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. This suggests that promoting labour 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 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 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 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 Europe1, Adam et al. (2007) 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. (2007), Coe and Zamarro (2010), Mazzonna and Perrachi (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 data2 and the differences in the legal age of retirement across countries as an instrument for the retirement decision. The results were mixed: while Rohwedder and Willis (2010), and Mazzona and Peracchi (2010) found a

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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 (2010) use the first wave of SHARE and Mazzona and Perrachi (2010) the first two waves of SHARE. Rohwedder and Willis (2010) complement SHARE data with comparable data from the ELSA and the HRS.
significant and quantitatively important negative effect of retirement on cognitive functioning\(^3\), Coe and Zamarro (2010) did not find a significant effect.

Our results provide an explanation for the mixed findings obtained by previous studies that have analysed the effect of retirement on cognitive functioning. We argue that our approach is able to circumvent some issues that may have biased the results from previous studies on this topic. First, most studies have based their identification strategy on cross-country differences in the early and statutory retirement age (Coe and Zamarro, 2010; Rohwedder and Willis, 2010; Mazzonna and Peracchi, 2010). This identification strategy is not without its limitations. For instance, Rohwedder and Willis (2010) use the cross-country differences in the early and statutory retirement age as an instrument for being retired in a model explaining the differences in level in cognitive test scores. Their empirical model showed that cognitive test scores of 60-64 year-old individuals were higher in countries where the early/statutory age of retirement is higher and the authors interpreted their results as evidence that retirement has a causal negative effect on cognitive functioning. However, such a relationship might be explained by other mechanisms than the direct effect of retirement on cognitive functioning. For instance, individuals living in countries where the mandatory retirement age is higher have more incentives to invest in human capital than those living in countries where the retirement age is lower. Indeed, in countries with a higher mandatory retirement age, individuals have a higher net present value of the return to human capital as they have a longer period of time in which they can reap the benefits from such investments (Ben-Porath, 1967). As a result, the larger effect of retirement on cognitive functioning found by Rohwedder and Willis (2010) might be explained by the fact that their estimate captures two different effects: the effect of retirement itself, but also the effect of human capital accumulation induced by a higher mandatory age of retirement.

The empirical framework used by Coe and Zamarro (2010) is less prone to such a bias as their model controls for country fixed effects and education level. However, the non-significant effect of retirement on cognitive functioning they found may have several explanations.\(^4\) Like Rohwedder and Willis (2010), Coe and Zamarro (2010) apply a

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

\(^4\) Coe and Zamarro’s (2010) IV coefficient estimate of retirement on memory score (ranging from 0 to 20, with a sample mean of 9.45) is relatively imprecise (-0.0390 with a 95%-confidence interval [-1.959; 1.881]) preventing any conclusion about the direction of the effect.
regression discontinuity design where the threshold points are set, at the country level, at the early and statutory retirement age. However, we show in this paper that the effect of retirement on cognitive functioning is not instantaneous, but appears with a lag, and thus provides a potential explanation for the impreciseness of Coe and Zamarro’s (2010) Instrumental Variable (IV) estimate. Second, their model also includes controls that are likely to capture part of the variability of the dependent variable that the analysis is actually interested in. For example, their empirical model includes as explanatory variables the number of limitations with Activities of Daily Living (Katz et al, 1970) and with Instrumental Activities of Daily Living (Lawton and Brody, 1969). It is likely that differences in those measures are the consequences, rather than the cause, of variations in cognitive functioning and that they thus capture part of the variation in the data that the model aims to explain. Some studies in neuropsychology have proposed using those measures of limitations with Instrumental Activities of Daily Living as a screening device for detecting cognitive impairment and dementia in elderly community dwellers (Barberger-Gateau et al., 1992; Castilla-Rilo et al., 2007). Note also that Coe and Zamarro’s (2010) model includes several other potential endogenous variables, such as participating in non-professional activities or level of household income, which are also likely to bias their coefficient estimates of interest.

Mazzonna and Perracchi (2010) also use cross-country data from Europe and the same identification strategy as Coe and Zamarro (2010). The main difference between the two studies is that Mazzonna and Perracchi model the effect of retirement on cognitive functioning as a linear function of retirement duration and use the number of years since the individual has reached the early and statutory retirement age. Contrary to the other studies (Adam et al., 2007; Coe and Zamarro, 2010), Mazzonna and Perracchi control for age using a linear specification. Not controlling for a potential non-linear age trend is thus likely to bias their results. More importantly, the age trend in cognitive functioning is likely to be heterogeneous across countries and may thus bias their results if the country-specific age slope is correlated with the differences in the age of eligibility for early or normal retirement.

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. Our identification approach follows the work of Bound and Waidmann (2007), Charles (2002), and Neumann (2008), who analysed the effect of retirement on health. 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 IV estimation. Furthermore, we show that the effect of retirement is not instantaneous, but appears with a lag. We also show that our estimates are robust to the inclusion of a more flexible specification of the age trend in cognitive functioning and are unlikely to be driven by a misspecification of the age trend.

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, 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 (Petersen et al., 1992; Small, 2001), episodic memory deficits being also largely considered as a hallmark symptom of Alzheimer’s disease (Adam, Van der Linden, et al., 2007; 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; Silver et al., 2001). At the same time, age-related cerebral modifications

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5 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).

6 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).
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 (Capruso 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 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, the effect of activities

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7 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).
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, 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 \( c_i \), as measured by the score obtained at a cognitive test (described below), depends on retirement status \( r_i \) and a smooth function of age \( f(\text{age}_i) \), along with an error term that can be decomposed into unobserved time-invariant heterogeneity \( \mu_i \) and an idiosyncratic error term \( v_i \).

Assuming linear separability, cognitive functioning is given by the following equation:

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c_i = r_i \beta + f(\text{age}_i) + \mu_i + v_i,
\]

Identification of the causal effect of retirement on cognitive functioning requires the error terms and the retirement decision to be uncorrelated, conditional on age. 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 (\( \beta \)) will be consistently estimated unless \( \nu_\alpha \) 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 Instrumental Variable (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 Moffit, 1984; 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. We thus compute two dummy variables equal to 1 if the individual reaches the corresponding threshold 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.

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Table A1 in the Appendix shows the normal retirement age for the different cohorts that we use for our empirical analysis. 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.
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.\(^9\) 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 Equation (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.\(^10\)

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. 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 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.

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\(^9\) This possibility has also been stressed by Rohwedder and Willis (2010).

\(^10\) This phase has, to some extent, been verified empirically (e.g. George and Maddox 1977; Ekerdt et al. 1985; Gall et al. 1997).
4. Data

4.1. The Health and Retirement Study

Our empirical analysis uses six waves (1998–2008) from the Health and Retirement Study (HRS). 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 (5,807 observations). Where information regarding the working status of participants was missing from the HRS data (101 observations) or where respondents reported never having worked (2,473 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). 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 (3,153 observations). In addition, we excluded from the sample individuals who reported having left their last job before the age of 50 (4,338 observations). Individuals with a missing cognitive score were dropped from the sample (557 observations). The final sample corresponded to an unbalanced panel including 54,793 observations for 14,803 individuals.

11 The HRS is sponsored by the National Institute of Aging (grant number NIA U01AG009740) and is being conducted by the University of Michigan.
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. 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. We use a dummy variable related to retirement status: an individual is defined as “Working” if he/she claims to be currently working for pay and “Retired” if he/she reports not working. HRS also includes information

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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.
about the year 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. Descriptive results

In this section we present the evolution of cognitive score at retirement using both Ordinary Least Squares (OLS) and FE estimators, suggesting that retirement is unlikely to have an instantaneous effect on cognitive functioning but occurs with a lag. For this purpose, we do not impose any functional form for the effect of retirement duration by including dummies for the number of years spent in retirement. We control for age by using a parametric specification (a second-order polynomial in age) and compare the results with a model that does not impose any functional form for age by including age dummies. Columns (i) and (ii) of Table 1 present the OLS results with either the age dummies or the second-order polynomial in age, respectively, while columns (iii) and (iv) present the coefficient estimates from the FE estimator. The coefficient estimates related to retirement remain approximately the same when using a second-order polynomial in age instead of age dummies, suggesting that the second-order polynomial in age is a good approximation of the age trend. The OLS results suggest that most of the drop occurs at the time of retirement, while retirement duration plays only a minor role in cognitive functioning. This negative effect occurring instantaneously at the time of retirement is quite important and occurs for individuals retiring within the past year. However, these results are likely to be driven by selectivity bias. Once we control for unobserved individual heterogeneity (columns (iii) and (iv)), the coefficient estimates related to retirement duration become smaller than the OLS estimates. This is what we would expect from the FE estimator, as this controls for unobserved individual heterogeneity, which is likely to be negatively correlated to retirement. More strikingly, the coefficient related to individuals retiring within the past year is close to zero and not significant at all. However, the coefficient estimates of the following years during retirement appear to be negative and significant. We also observe that most of the drop occurs just at the beginning of the retirement period (within 3 years after retirement), while it tends to stabilise later on.

[Table 1 about here]
5.2. Main results

The previous section showed that the negative effect of retirement on cognitive score remains, even when individual heterogeneity is controlled for. However, time-varying shocks in cognitive functioning may induce older workers to leave the labour force. Nevertheless, as suggested by the FE estimator in the previous section, we do not observe a significant drop when the individual has only retired within the past year. This could be considered as supportive evidence that the effect of retirement on cognitive functioning captured in the FE model is not due to a negative cognitive shock, such as a negative health shock, occurring between two waves, which would have induced the individual to retire. However, the within estimator exacerbates measurement error and is likely to suffer from attenuation bias.

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. Figure 1 presents the estimated retirement probability changes (Figure 1a) and cognitive test score changes (Figure 1b) as individuals become one year older between the ages of 55 and 70, controlling for individual fixed effects. As expected, we observe a significant increase in the probability of retiring at age 62, which corresponds to the minimum age at which social security benefits can be claimed. 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, Figure 1b 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. This graph suggests however that there is a significant decrease in cognitive functioning

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, \( d_{it}^a = \mathbb{I}[\text{age}_{it} \geq a] \), \( \alpha_i \) is the individual fixed effect, and \( \eta_{it} \) is the error term. Figure 1 reports the estimates of the parameters \( \gamma_a \) with 95%-confidence intervals.
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 Figure 1a. 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 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 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 11 percentage points at age 63 and by 5.5 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 ($F(2, 12434) = 170.27$). The Sargan-Hansen test of overidentifying restriction does not reject the hypothesis that our instruments are valid. Column (ii) presents the coefficient estimates of the reduced-form regression that includes 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 Figure 1b. 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.

[Table 2 about here]

The effect on memory score of being retired for one year or more is negative and highly significant. This suggests that individuals retiring experience a drop in cognitive test score by about 1 point (95%-confidence interval -1.71 to -.28). This corresponds to about a 10% decrease in cognitive score (compared to the sample average score). The estimate is larger than in the model that assumes exogeneity of retirement. 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 hours 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.

5.3. Functional form for the age trend
Our identification strategy relies on age-related instruments and it may therefore rely 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 3. 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 coefficient estimates related to the polynomials in age are significant. These results suggest that the quadratic specification is satisfactory for capturing non linearity in age.

[Table 3 about here]

5.4. 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. The coefficient estimates of the FE estimator presented in Table 1 (column (iv)) suggest that cognitive functioning tends to decrease most at the beginning of the retirement period (after one year of retirement), while it seems to stabilise later on. This observed pattern suggests a logarithmic relationship between the length of the retirement period and cognitive functioning. As an illustration, we plot, in Figure 2, the coefficient estimates from column (iv) of Table 1 along with the predicted value of the effect of retirement duration on
cognitive functioning. Here we use the logarithmic specification for retirement duration instead of the dummies for years spent in retirement.\textsuperscript{14} This figure suggests that the logarithmic specification fits quite well with the observed pattern obtained when using dummies for the number of years spent in retirement. We thus reformulate our IV approach by taking as the endogenous variable the logarithm of the length of retirement\textsuperscript{15} and using the logarithm of the time period since the individual reached the age of 62 years and the logarithm of the time period since the individual reached the normal age of retirement.

Table 4 presents the results of the model. The coefficient estimate of retirement duration 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. As a check, we also tested our model by specifying the effect of retirement duration on cognitive functioning as a linear function (See Table 5), as Mazzonna and Perracchi (2010) did. The IV estimates of the coefficient related to retirement duration are not significant, suggesting that the data do not fit with the linear specification. 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.

Table 4 and 5 about here]

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).\textsuperscript{16} The empirical results highlight a significant negative causal impact of retirement on cognitive functioning, in accordance with the findings of Rohwedder and Willis (2010).

\textsuperscript{14} The coefficient estimate related to the logarithm of retirement duration is -0.163 with a standard error of 0.037.

\textsuperscript{15} 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 for less than one year.

\textsuperscript{16} It is worth noting that our results rely mainly 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, executive functioning, etc. (Tulving, 2002).
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%. We also show 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 findings also show 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 much 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, which aim at “optimizing opportunities for health, participation, and security in order to enhance quality of life as people age” (WHO, 2002).

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.
References


### Tables and Figures

**Table 1: Cognitive functioning and retirement duration**

<table>
<thead>
<tr>
<th>Retirement duration (in years):</th>
<th>OLS (i)</th>
<th>OLS (ii)</th>
<th>FE (iii)</th>
<th>FE (iv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1</td>
<td>-0.640***</td>
<td>-0.635***</td>
<td>0.029</td>
<td>0.024</td>
</tr>
<tr>
<td>[1; 2[</td>
<td>-0.521***</td>
<td>-0.519***</td>
<td>-0.132*</td>
<td>-0.138*</td>
</tr>
<tr>
<td>[2; 3[</td>
<td>-0.741***</td>
<td>-0.744***</td>
<td>-0.184**</td>
<td>-0.198***</td>
</tr>
<tr>
<td>[3; 4[</td>
<td>-0.587***</td>
<td>-0.587***</td>
<td>-0.193**</td>
<td>-0.202**</td>
</tr>
<tr>
<td>[4; 5[</td>
<td>-0.800***</td>
<td>-0.795***</td>
<td>-0.210**</td>
<td>-0.221**</td>
</tr>
<tr>
<td>[5; 6[</td>
<td>-0.825***</td>
<td>-0.824***</td>
<td>-0.378***</td>
<td>-0.390***</td>
</tr>
<tr>
<td>[6; 7[</td>
<td>-0.769***</td>
<td>-0.770***</td>
<td>-0.241**</td>
<td>-0.259***</td>
</tr>
<tr>
<td>[7; 8[</td>
<td>-0.893***</td>
<td>-0.893***</td>
<td>-0.405***</td>
<td>-0.417***</td>
</tr>
<tr>
<td>[8; 9[</td>
<td>-0.883***</td>
<td>-0.887***</td>
<td>-0.239**</td>
<td>-0.257**</td>
</tr>
<tr>
<td>[9; 10[</td>
<td>-0.873***</td>
<td>-0.881***</td>
<td>-0.410***</td>
<td>-0.423***</td>
</tr>
<tr>
<td>[10; 11[</td>
<td>-1.006***</td>
<td>-1.006***</td>
<td>-0.474***</td>
<td>-0.482***</td>
</tr>
</tbody>
</table>

*Age controls: Age dummies, Quadratic*

(Within-)R²: 0.054, 0.054, 0.041, 0.040

Number of observations: 48,279, 48,279, 48,279, 48,279

Note: Health and Retirement Study 1998-2008. All respondents were aged between 51 and 75 and were either working or had been retired for 10 years or less. Robust standard errors are in parentheses. (*), (**), (***), mean that the coefficient estimate is significantly different from zero at the 10%, 5%, 1% levels, respectively.
Figure 1: 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: $y_{it} = \alpha_i + \sum_{a=56}^{70} \gamma_y d_{it}^a + \eta_{it}$, where $y_{it}$ is either the retirement dummy, or the cognitive test score, $d_{it}^a = \text{I}[\text{age}_i \geq a]$, $\alpha_i$ is the individual fixed effect, and $\eta_{it}$ is the error term. The figures report the estimates of the parameters $\gamma_y$ with 95%-confidence intervals.
Table 2: Cognitive functioning and retirement. FE-IV estimates

<table>
<thead>
<tr>
<th>Retired for at least one year</th>
<th>Cognitive score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First stage (i)</td>
</tr>
<tr>
<td>Retired for at least one year</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(0.364)</td>
</tr>
</tbody>
</table>

**Instruments:**

- > 62 years old: 0.105*** -0.101** -
  (0.007) (0.044)
- > Normal age of retirement: 0.056*** -0.067 -
  (0.006) (0.046)

**Controls:**

- Age: 0.044*** 0.455*** 0.503***
  (0.006) (0.047) (0.048)
- Age²: -0.001** -0.046*** -0.047***
  (0.000) (0.004) (0.004)

Test of overidentifying restriction (p-value) 0.795
Durbin-Wu-Hausman test (p-value) 0.016
Within-R² 0.238 0.045
N 54,793 54,793 54,793

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%, 5%, 1% levels, respectively.

Table 3: Cognitive functioning and retirement. FE-IV estimates. Tests for different functional forms for age

<table>
<thead>
<tr>
<th>Retired for at least one year</th>
<th>Cognitive score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(i)</td>
</tr>
<tr>
<td>Retired for at least one year</td>
<td>-1.019***</td>
</tr>
<tr>
<td></td>
<td>(0.366)</td>
</tr>
<tr>
<td>Age</td>
<td>-0.101***</td>
</tr>
<tr>
<td>Age²/10</td>
<td>-0.047***</td>
</tr>
<tr>
<td>Age³/100</td>
<td></td>
</tr>
<tr>
<td>Age⁴/1000</td>
<td></td>
</tr>
</tbody>
</table>

Test of overidentifying restriction (p-value) 0.000 0.795 0.775 0.911
Durbin-Wu-Hausman test (p-value) 0.017 0.016 0.237 0.246
N 54,793 54,793 54,793 54,793

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%, 5%, 1% levels, respectively.
Figure 2: Cognitive score and retirement duration

Note: Health and Retirement Study 1998-2008. All individuals were aged between 51 and 75 and were either working or had been retired for 10 years or less. The point estimate corresponding to zero years in retirement corresponds to individuals who are either working or retired for less than one year. The black points [OR dots??] represent the coefficient estimates from column (iv) of Table 1, while the solid line is obtained from the same model that adopts the logarithm of retirement duration (plus one) as the functional form.

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

<table>
<thead>
<tr>
<th>FE-IV estimates</th>
<th>Log(Retirement duration+1)</th>
<th>Cognitive score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First stage (i)</td>
<td>Reduced form (ii)</td>
</tr>
<tr>
<td>Log(Retirement duration+1)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Log(Years since age 62+1)</td>
<td>0.145*** (0.009)</td>
<td>-0.072* (0.039)</td>
</tr>
<tr>
<td>Log(Years since normal age of retirement+1)</td>
<td>0.068*** (0.009)</td>
<td>-0.059 (0.047)</td>
</tr>
<tr>
<td>Age</td>
<td>-0.092*** (0.011)</td>
<td>0.367*** (0.063)</td>
</tr>
<tr>
<td>Age^2</td>
<td>0.013*** (0.001)</td>
<td>-0.039*** (0.005)</td>
</tr>
</tbody>
</table>

Test of overidentifying restriction (p-value) 0.638
Durbin-Wu-Hausman test (p-value) 0.085
Within-R^2 0.529 0.045
N 54,793 54,793 54,793

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%, 5%, 1% levels, respectively.
Table 5: Cognitive functioning and retirement duration (linear specification).
FE-IV estimates

<table>
<thead>
<tr>
<th></th>
<th>Retirement duration</th>
<th></th>
<th>Cognitive score</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First stage (i)</td>
<td>Reduced form (ii)</td>
<td>IV (iii)</td>
<td></td>
</tr>
<tr>
<td>Retirement duration</td>
<td>-</td>
<td>-</td>
<td>-0.095</td>
<td>(0.139)</td>
</tr>
<tr>
<td>Years since age 62</td>
<td>0.132*** (0.020)</td>
<td>-0.026 (0.023)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Years since normal age of retirement</td>
<td>0.088*** (0.019)</td>
<td>0.007 (0.021)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>-1.370*** (0.098)</td>
<td>0.372*** (0.137)</td>
<td>0.230 (0.323)</td>
<td></td>
</tr>
<tr>
<td>Age$^2$</td>
<td>0.137*** (0.009)</td>
<td>-0.039*** (0.012)</td>
<td>-0.026 (0.031)</td>
<td></td>
</tr>
<tr>
<td>Test of overidentifying restriction (p-value)</td>
<td>0.377</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Durbin-Wu-Hausman test (p-value)</td>
<td>0.640</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within-R$^2$</td>
<td>0.649</td>
<td>0.045</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>54,793</td>
<td>54,793</td>
<td>54,793</td>
<td></td>
</tr>
</tbody>
</table>

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%, 5%, 1% levels, respectively.
Appendix

Table A1: Normal retirement age in the US

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