heterogeneity and to circumvent the issue of the endogenous retirement decision by using the eligibility age for social security as an instrument. The panel dimension of the data allows us to control for time-invariant heterogeneity, such as the cohort effect, and thus strengthens the validity of the conditional independence and exclusion restrictions underlying instrumental variable (IV) estimation. Moreover, contrary to the previous studies investigating the effect of retirement on cognitive functioning, our analysis focuses on data from a single country with individuals facing basically the same institutional settings and constraints. Furthermore, we find suggestive evidence that the effect of retirement on cognitive functioning is not instantaneous, but appears with a lag.

The paper is organised as follows. Section 2 presents a review of the neuropsychological literature regarding cognitive ageing and the relationship between activities and cognitive functioning. Section 3 describes the econometric approach used to address the empirical issues and Section 4 presents the data and our measure of cognitive functioning, used in the empirical model. Section 5 details the results from the empirical analysis. Finally, Section 6 concludes and draws out implications from the analysis.

2. Cognitive ageing and the relationship between activity and cognitive functioning

Older individuals face many challenges associated with physical and mental deterioration. Among these, the age-related decline in some important components of cognitive functioning, i.e. fluid abilities,[4] has been well documented: a large amount of evidence suggests that ageing is associated with a decline in the ability to perform several cognitive tasks (Dixon et al., 2004; Schaie, 1994). More particularly, ageing has a salient effect on episodic memory tasks[5] (Petersen et al., 1992; Small, 2001), episodic memory deficits being also largely considered as a hallmark symptom of Alzheimer's disease (Adam et al., 2007b; Dubois et al., 2007).

However, this decline in fluid abilities 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, 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 means 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 a direct relationship between the severity of the factor that disrupts performance (such as the degree of brain modification 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 are thus less susceptible to disruption in their cognitive functioning. Individual heterogeneity may stem from innate or genetic differences, or from different life experiences, such as occupational attainment or leisure activities.

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 (Capurso 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/her 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, mainly in the field of active ageing policies promoting participation (WHO, 2002), to affect the pattern of cognitive ageing.

However, the way the causality runs between activities and the brain remains an open question in neuropsychology. Do activities improve cognitive functioning or are brighter people more often engaged in cognitively demanding activities? While there is some kind of consensus regarding the effect of cognitive functioning on activities,[6] the effect of activities on cognitive functioning is more open to debate. One argument favouring this latter 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,

[3] Rohwedder and Willis's (2010) results suggest that retirement causes a drop close to 40% in average cognitive score.

[4] Fluid abilities include skills such as processing speed, working memory, and long-term memory. It is worth noting that other aspects of cognitive functioning, known as crystallised abilities (such as verbal abilities or knowledge), have been shown to remain stable, or even to improve with age (Dixon et al., 2004; Park et al., 2002; Schaie, 1994).

[5] 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. a previous holiday).

[6] Several studies have shown that cognitive impairment is associated with an increase in limitations on activities of daily living (Agüero-Torres et al., 1998; Bennett et al., 2002; Moritz et al., 1995).

Winocur (1998) showed that these brain modifications affect the cognitive abilities of older rats. A second argument in favour of the causal effect of activities on cognitive functioning can also be found in studies such as that of Maguire et al. (2000), which showed that taxi drivers in London, who had developed an intensive knowledge of orientation in the city, had a significantly larger posterior hippocampi than control subjects, and above all, that the amount of occupational experience was correlated with the size of the hippocampus. Those studies suggest therefore that activities have a direct effect on cognitive functioning.

The aim of our study is to address the causal impact of lifestyle on the 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.

3. Empirical strategy

The aim of the empirical analysis is to test the hypothesis that retirement affects cognitive functioning. In our model, we assume that cognitive functioning (c_{it}), as measured by the score obtained at a cognitive test (described below), depends on retirement status (r_{it}) and a smooth function of age ($f(age_{it})$), along with an error term that can be decomposed into unobserved time-invariant heterogeneity (μ_i) and an idiosyncratic error term (ν_i). Assuming linear separability, cognitive functioning is given by the following equation:

$$C_{it} = r_{it}\beta + f(age_{it}) + \mu_i + \nu_{it}, \quad (1)$$

Identification of the causal effect of retirement on cognitive functioning requires the error term to be mean independent of retirement, age, and the unobserved time-invariant heterogeneity. This requirement is unlikely to hold: first, retirement and cognitive functioning may be endogenous: decreasing cognitive functioning may induce retirement. Second, individual heterogeneity may be correlated with both the retirement decision and cognitive functioning.

The fixed effects (FE) estimator allows measurement of the parameters of interest, controlling for time-invariant individual heterogeneity. The effect of retirement on cognitive functioning (β) will be consistently estimated unless ν_{it} is correlated to the retirement decision. This requirement is unlikely to hold if, for example, retirement is induced by a negative health shock that is also correlated to cognitive functioning. Furthermore, the FE estimates are also susceptible to attenuation bias from measurement error in the retirement variable (Griliches and Hausman, 1986). We deal with those two issues by using IV methods. To be valid, the instruments must be related to the retirement decision and correlated to cognitive functioning only through the effect of retirement. Large spikes in the retirement hazard at ages 62 and 65 have been well noted in the literature, and financial incentives induced by social security have been found to play a significant role in explaining such spikes, especially at age 62 (Burtless and Moffitt, 1984; Peracchi and Welch, 1994; Ruhm, 1995; Gruber and Wise, 1999; Coile and Gruber, 2001). 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 and where the financial incentives to retire are the strongest, 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 on January 2, 1938, and later. Note however that most of individuals in our analytical sample are still facing the normal age of retirement set at age 65 or had not yet reached the normal age of retirement during the sample period. Our identification strategy thus does not heavily rely on the change in the retirement age across cohorts but on the discontinuity in the proportion of retired people at the eligibility age for social security benefits and the normal age of retirement, conditional on a smooth function of age. The instrumental variables are thus computed as two dummy variables equal to 1 if the individual reaches either the corresponding age-thresholds 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 effect on cognitive functioning, except through retirement.

Identifying the causal effect of retirement on cognitive functioning involves another issue: the effect of changes in lifestyle on cognitive functioning may not be immediate.[7] Indeed, it is unlikely that retirement has an instantaneous impact on cognitive functioning. We might expect that the effect of a changing environment would occur with a lag. Cognitive functioning should therefore be modelled, not as a function of current environmental variables, but with a lag. As a result, the cognitive functioning equation should include as an endogenous variable a dummy for being retired for at least one year, and the instruments should then become threshold dummies for reaching 63 years and the normal age of retirement *plus one*. The empirical strategy consists first of estimating Eq. (1) using the two-stage least squares FE estimator with these age threshold dummies as instruments for being retired for at least one year.

There are at least two explanations as to why we should expect the effect of retirement not to be instantaneous. First, we might expect that the changes in activities would translate only progressively into changes in cognitive functioning. A second potential explanation comes from the gerontological literature that describes the different phases of retirement. Atchley (1976, 1982) has suggested that retirees may experience a "honeymoon phase" following retirement, which is characterised by a period in which the individual engages in different activities that he/she has put off for years because of work-related constraints. This engagement in desired activities may attenuate the negative effect of retirement on cognition.[8]

Moreover, the effect of retirement on cognitive functioning may also be a cumulative process where the effect of being retired would also depend on the exposure to retirement, i.e. the period of time since the individual retired.[9] This last point is crucial in terms of the consequences of retirement reforms aimed at increasing the age of retirement. If retirement simply has a constant effect on cognitive functioning, we would not expect an increase in retirement age to have much impact on the dependency of the elderly because of cognitive impairment at older age. If, however, the impact is cumulative, then an increase in the age of retirement may result in an

[7] This possibility has also been stressed by Rohwedder and Willis (2010).

[8] This phase has, to some extent, been verified empirically (e.g. George and Maddox, 1977; Ekerdt et al., 1985; Gall et al., 1997).

[9] There are some descriptive evidence for such a cumulative effect (Adam et al., 2007a). Mazzonna and Peracchi (2010) also take into account retirement duration in their model.

improvement in cognitive functioning later in life. So, an increase in the age of retirement would probably delay the appearance of cognitive impairment at older age, and thus decrease long-term care expenditures.

4. Data

4.1. The Health and Retirement Study

Our empirical analysis uses six waves (1998–2008) from the Health and Retirement Study (HRS).[10] The HRS has been following a sample of Americans born between 1931 and 1941 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 carried out by telephone, although exceptions were made when the individual had health limitations or when the household had no telephone. The data contain a wide range of information about mental and physical health, employment status, financial situation, the family, and activities of the respondents.

In our study, we restricted the sample to respondents aged between 51 and 75 (82,462 observations). We excluded proxy interviews from the analysis, as the memory test was not performed by those individuals (5807 observations). Where information regarding the working status of participants was missing from the HRS data (101 observations) or where respondents reported never having worked (2473 observations), these individuals were also dropped from the analytical sample. Moreover, all individuals who reported returning to work during the sampling period were dropped from the study (11,240 observations).[11] Including those individuals in the sample would require the assumption that the effect on cognitive functioning of leaving the labour force or going back into the labour force would be symmetric. Moreover, we could argue that individuals going back to work are more likely to remain active in the labour market (e.g. looking for a job) during their non-working period. We also excluded from the analysis individuals for whom the information regarding the year they left their last job was missing (3575 observations). In addition, we excluded from the sample individuals who reported having left their last job before the age of 50 (4334 observations). Individuals with a missing cognitive score were dropped from the sample (555 observations). The final sample corresponded to an unbalanced panel including 54,377 observations for 14,710 individuals.

4.2. The measure of cognitive functioning

The HRS contains measures of cognitive functioning based on simple tests. Our 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 analysing this particular cognitive domain is twofold: first, this cognitive aspect is particularly affected by ageing; some studies even argue that this cognitive function is among the first to decline with ageing (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), and it 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.[12] 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. Following this, 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 10.6 and a standard deviation of 3.4.

4.3. 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/she is definitively out of the labour force with the intention of staying out permanently. Akin to Coe and Zamarro (2011), Mazzonna and Peracchi (2010), and Rohwedder and Willis (2010), an individual is defined as "Working" if he/she claims to be currently working for pay and "Retired" if he/she reports not working.[13] HRS also includes information about the year and the month the individual's last job ended, and we use this to measure retirement duration and the dummy variable reporting whether the individual has been retired for at least one year.

5. Results

5.1. Main results

Before turning to the IV estimation, we will first describe retirement behaviour and the profile of cognitive functioning around the key age of retirement in the United States. Fig. 1 presents the estimated cognitive test scores by age from 55 to 70 years, controlling for individual 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. Fig. 2 presents the estimated retirement probability changes (Fig. 2a) and cognitive test score changes (Fig. 2b) as individuals become one year older between the ages of 55 and 70, controlling for individual fixed effects.[14] As expected, we observe

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

[11] We assess the sensitivity of our results to the inclusion of those individuals in the sample in Section 5.4.3.

[12] Note that, in practice, the HRS 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 evidence of such a learning effect with the first two waves of the HRS, where individuals were asked to recall the same list of words.

[13] In our sample, the vast majority of non-working individuals report being retired (86.3%). 8.2% report being out of the labour force, 3.9% report being disabled, 0.8% report being unemployed, and 0.8% report being partly retired (although they report not working for pay). Thus strictly speaking, our study analyses the effect of not working for pay at older ages.

[14] More specifically, we estimate the following model: $y_{it} = \alpha_i + \sum_{a=56}^{70} \gamma_a d_{it}^a + \eta_{it}$, where y_{it} is either the retirement dummy, or the cognitive test score, $d_{it}^a = 1[age_{it} \geq a]$, α_i is the individual fixed effect, and η_{it} is the error term. Fig. 2 reports the estimates of the parameters γ_a with 95%-confidence intervals.

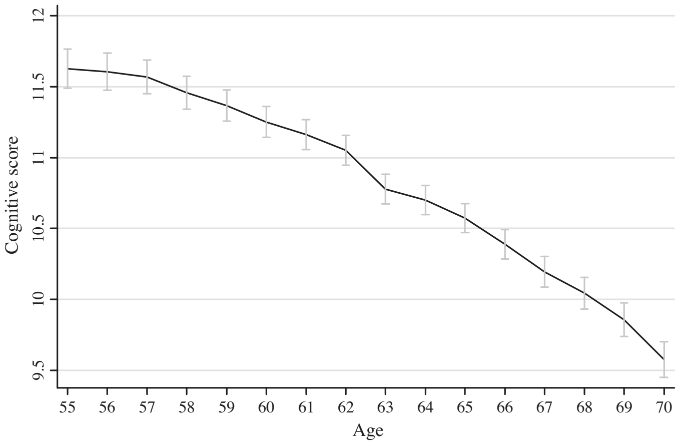

Fig. 1. Age profile of cognitive test score. *Note*: Health and Retirement Study 1998–2008. The estimates are based on a fixed-effect model including age dummies as explanatory variables.

a significant increase in the probability of retiring at age 62. We also observe a small increase in the probability of retiring at age 65 and 66, the age at which full social security benefits can be claimed (depending on the cohort), but this increase is far less important than for age 62. Strikingly, Fig. 2b highlights a significant drop in cognitive scores from age 62 to 63. We also observe a significant drop at age 66 and 67, but these drops are much lower in magnitude. There is no biological reason for changes in the process of cognitive decline at those particular ages. Ageing 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. These figures suggests however that there is a significant decrease in cognitive functioning after reaching the minimum age of eligibility for receiving social security benefits, which also corresponds to the peak age of retirement in the United States, as shown in Fig. 2a. This first descriptive result supports our hypothesis that retirement is accompanied by a decline in cognitive functioning and that this decline is not likely to occur immediately at the time of retirement.

In light of those previous results, we consider an FE-IV estimator where the endogenous variable is a dummy that is equal to one when the individual has been retired for at least one year. As a consequence, we use as instruments age-threshold dummy variables for reaching the minimum age for being eligible for social security benefits plus one (63 years) and the normal retirement age plus one (normal retirement age depending on the cohort considered). The FE-IV estimator uses only the dummy for being retired for at least one year as an endogenous variable and thus does not take into account retirement duration. So the coefficient related to the retirement variable in the FE-IV model has to be interpreted as the average short term effect of retirement on cognitive functioning, which roughly corresponds in our sample to a within average effect of about 5 years post retirement. Second-order polynomials of age are included as controls in order to account for the "normal" cognitive ageing process. The effect of age is assumed to be quadratic, allowing cognitive functioning to decline at an increasing rate with ageing. The next section will discuss the sensitivity of our results to different functional forms for the age trend.

Table 1 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 probability of being retired (for at least one year) are displayed in column (i). The instruments, i.e. the eligibility ages (plus one) for social security, have large and highly significant effects on the probability of being retired for at least one year. This probability increases by about 10.8 percentage points at age 63 and by 6.8 points when being strictly older than the normal retirement age. The *F*-test of joint significance of the instruments proposed by Bound et al. (1995) confirms that the instruments are significant predictors of retirement ($F(2, 12{,}361) = 193.05$). The Sargan–Hansen test of overidentifying restriction does not reject the hypothesis that our instruments are valid. Column (iii) presents the coefficient estimates of the reduced-form regression that includes

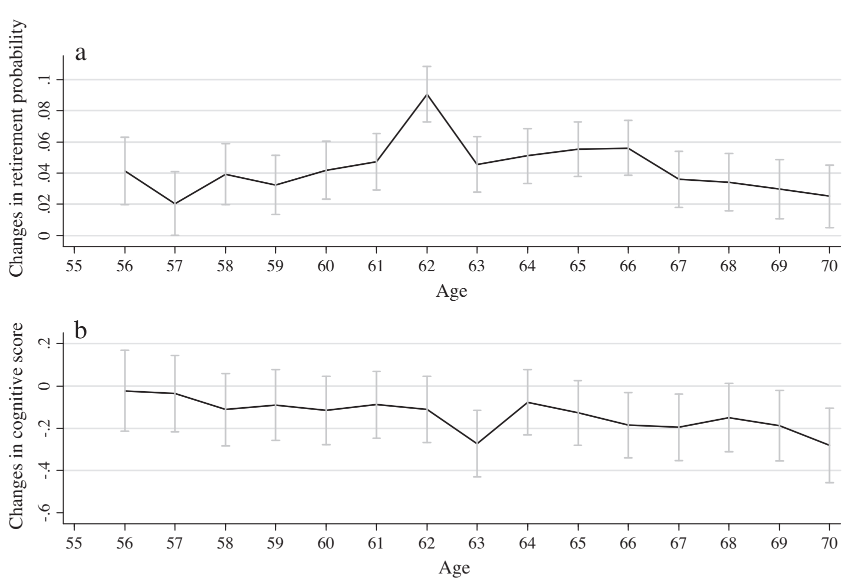

Fig. 2. Changes in retirement probability and changes in cognitive test scores by age. *Note*: Health and Retirement Study 1998–2008. All respondents were aged between 55 and 70. The figures show the coefficient estimates and the corresponding 95%-confidence interval (vertical grey lines) from the following model: $y_{it} = \alpha_i + \sum_{a=56}^{70} \gamma_a d_{it}^a + \eta_{it}$, where y_{it} is either the retirement dummy, or the cognitive test score, $d_{it}^a = 1[age_{it} \geq a]$, α_i is the individual fixed effect, and η_{it} is the error term. The figures report the estimates of the parameters γ_a with 95%-confidence intervals.

Table 1
Cognitive functioning and retirement. FE-IV estimates.

	Retired for at least one year	Cognitive score		
	First stage (i)	FE (ii)	Reduced form (iii)	IV (iv)
Retired for at least one year	–	−0.148***	–	−0.942***
		(0.049)		(0.339)
Instruments				
>62 years old	0.108***	–	−0.100**	–
	(0.007)		(0.044)	
>Normal age of retirement	0.068***	–	−0.067	–
	(0.006)		(0.046)	
Controls				
Age	0.021***	0.457***	0.458***	0.478***
	(0.006)	(0.045)	(0.047)	(0.046)
Age^2	0.001	−0.047***	−0.046***	−0.046***
	(0.000)	(0.004)	(0.004)	(0.004)
Test of overidentifying restriction (p-value)				0.944
Durbin–Wu–Hausman test (p-value)				0.017
Within-R^2	0.242	0.045	0.045	–
N	54,377	54,377	54,377	54,377

Note: Health and Retirement Study 1998–2008. All respondents were aged between 51 and 75. Robust standard errors are in parentheses.
* Mean that the coefficient estimate is significantly different from zero at the 10% level.
** Mean that the coefficient estimate is significantly different from zero at the 5% level.
*** Mean that the coefficient estimate is significantly different from zero at the 1% level.

only the second-order polynomial in age and the instruments as explanatory variables. The coefficients related to the age thresholds suggest that there is a drop at those specific ages, especially at age 63, in accordance with the results presented in Fig. 2b. More interestingly, the relative difference in the coefficient estimates between the two instruments in the first-stage equation is about the same as the relative difference observed in the reduced-form equation.

The effect on memory score of being retired for one year or more is negative and highly significant (see column (iv)). This suggests that individuals retiring experience a drop in cognitive test score by about 1 point (coefficient estimate: −0.942; 95%-confidence interval −1.61 to −0.28). This corresponds to about a 10% decrease in cognitive score (compared to the sample average score).[15] The estimate is larger than in the model that assumes exogeneity of retirement (see column (ii)). The Durbin–Wu–Hausman test rejects the null hypothesis of exogeneity of retirement at the 5%-level. This might be explained by several reasons: First, the presence of measurement errors in the retirement variables are likely to bias downward the within estimates. Furthermore, the effect of retirement on cognitive functioning is likely to be heterogeneous. As a result, the IV estimates identify a Local Average Treatment Effect (Imbens and Angrist, 1994): the effect of retirement for those who effectively retire at those specific ages. By contrast, the FE estimator estimates the average effect of being retired for all those who have retired during the sample period. One potential explanation for the difference between the FE estimator and the FE-IV estimator is that the FE estimator also takes into account the effect of retirement for individuals who had been working for a few hours per week, or had already been partially retired. For those individuals, we might expect that the effect of this transition on cognitive functioning might be much lower than for full-time workers who retire more "sharply". This sharper change in work intensity is also more likely to occur at those specific eligibility ages, especially at the minimum age for being eligible for social security benefits as many workers had been "constrained" to wait for this age before being able to afford to retire. As an illustration, we compared the average number of hours worked by individuals who retired at those specific ages to those who retired at another age during the sampling period. Controlling for a linear age trend, we found that those who retired at those specific ages were working, on average, about 2 h more than individuals who retired at another age. Finally, it should be noted that this identified local average effect is of particular interest for policy makers as it corresponds to the effect of retirement on cognitive functioning induced by the eligibility age for retirement, which is the main tool used by many countries to increase labour force participation of older workers.

5.2. Functional form for the age trend

Our identification strategy is based on age-related instruments and it may therefore depend on the functional form adopted to control for the "normal" cognitive ageing process. In this section, we test the robustness of our results by testing four different functional forms for age. We adopt four specifications for age trend: linear, quadratic, cubic, and quartic. The results from the FE-IV estimators are presented in Table 2. From this table, we see that the coefficient estimates of being retired for at least one year are quite insensitive to the functional form adopted, although the standard errors increase substantially once we use the cubic and quartic functional form for age. The model with the linear specification is the only one to fail to pass the overidentification test, suggesting misspecification. This confirms the importance of taking into account the fact that cognitive decline due to ageing tends to be faster at older age. Note also that for the cubic and quartic specification, none of the coefficent estimates related to the polynomials in age are significant. These results suggest that the quadratic specification is satisfactory for capturing non linearity in age.

[15] We have also estimated the model for men and women separately and found no significant difference in the effect of retirement between men and women. Note however that the coefficient estimate is larger for men (coefficient estimate: −1.210; standard error: 0.437) than for women (coefficient estimate: −0.726; standard error: 0.514), the latter being not significantly different from zero. Under other model specifications the coefficient estimate for women is negative and significantly different from zero but the effect more salient for men. A potential explanation of this would be that the transition between professional activity and retirement is steeper for men compare to women: men being more work-centered than women, while family centrality is higher among women than among men (Mannheim, 1993; Sharabi and Harpaz, 2011). This interpretation remains however speculative and open for further research.

Table 2
Cognitive functioning and retirement. FE-IV estimates. Tests for different functional forms for age.

	Cognitive score			
	(i)	(ii)	(iii)	(iv)
Retired for at least one year	−1.121***	−0.942***	−0.960	−0.924
	(0.340)	(0.339)	(0.671)	(0.680)
Age	−0.096***	0.478***	0.437	−3.217
	(0.014)	(0.046)	(1.111)	(6.782)
$Age^2/10$	–	−0.046***	−0.039	0.842
		(0.004)	(0.180)	(1.631)
$Age^3/100$	–	–	−0.000	−0.094
			(0.009)	(0.174)
$Age^4/1000$	–	–	–	0.004
				(0.007)
Test of overidentifying restriction (*p*-value)	0.000	0.944	0.941	0.830
Durbin–Wu–Hausman test (*p*-value)	0.004	0.017	0.216	0.241
N	54,377	54,377	54,377	54,377

Note: Health and Retirement Study 1998–2008. All respondents were aged between 51 and 75. Robust standard errors are in parentheses.
* Mean that the coefficient estimate is significantly different from zero at the 10% level.
** Mean that the coefficient estimate is significantly different from zero at the 5% level.
*** Mean that the coefficient estimate is significantly different from zero at the 1% level.

5.3. Cognitive functioning and retirement duration

The analysis until now has modelled the effect of retirement as a discrete change in cognitive functioning occurring with a lag. However, the length of exposure to retirement may also affect cognitive functioning. In other words, retirement may have a cumulative effect and this would imply that cognitive functioning depends not only on the status of working/being retired but also on the length of the retirement period. This possibility has also been raised by Adam et al. (2007a) and Mazzonna and Peracchi (2010). We thus reformulate our IV approach by taking retirement duration as endogenous variable and test two specifications where the effect of retirement duration is either assumed to be linear or logarithmic[16] and using as instruments the time period since the individual reached the age of 62 years and the time period since the individual reached the normal age of retirement, either in linear or logarithmic specification.

Tables 3 and 4 presents the results of the model using the linear and logarithmic specification, respectively. The coefficient estimate of retirement duration for the logarithmic specification is negative and significant at the 5%-level and supports the hypothesis that retirement duration may also play a role in the evolution of cognitive decline at older age. Regarding the linear specification, the IV estimate of the coefficient related to retirement duration is not significant, suggesting that the data do not fit with the linear specification.

As an illustration, we compute the predicted cognitive test score using our estimates from column (iii) in Table 3 for two hypothetical individuals: one individual retiring at 62 years old and the other one retiring at 65 years old. Fig. 3 illustrates the evolution of cognitive functioning for those two individuals. It shows that most of the drop in cognitive functioning occurs at the beginning of retirement, as a result of the logarithmic specification. It thus suggests that the difference in cognitive functioning between the early and the late retirees is likely to be relatively small at later stage of the retirement period. These results thus support our previous findings that most of the drop in cognitive functioning due to retirement occurs at the beginning of the retirement period and tends to stabilise afterwards.

5.4. Robustness checks

5.4.1. The delayed effect of retirement on cognitive functioning

As suggested by Figs. 1 and 2, our main empirical analysis assumes that the retirement effect on cognitive functioning is likely to occur with a delay, either because the environmental changes do not affect instantaneously cognitive functioning, or because the “honeymoon” effect of retirement may attenuate the negative effect of retirement. Our model thus assumes that cognitive functioning remains stable for individuals retired within the year (i.e. it assumes that cognitive functioning of newly retired individuals is the same as for workers). It is however possible that the honeymoon effect provides an instant positive boost to cognitive functioning, perhaps by an immediate reduction in job stress, that would increase the level of cognitive functioning above the level of the workers. This potential effect may have consequences for our identification strategy as the control group for those retired for more than one year is not only workers but actually a weighted average of workers and recently retired individuals. In the extreme case, the negative and significant effect of being retired for more than one year found in our model may simply be a return to the pre-retirement levels and not a reduction relative to working. In order to test for this potential bias, we re-estimated our model and

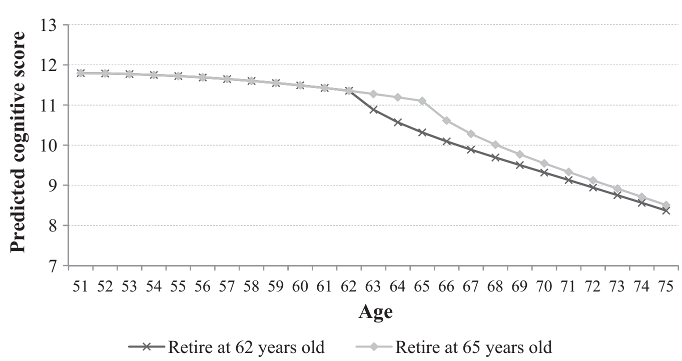

Fig. 3. Predicted age profile of cognitive functioning. *Note*: This figure illustrates the effect of retirement on cognitive functioning of two hypothetical individuals who only differ with respect to their retirement age. The age profiles are based on the coefficient estimates reported in column (iii) of Table 3.

[16] Note that, in order to take into account the differing effect of retirement on cognitive functioning, we set the logarithm of retirement duration to zero for individuals who were still working or who had been retired within the year. Note also that one unity has been added to retirement duration (and the time period since the individual reached the age of 62 years/ the normal age of retirement) before transforming it to log.

Table 3
Cognitive functioning and retirement duration (logarithmic specification). FE-IV estimates.

	Log(retirement duration + 1)	Cognitive score		
	First stage (i)	FE (ii)	Reduced form (iii)	IV (iv)
Log(retirement duration + 1)	–	−0.138*** (0.036)	–	−0.567** (0.238)
Instruments				
Log(years since age 62 + 1)	0.135*** (0.009)	–	−0.072* (0.039)	–
Log(years since normal age of retirement + 1)	0.090*** (0.010)	–	−0.059 (0.047)	–
Controls				
Age	−0.118*** (0.012)	0.418*** (0.046)	0.370*** (0.063)	0.309*** (0.076)
Age^2	0.015*** (0.001)	−0.043*** (0.004)	−0.039*** (0.005)	−0.031*** (0.008)
Test of overidentifying restriction (*p*-value)				0.845
Durbin–Wu–Hausman test (*p*-value)				0.068
Within-R^2	0.523	0.045	0.045	–
N	54,377	54,377	54,377	54,377

Note: Health and Retirement Study 1998–2008. All respondents were aged between 51 and 75. Robust standard errors are in parentheses.
* Mean that the coefficient estimate is significantly different from zero at the 10% level.
** Mean that the coefficient estimate is significantly different from zero at the 5% level.
*** Mean that the coefficient estimate is significantly different from zero at the 1% level.

Table 4
Cognitive functioning and retirement duration (linear specification). FE-IV estimates.

	Retirement duration	Cognitive score	
	First stage (i)	Reduced form (ii)	IV (iii)
Retirement duration	–	–	−0.072 (0.127)
Instruments			
Years since age 62	0.120*** (0.020)	−0.027 (0.023)	–
Years since normal age of retirement	0.120*** (0.019)	0.006 (0.021)	–
Controls			
Age	−1.333*** (0.098)	0.367*** (0.137)	0.284 (0.302)
Age^2	0.132*** (0.009)	−0.039*** (0.012)	−0.031 (0.028)
Test of overidentifying restriction (*p*-value)			0.308
Durbin–Wu–Hausman test (*p*-value)			0.729
Within-R^2	0.636	0.045	
N	54,377	54,377	54,377

Note: Health and Retirement Study 1998–2008. All respondents were aged between 51 and 75. Robust standard errors are in parentheses.
* Mean that the coefficient estimate is significantly different from zero at the 10% level.
** Mean that the coefficient estimate is significantly different from zero at the 5% level.
*** Mean that the coefficient estimate is significantly different from zero at the 1% level.

included as additional endogenous variable a dummy variable that is equal to one if the individual is retired for less than one year and zero otherwise. The related instruments are one dummy variable for being 62 year-old, and a dummy variable for being aged the age of eligibility for full retirement benefits. Given this new specification, the control group only includes working individuals, the dummy for being retired within the year captures the immediate effect of retirement on cognitive functioning, and the dummy for being retired for more than one year captures the average short-term effect of retirement, the main variable of interest. Table 5 presents the results. The coefficient estimate of the dummy variable for being retired within one year is positive but with large standard error precluding any interpretation.[17] More importantly, the coefficient estimate for being retired for more than one year remains negative and significant, and close to our main results, although slightly lower in magnitude. This result supports our hypothesis that retirement has a negative effect on cognitive functioning and that this effect is unlikely to be instantaneous.[18]

Another robustness check consists in assessing the sensitivity of our results to the choice of the delay between retirement and its impact on cognitive functioning. Fig. 4 presents the coefficient estimate of the effect of retirement on cognitive functioning using different delay period from 0 months (instantaneous effect)

[17] We have also tested this specification for the model that uses the logarithm of retirement duration instead of the dummy for being retired for more than one year and found similar results as those presented in Table 3. Those results are available upon request.

[18] This provides a potential explanation for the impreciseness of Coe and Zamarro's (2011) IV estimate of the effect of retirement on cognitive functioning obtained by applying a regression discontinuity design where the threshold points are set, at the country level, at the early and statutory retirement age.

Table 5
Cognitive functioning and retirement (controlling for those retired within the year). FE-IV estimates.

	Retired within a year	Retired for at least one year	Cognitive score	
	First stage (i)	First stage (ii)	Reduced form (ii)	IV (iii)
Working	–	–	–	–
Retired within the year	–	–	–	0.330 (0.921)
Retired for at least one year	–	–	–	−0.846** (0.373)
Instruments				
Being 62 years old	0.055*** (0.007)	0.022*** (0.008)	−0.022 (0.059)	–
Being the normal age of retirement	0.022*** (0.006)	0.027*** (0.007)	0.030 (0.058)	–
>62 years old	−0.004 (0.005)	0.110*** (0.007)	−0.115** (0.051)	–
>Normal age of retirement	−0.012*** (0.004)	0.079*** (0.007)	−0.061 (0.050)	–
Controls				
Age	0.036*** (0.003)	0.017*** (0.006)	0.461*** (0.048)	0.460*** (0.065)
Age^2	−0.003*** (0.000)	0.001** (0.001)	−0.047*** (0.004)	−0.045*** (0.005)
Test of overidentifying restriction (*p*-value)				0.675
Durbin–Wu–Hausman test (*p*-value)				0.069
Within-R^2	0.009	0.242	0.045	–
N	54,377	54,377	54,377	54,377

Note: Health and Retirement Study 1998–2008. All respondents were aged between 51 and 75. Robust standard errors are in parentheses.
* Mean that the coefficient estimate is significantly different from zero at the 10% level.
** Mean that the coefficient estimate is significantly different from zero at the 5% level.
*** Mean that the coefficient estimate is significantly different from zero at the 1% level.

to 24 months post retirement (the model with the delay fixed at 12 months corresponds to the IV model presented in Table 1). The results show that the coefficient estimates remain significant at the 5%-level for most of the delay chosen, even for the immediate effect. However the effect is more salient when the delay is fixed at about one year after retirement, the largest effect being identified for a delay of 14 months.[19] Those results confirm that the effect of retirement on cognitive functioning is likely to occur with a delay of about one year post retirement.

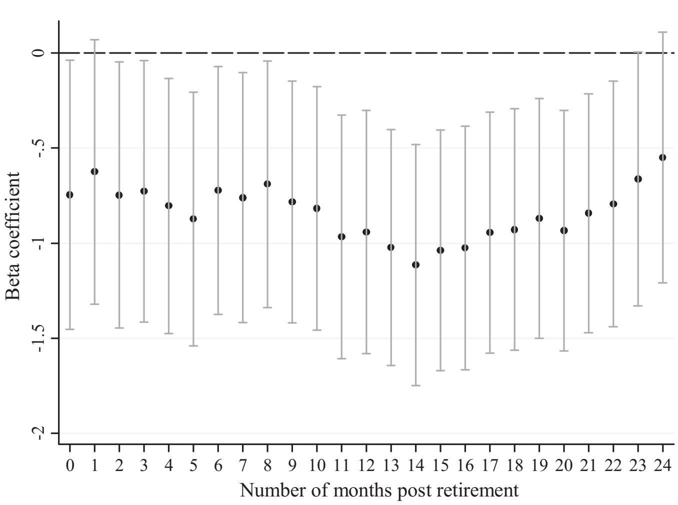

Fig. 4. Sensitivity analysis on the delayed effect of retirement on cognitive functioning. *Note*: Health and Retirement Study 1998–2008. All respondents were aged between 51 and 75. The black dots correspond to the point estimates of the IV model of the effect of retirement on cognitive functioning (Eq. (1)) using different delay periods (from 0 to 24 months) between retirement and its impact on cognitive functioning. The vertical bars represent the respective 95% confidence interval.

5.4.2. Other measures of cognitive functioning

Our results are based on one single cognitive task (i.e. a task of word recall), which calls into question the generalisability of our results to the whole cognitive functioning. Nevertheless, it is widely recognised that word recall tests involve a broad network of brain regions (i.e. frontal regions, hippocampus, etc.; Desgranges et al., 1998; Tulving, 2002) and that this kind of task is multi-determined, i.e. it implies a variety of other cognitive functions such as language, attention and executive functioning (Tulving, 2002).

Although HRS includes several other measures of cognitive functionning,[20] most of them are only asked to individuals being 65 year-old or older and thus are not suited for our study. There is however another measure of cognitive functioning that can be used for our analysis. This measure is based on the serial 7 subtraction from 100 (up to five times): Individuals are asked to subtract 7 five times from 100. This test is aimed to assess working memory, i.e. the ability to actively hold information in the mind needed to do complex tasks such as reasoning, comprehension and learning. The measure ranges from 0 to 5.[21] The coefficient estimate of being retired for one year or more is negative and significant confirming our previous results (coefficient estimate: −0.279; standard error: 0.126).

[19] We observe that the coefficient estimate tends to become lower in magnitude when allowing for longer delays because the control group includes then individuals that are already affected by cognitive decline due to retirement.

[20] For an overview of the available measures of cognitive functioning, see Fisher et al. (2009).

[21] Note that we treat an answer as correct when the individual correctly subtracts 7 from the last number he reported, not only the theoretical one (it means that if the individual reported 92 in the first round, and 85 in the second round, the second answer is considered as correct).

Furthermore, the magnitude of the effects on the word recall test and the serial 7 subtraction test are close to each other: the effect on the normalised word recall test score corresponds to −0.278 (standard error: 0.100) while the effect on the normalised serial 7 subtraction score is −0.230 (standard error: 0.104).[22]

5.4.3. The sample selection

The analytical sample excludes individuals who are observed going back to work during the survey period. As a result, non-working individuals in our sample are the most likely to fit to the definition of retirement: a permanent withdrawal from the labour force. The sample selection might however lead to a selection bias if for example individuals do not find a job anymore because of their lower cognitive functioning. However, those individuals are also likely to be more active than permanently retired individuals given they are more likely to actively look for a job. We would thus expect that those individuals are less likely to be affected during this transition period. We performed several tests in order to check the sensitivity of our results. First, we keep individuals observed going back to work during the sample period and define their non-working duration in the same way as the retired individuals. In such a case, the IV models provide estimates that are close to our main results for both the dummy estimates (coefficient estimate: −1.232; standard error: 0.380). and the log of retirement duration (coefficient estimate: −0.798; standard error: 0.274) and show that our IV strategy is insensitive to the selected sample we use for our main results.[23]

The analysis until now has defined retirement as a dummy variable for working or not. However, an individual who has reduced substantially his working hours and is only working a few hours per week might also experience a cognitive decline. As those individuals are still recorded as working according to our definition, this might bias upward the IV estimate of the effect of retirement on cognitive functioning. In order to check for this possibility we restrict the sample to individuals who are working full time by dropping all individuals who have been observed working 35 h or less per week, conditional on working and performed the analysis. Results are robust to this sample selection confirming our main findings (coefficient estimate: −0.810; standard error: 0.318).

6. Conclusion

This paper has analysed the effect of retirement on cognitive functioning, measured by a word learning and recall test, using longitudinal data on older Americans from 1998 to 2008 (HRS). The empirical results highlight a significant negative causal impact of retirement on cognitive functioning, in accordance with the findings of Rohwedder and Willis (2010) and Mazzonna and Peracchi (2010). This negative effect remains even when controlling for individual heterogeneity and the endogeneity of the retirement decision. We show, by using eligibility for social security as an instrument for retirement, that this relationship is unlikely to be due to reverse causality. Our results highlight a significant negative effect of retirement on cognitive functioning, close to 10%. They also suggest that the effect of retirement on cognitive functioning is not instantaneous but appears with a lag and this might thus provide an explanation for the mixed findings from previous studies.

Our results also suggest that, although the effect of retirement on cognitive functioning is not instantaneous, most of the drop occurs at the beginning of the retirement period and tends to stabilise afterwards. This finding thus suggests that, even though reforms aimed at delaying the legal age of retirement could lead to some positive externalities in terms of improved cognitive functioning, we should not expect that an increase in retirement age will have a large impact on the dependency of the elderly (i.e. the long-term retired) because of cognitive impairment at older age.

From 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 would be necessary to specify the effect of professional activities on cognition (and more particularly on memory functioning). Indeed, the first question to be investigated is whether the impact of the retirement on cognitive functioning depends on the type of professional activity undertaken while employed: physical versus intellectual work; light versus heavy 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 labour is associated with worse cognitive functioning (Jorm et al., 1998; Potter et al., 2008). A second important question is to determine whether the relationship 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 interaction 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).

Our findings have implications that go beyond the consequences of retirement on cognitive functioning. They show that individuals have some control over the evolution of their cognitive functioning through the activities they undertake and thus that there is scope for policy interventions to affect the pattern of cognitive ageing. They provide support for active ageing policies, particularly in the field of participation. Let us indicate here the three key policy proposals in this field highlighted by the World Health Organization (WHO, 2002): "(1) Provide education and learning opportunities throughout the life course; (2) Recognize and enable the active participation of people in economic development activities, formal and informal work and voluntary activities as they age, according to their individual needs, preferences and capacities; and (3) Encourage people to participate fully in family community life, as they grow older."

Finally, it should be emphasised that memory loss and dementia among the elderly represent a major public health burden, especially in the current context of population ageing. Cognitive impairments, even those not reaching the threshold for 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 labour force participation at an older age may not only ensure the sustainability of social security systems but may also create positive health externalities.

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[22] Results are available upon request.

[23] We have also estimated the model by restricting the sample to individuals reporting working or being fully retired and found similar results than those presented in this paper. Results are available upon request.

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