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The Impact of Social Activities on Cognitive Ageing: Evidence from Eleven European Countries

Dimitris Christelis* and Loretti I. Dobrescu **

Abstract

Using micro data from eleven European countries, we investigate the impact of being socially active on cognition in older age. Cognitive abilities are measured through scores on numeracy, fluency and recall tests. We address the endogeneity of social activities through panel data and instrumental variable methods. We find that social activities have an important positive effect on cognition, with the results varying by gender. Fluency is positively affected only in females, while numeracy only in males. Finally, recall is affected in both sexes. We also show that social activities, through their effect on cognition, influence positively households' economic welfare.

JEL Classification: I10, J14, C23

Keywords: Cognition, Social Activities, Ageing, SHARE, Panel Data.

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1. Introduction

The extent to which older individuals preserve their cognitive skills has a significant impact on how well they age. One of the many benefits that higher cognition brings is the increased likelihood to achieve better economic outcomes, even in older age. In fact, there is by now a well-documented positive association between cognition and economic performance. For instance, cognitive abilities are found to be strongly positively correlated with financial literacy (Delavande, Rohwedder and Willis, 2008), and with wealth and risky portfolio holdings (Smith, McArdle and Willis, 2010; Lee and Willis, 2001; McArdle, Smith and Willis, 2009). Moreover, Banks, O'Dea and Oldfield (2010) have shown that higher cognition enhances consumption smoothing and life-satisfaction in retirement.

Given the importance of cognitive abilities in old age, many researchers have investigated their determinants. One of the main findings documented in the literature is the positive association between engaging in social activities and cognitive ability. But is this relation causal? In other words, is this positive association due to the fact that an active social life actually causes the preservation of cognitive skills? Using panel data from eleven European countries, we address this issue and document the considerable positive causal impact of social activities on cognition.

The traditional focus of research on cognition and social involvement has been on relatively objective measures of social isolation/connectedness. These include: i) participation in activities that prominently involve social interaction, namely doing volunteer work (Beland et al., 2005), attending an educational or training course (Katzman, 1993), going to a sports club, taking part in activities of a religious (Wilson et al., 2002a), and political or community-related organization (Beland et al., 2005); ii) the number of friends and relatives contacted regularly, i.e., social network size (Crooks et al., 2008; Stevens et al., 2001; Glei et al., 2005);[1] iii) social or emotional support (Glei et al., 2005; Boult et al., 1994; Fratiglioni et al., 2000; Yeh and Liu, 2003; Seeman, Lusignolo and Berkman, 2001).[2]

Regardless of the definition of social involvement, empirical evidence shows older adults who are more socially active perform at higher cognitive levels (Jopp and Hertzog, 2007), experience slower decline in cognitive abilities (Bassuk, Glass and Berkman, 1999; Zunzunegui et al., 2003; Wang et al., 2002; Fratiglioni, Paillard-Borg and Winblad, 2004; Barnes et al., 2004; Lovden, Ghisletta and Lindenberger, 2005; Ertel, Glymour and Berkman, 2008)[3], and are less likely to suffer from mental problems, like dementia (Fratiglioni et al., 2000; Verghese et al., 2003; Karp et al., 2005; Saczynski et al., 2006).[4]

Several studies reported on *four channels* through which maintaining an active social life may help preserve cognitive functions. First, the lack of a social network that satisfies older individuals' need for social contact may cause loneliness, [5] which has also been used to predict mental problems, including depression (Prince et al., 1997). Second, by providing meaningful social roles and a sense of purpose in old age (Berkman, 2000), social activities could have direct neurohormonal influences on the brain, including the reduction of the stress response (Fratiglioni et al., 2004). Third, since social activities provide the challenge of effective communication and participation in complex interpersonal exchanges, they have

[1] Crooks et al. (2008) documented that having a larger social network has a protective influence on the cognitive function of elderly women, while Stevens et al. (2001) found that social network size is linked to higher recall ability, whereas the number of social contacts is linked to better self-assessed memory capacity.

[2] On one hand, Glei et al. (2005) found that voluntary social interactions may have a greater impact on cognitive function than family or intimate ties. When adjusting for frequency of contact with friends and colleagues, Boult et al. (1994) found that social support was associated with a reduced risk of developing disability up to four years later. On the other hand, Fratiglioni et al. (2000) found single persons at greater risk for dementia compared with their married counterparts. Similarly, Yeh and Liu (2003) found that better cognition was associated with marital status and perceived support from friends, while Seeman, Lusignolo and Berkman (2001) showed that emotional support at entry in their study predicted maintaining cognitive functioning at the 7.5-year follow-up.

[3] Bassuk et al. (1999) found that elderly persons who had no social ties were at increased risk for cognitive decline, compared with those who had five or six social ties; this relation persisted even after controlling for ill health, activities of daily living, socioeconomic status, sex, and ethnicity. In the same vein, Zunzunegui et al. (2003) has shown that social disengagement and unsatisfying contact with children were associated with greater risks of subsequent dementia or cognitive decline.

[4] Verghese et al. (2003) found that participation in cognitively stimulating leisure activities protected against the development of dementia.

[5] Andersson (1992), Cutrona, Russel and Rose (1986), Jones and Moore (1986), Weiss (1989).

been thought to inhibit cognitive decline in the elderly (Berkman, 2000). Finally, social activity might also require a degree of physical activity above and beyond regular exercise and walking, which could enhance physical health (Colcombe and Kramer, 2003; Fratiglioni et al., 2004). Moreover, an active social life may induce greater self-esteem and better self-care practices, i.e., regular exercise and smoking abstention (Hurst, 1997).

The empirical approaches used in these studies, however, cannot handle the problem of the correlation of social activities with unobservables that also affect cognition. Such unobservables might be both time-invariant (e.g. personality traits) and time-varying (e.g. health problems), and their presence will most likely bias the estimate of the effect of social activities on cognition. Unless this issue is addressed, one cannot be sure that the strong observed association between cognition and social activities is due to the causal impact of the latter on the former. One way to deal with this problem is to use panel data and instrumental variable (IV) methods.

In our study, we use the first two waves of the Survey of Health, Ageing and Retirement in Europe (SHARE) and employ both these methods to control for the endogeneity between social activities and cognition. As a result, we are able to demonstrate the positive causal impact of the former on the latter. We examine several indicators of cognition, namely immediate and delayed recall capacity, as well as numeracy and fluency. In addition, we are able to retrieve from our micro data information on a number of social activities, including volunteering, participation in a political organization or a social club, and attendance of an educational course. Our results confirm that social activities indeed have a strong positive impact on cognition, with the results differing between the two sexes. In the case of females, social activities have a positive effect on fluency and recall, whereas for males social activities have a strong positive impact on recall and numeracy.

There are two other studies that are related to ours. Hu et al. (2012) use cross-sectional data from the China Health and Retirement Longitudinal Study and find a positive association between social activities and cognition (especially with respect to short-term memory) for the Chinese elderly. They also try to address the issue of the endogeneity of social activities by using IV methods, but their instruments are not related strongly enough to their measures of social activities. Engelhardt et al. (2010) use the first wave of SHARE and a stochastic frontier approach in order to show the positive association between social activities and cognition. Compared to those studies, our use of panel data and IVs that are strongly related to the potentially endogenous social activities variables allows us to firmly establish the causal impact of social activities on cognition.

The structure of the paper is as follows: Section 2 describes the data. Our estimation methodology and baseline results are presented in Section 3. Several robustness checks are performed in Section 4. Section 5 concludes.

2. Data

We use data from the first two waves of SHARE, which took place in 2004-5 and 2006-7 in eleven European countries (Sweden, Denmark, Germany, the Netherlands, Belgium, France, Switzerland, Austria, Italy, Spain and Greece).[6] SHARE surveys those aged fifty and above and collects data on demographics, physical and mental health (including the administration of tests like grip strength), cognition, social activities, housing, employment, income, housing, assets and expectations.[7]

There are two questions in SHARE that convey information on the social activities that the respondents engaged in the last month. The first one asks about the type of social activity

[6] The second wave took place also in the Czech Republic, Poland, and Ireland, but given that we need to work with the two-wave panel data we do not use the information from these countries.
[7] More detailed information on waves 1 and 2 of SHARE can be found in Börsch-Supan *et al*. (2005), Börsch-Supan and Jürges (2005), Börsch-Supan *et al*. (2008).

carried in the last month and offers as choices voluntary or charity work, care for sick or disabled adult or help to family, friends or neighbours, educational or training course, going to a sport, social or other kind of club, participating in a religious organization (church, synagogue, mosque, etc.) or in a political or community-related organization. The second one enquires about how often the above activities are performed. There are three possible answers to this second question, expressed as almost daily, almost every week and less often than almost weekly.

In our study, we will use two definitions for the number of activities: i) a narrow one, consisting of voluntary or charity work, educational or training course, going to a sport, social or other kind of club, and participating in a political or community-related organization; ii) a wider one that includes all seven activities. Moreover, our main specification will include those activities that are performed either almost daily or almost every week. In Section 4 we will check how our results are affected when we use different definitions of social activities.

In order to get information on the respondents' cognitive abilities we use four SHARE questions that are meant to assess their immediate and delayed recall, numeracy and fluency.

To evaluate the recall capacity, the respondents were read a purposefully long list of words, in order to make it difficult for anyone to recall all of them. For the immediate memory, they were asked to recall aloud as many of the words as possible, immediately after the interviewer finished reading them the list. For the delayed memory, they were asked to recall the same words aloud at a later time, i.e., after 5 questions. The two corresponding variables we use recorded the number of words respondents could recall.

For the fluency, we use a variable showing the number of animals respondents named in one minute, excluding repetitions and proper nouns.

Finally, there are several questions in SHARE that provide information on numeracy. The possible answers are shown in a card and the interviewers are instructed not to read them out to the respondent. There are five different numeracy questions: (1) how many people out of one thousand would be expected to get the disease if the chance of getting a disease is 10 percent;[8] (2) what is the sale cost of a sofa, given the initial price and a 50 percent discount;[9] (3) what is the initial price of a car if two-thirds of what it costs new is 6,000 euro;[10] (4) what is the final balance of a savings account that initially hold 2,000 euro, at 10 percent interest after 2 years.[11] The score is assigned as follows: if a person answers (1) correctly she is then asked (3) and if she answers correctly again she is asked (4). Answering (1) correctly results in a score of 3, answering (3) correctly but not (4) results in a score of 4, while answering (4) correctly results in a score of 5. On the other hand, if she answers (1) incorrectly she is directed to (2). If she answers (2) correctly she scores 2, otherwise she gets a score of 1.

There are two ways of interpreting the numeracy score. The first would be as an indicator of the level of numeracy, while the second as the number of numeracy questions correctly answered. The second interpretation depends on the assumption that respondents who answered question (1) correctly would have also answered (2) correctly, as (2) is considered to be easier than (1). In addition, this interpretation requires the assumption that those who did not answer (1) correctly would not have answered (3) and (4) correctly either, as the last two questions are more difficult than (1).

The first interpretation of the numeracy score is preferable, given that it rests on fewer assumptions than the second. However, it has the disadvantage that it requires a non-linear ordered probit (or logit) model for estimation, which has some serious limitations, as we discuss below. On the other hand, the interpretation of the numeracy score as the number of

[8] The possible answers are 100, 10, 90, 900 and other answer.
[9] The possible answers are 150, 600 and other answer.
[10] The possible answers are 9,000, 4,000, 8,000, 12,000, 18,000, and other answer.
[11] The possible answers are 2,420, 2,020, 2,040, 2,100, 2,200, 2,400 and other answer.

correctly answered questions allows for the use of linear or count data models, which in turn give estimates that are more trustworthy than those obtained from an ordered probit or logit model. Therefore, we will use a linear model as our baseline in order to estimate the effect of social activities on numeracy, but we will also report results from an ordered probit model as a robustness check.

After merging the waves 1 and 2 SHARE data we ended up with a sample of 34,824 households and 54,415 individuals.[12] Information on the social activities carried out, by country as well as on our four measures of cognition can be found in Table 1. We note that the highest score on numeracy was registered by Switzerland, with 2.75 questions answered correctly out of 4, while the lowest score recorded in Spain (1.45 out of 4). Spain represents the lowest extreme also in the case of both immediate and delayed recall, with respondents managing to remember on average only 3.54 and 2.33 words out of the 10 words read to them, respectively. The opposite was registered in Denmark, where respondents remembered 5.42 words immediately and 4.16 words after some time. In terms of fluency, Spain scored once again the lowest number of points (14.16 words per minute), while Swedish respondents achieved the highest score among all countries (22.63 words per minute).

With respect to our social activities-related variables of interest, we note that the countries with the highest prevalence of often performed social activities (in the wider sense) are Netherlands and Sweden (roughly 80% and 78%, respectively), while the lowest prevalence can be found in Spain (22%). Netherlands registers the highest prevalence (roughly 50%) also when we focus on the narrow definition of social activities (i.e., voluntary or charity work, educational or training course, sport, social or other kind of club and taking part in a political or community-related organization), but in this case the lowest number of these activities was registered in Greece (8.6%). The largest average share of respondents

[12] We use Release 2.4 of the wave 1 and 2 data.

taking part in a political or community-related organization or caring for a sick or disabled adult can be found in Belgium (3.8% and 7.8%, respectively), while the lowest in Spain (0.5% and 2.2%, respectively). Spanish are also less likely to provide help to family, friends or neighbors (at 3.2%) and, together with Greeks, less likely to do voluntary or charity work (at 1.3% and 1.4%, respectively). However, Greeks are more likely to participate in religious organizations (at about 22%) and less likely to attend a sport, social or any kind of other club (at 4.2%), which is the opposite of Danes (only 3.3% attend religious organizations, but 30.5% go to a sport or social club). Finally, following an educational or training course is most widespread in Switzerland (7.4%) and least common in Italy (0.8%).

One can get a first idea of the association between cognitive test scores and social activities by plotting the mean of each test score by the number of social activities performed; we show these plots in Fig. 1.[13] It is immediately obvious that the data suggest a strong positive association between social activities and all four cognitive test scores. Interestingly, there is some evidence that this association is nonlinear, especially with respect to numeracy, fluency and delayed recall. As we discuss below, we will allow in our empirical specifications for nonlinear effects of social activities on cognitive test scores.

3. Estimation methodology and empirical results

We examine the association between cognitive abilities and social activities by estimating linear equations that correlate cognitive test scores with measures of such activities. The estimation methods that we use include ordinary least squares (OLS), panel linear fixed effects (FE), cross-sectional instrumental variables (IV), and panel linear fixed effects with instrumental variables (FE-IV).

[13] We use the number of narrowly defined social activities that are also often performed, and we group together individuals with three and four activities, given that there are very few who engage in four activities.

In all our main specifications, the outcome variables will be the four scores in the numeracy, fluency, and immediate and delayed recall tests. For the variable denoting social activities we will use the number of narrowly-defined activities (as described in Section 2 above) in which the respondents engage at least once a week.[14] More specifically, each outcome *y* of a particular cognitive test will be a linear function of a vector of covariates $\boldsymbol{x}$ and a polynomial *g* in the number of social activities *na*, i.e.,

$$y_{it} = \boldsymbol{x}_{it}\boldsymbol{\beta} + g(na_{it}) + u_{it} \quad (1)$$

where *i* indexes individuals and *t* denotes time. Given the strong evidence (as seen in Fig. 1) of a nonlinear association between the number of social activities and the cognitive scores, we need to investigate the use of polynomials of different degrees in *na*. We will thus try polynomials of up to the third degree, and we will show results from the polynomial specification that gives the best fit, as determined by the value of the Akaike information criterion (AIC).[15]

Each estimation method that we use is based on some assumptions about the correlation of both the variable denoting social activities and of the other variables included in the specification with the error term u_{it}. We assume that u_{it} is equal to the sum of a time invariant error a_i and a time varying error w_{it} (i.e., $u_{it} = a_i + w_{it}$). Examples of time invariant unobservables that enter in a_i include personality traits like intellectual curiosity

[14] In section 4 we will report additional results involving other cognition-related outcomes and different definitions of the number of social activities.

[15] If in a particular instance a linear specification is to be preferred, then $g(na_{it}) = \gamma_1 na_{it}$ and the marginal effect (m.e.) of the number of activities na on the outcome *y* is going to be equal to γ_1. If, on the other hand, the AIC suggests that a quadratic polynomial $g(na_{it}) = \gamma_1 na_{it} + \gamma_2 na_{it}^2$ is preferable, then the m.e. of na is going to be equal to $\gamma_1 + 2\gamma_2 na_{it}$. Finally, if a cubic polynomial $g(na_{it}) = \gamma_1 na_{it} + \gamma_2 na_{it}^2 + \gamma_3 na_{it}^3$ is chosen, then the m.e. of na is going to be equal to $\gamma_1 + 2\gamma_2 na_{it} + 3\gamma_3 na_{it}^2$. Obviously, if a quadratic or a cubic specification of $g(na_{it})$ is chosen, then the m.e. is going to differ across the population, and thus in our results we report its weighted average (calculated using the sampling weights) across all units in our estimation sample.

and the ease of relating to and learning from others. On the other hand, time-varying unobservables that enter into w_{it} could include particular physical health problems, or psychological stress.

As already noted, we include in our specifications a number of control variables. These include age,[16] gender, whether the respondents have a partner and the number of their children (if any), education,[17] respondents' family income and their health status.[18] Moreover, we include an indicator for whether, as reported by the interviewer, there were other people present when the respondents took the cognitive tests, given that such a presence could have an effect on the respondents' test score. Finally, we include country fixed effects in all specifications in order to capture country-specific factors that might affect our outcomes. When we use panel data methods, time invariant controls like gender, education (which does not change in our sample of the 50+) and country fixed effects will drop out of the estimation. In all our specifications we estimate robust standard errors clustered at the household level in order to capture any unobservable interactions between persons living in the same household.

We first estimated an OLS specification, which gives consistent results if no regressor is correlated with either a_i or w_{it}. Results are shown in Panel A of Table 2, and the values of the AIC for the various polynomial specifications can be found in Panel A1 of Table A.1 in the Appendix. We note the strong statistical significance of the marginal effect (m.e.) of the number of social activities in the equations of all four cognitive test scores. The m.e. in the equation for numeracy is equal to 0.102, which implies that if one moved from engaging in no social activities to engaging in all four of them, the numeracy score would increase by

[16] We use three dummies for age that will denote being between 60 and 70, 70 and 80, and above 80, respectively, with those below 60 forming the base age group.

[17] We use two dummies denoting whether respondents have any post-secondary education and whether they have finished high school without getting any further education, respectively.

[18] Information on health status is captured by a dummy that is equal to one when respondents report their health to be fair or bad, and by a variable denoting the number of activities of daily living (ADLs) in which they feel limited.

0.408, which is about equal to 0.34 standard deviations (SDs) of the test score (the SD of the numeracy score is about 1.2). The same change in the number of social activities would result in an increase of 4.24 words (=4*1.154) in the fluency score, i.e., an increase of 0.59 SDs (the SD of the fluency score is equal to 7.87). Similarly, four additional social activities would improve the scores for immediate and delayed recall by 0.84 and 0.97 words, respectively, which would represent 0.43 and 0.48 of the respective SDs of the two memory scores. All in all, the OLS results indicate important associations between social activities and all four cognitive scores.

Unfortunately, it is likely that these associations do not represent causal effects, as the number of social activities could be very well related to unobservable personality traits present in a_i (e.g. intellectual curiosity). In order to take care of the correlation of social activities (as well as of all the other regressors) with a_i, we proceeded to estimate panel models with fixed effects (FE). As the FE model can be estimated by using observations that appear at least twice in the sample, and given that we have to work with the two first waves of SHARE, only the observations from the balanced panel are included in the FE estimation. Consequently, our estimation sample contains about 36,100 observations (as opposed to about 56,900 observations when using OLS).

As expected, the FE results (shown in Panel B of Table 2)[19] were a bit weaker than the OLS ones. However, social activities still remained relevant for three of the four cognitive scores (the exception being the immediate recall score). Using the same conceptual experiment as before (i.e., changing from engaging in no social activities to engaging in four of them), our FE results imply that these additional social activities would result in increases of about: i) 0.11 SDs for the numeracy score; ii) 0.20 SDs for the fluency score; iii) 0.46 SDs for the delayed recall score.

[19] The AIC values of the various specifications can be found in Panel B1 of Table A.1.

We also performed a random effects panel estimation, in which one assumes that no control variables (including the one denoting social activities) are correlated with a_i. After testing this model against the FE one using a Hausman specification test, we found that the null of no correlation of any variable with a_i was decisively rejected.[20] As a result, the FE specification was found preferable to the random effects one.

Having established the existence of an effect of social activities on cognition, it is important to understand how this can affect the economic welfare of older individuals. To this purpose, we use the results of Smith et al. (2010, henceforth SMW), who investigate the economic effect of cognition in older age.

First, let us consider our finding that engaging in four social activities increases numeracy by 0.11 SDs compared to having no social activities at all. In the 2006 US Health and Retirement Study (HRS) sample used by SMW, this result implies an increase of roughly 2,150 dollars in total household wealth and about 1,100 dollars in financial wealth.[21] Second, if we average the increase in immediate and delayed recall as SMW do, we get an increase of 0.23 SDs in the combined memory score. In the same HRS sample, this change in cognition would boost total and financial wealth by roughly 1,900 and 1,700 dollars, respectively.

Therefore, the overall increase in total household wealth due to a higher level of social activity would be about 4,050 dollars, while the corresponding increase in financial wealth would be about 2,800 dollars. These figures confirm that the positive impact (via higher cognition) that engaging in social activities has on older households' welfare is economically important.

[20] We use the bootstrap to calculate the variance of the difference of the two estimators, as described in Cameron and Trived (2005, p. 378 and p. 718).

[21] We use in our calculations the results for the financial respondent as recorded in Table 4 in SMW. When computing the effect of the change in the level of the cognition variables in SMW, we also use the results in McArdle et al. (2009). This latter study uses the exact same sample as SMW and also records the SDs of the cognition variables.

Having finalized the choice of the estimation method, we investigated whether our results differed by sex, both in the OLS and the FE models. The estimates for the two separate models are shown in Panels A2, A3, B2 and B3 of Table 2. For the OLS case, the effect of the number of social activities is statistically significant and sizeable in all specifications and in both sexes. In the FE case, however, the pattern of results is quite different. First, the effect of social activities on numeracy is statistically significant only for males, and it is by about 138% (=(0.081/0.034)-1) stronger than that of the whole sample. Using the SMW results, this higher level of numeracy would lead to increases in total and financial household wealth of about 5,100 dollars and 2,600 dollars, respectively.

Second, the opposite pattern is present for the fluency and immediate recall scores. The effect of social activities on these two cognitive indicators, is relevant only for females. In this case, results were stronger than those for the whole sample by about 3% (=(.399/.387)-1) and 78% (=(.064/.036)-1) for fluency and immediate recall, respectively. On the other hand, there were no major differences between the two sexes with respect to the effect of social activities on the delayed recall score, which remained important and about equal to that estimated from the whole sample.

All in all, the results obtained using our preferred estimation method (FE) suggest once more that social activities have a sizeable impact on all four cognitive scores. After splitting the sample by sex, however, we find substantial differences between males and females on which aspects of cognition are affected by such activities.

4. Robustness checks

In this section we will discuss a number of tests that we performed in order to check the robustness of our results. Due to space limitations we cannot show all our results, which are available from the authors upon request.

First, we wanted to take into account the correlation of the social activities with the overall error term u_{it} through the time-varying error w_{it}, and not just through a_i. Thus, we explored the use of IV methods as an alternative to FE, as they account for the correlation of social activities with a_i or w_{it}, or with both. We chose as instruments two variables that denote health problems in the respondent's partner, namely the number of problems in ADLs and in instrumental activities of daily living (IADLs).[22] The reason behind this choice of instruments is that the partner's health problems represent exogenous shocks that hit a person other than the respondent, and that are likely to negatively affect a respondent's ability to engage in social activities, but have no effect on his/her cognition. A possible objection to using these two variables as instruments would be that they might affect the respondent's cognition (by negatively affecting him/her psychologically). This might in turn affect his/her responses in the cognition tests. In order to control for this effect, we included in our specifications an indicator denoting whether the respondent felt depressed in the last month, but our results did not change at all. Therefore, we will present the IV results obtained without including the depression indicator in the specification.

The IV results can be found in Table 3. We first note that our two instruments of choice are very strongly correlated with the number of social activities, both in the whole sample and for females. This can be seen from the value of the F-test of the significance of the two instruments obtained from the first stage regression of the potentially endogenous variable on all the control variables and our instruments. In the case of males, the value of the F-test suggests that our instruments are weaker than desired. Furthermore, results from Hansen's J-test for overidentifying restrictions do not reject the null hypothesis that our two instruments are exogenous.

[22] This choice of instruments implies that we can use only couples in our estimation sample, which now contains about 34,000 observations. On the other hand, we can still use the observations that appear only once in it.

It is also important to check whether the use of instruments is justified, i.e. whether the variable denoting social activities is indeed endogenous. In order to check this, we performed a *C* test of the exogeneity. As can be seen from the results in Table 3, it is clear that the null hypothesis of no endogeneity is decisively rejected.[23] Therefore, the number of activities is indeed correlated with u_{it}, either through w_{it} or through a_i, or through both.

When examining the IV results it is immediately evident that they are much stronger than both the OLS and the FE ones. In particular, the IV m.e. for numeracy is about 20 times larger than the OLS one, while the IV results for fluency are more than 5 times stronger. In addition, the IV results for immediate and delayed recall are about 11 times larger than their OLS counterparts. Similar differences occur in the results for both sexes. It is a bit unusual to obtain IV results that are so much stronger than the OLS ones. Typically IV results are weaker, and one would expect the same to apply in our case if, for instance, there are unobservables in u_{it} that positively affect both cognition and social activities. On the other hand, the larger IV results could be justified by an increased engagement in an unobservable activity (e.g. reading books) that increases cognition but decreases the time one could devote to social activities.

One could try to take care of the possible correlation of social activities with both a_i or w_{it} by engaging in fixed effects estimation with instrumental variables (FE-IV). When we used this method, however, we found that our instruments for cross-sectional IV (the partner's number of ADLs and IADLs), were no longer strongly correlated with the social activities variable. Therefore, we added as instrument the partner's number of social activities, which turned out to be very strongly correlated with our potentially endogenous

[23] The C test of exogeneity is a test of orthogonality conditions and is equal to the difference in the Hansen-Sargan statistic between the model in which the regressor is endogenous and the one in which it is exogenous. See Hayashi (2000, pp. 218-221, 233-234) for a description of the *C* test of the endogeneity of a regressor in the context of IV estimation.

variable. Once more, the use of this instrument rests on the assumption that the social activities of one partner do not have any effect on the cognition of the other.

Before estimating the FE-IV specification with the additional instruments, we used them in the cross-sectional IV model and we found that our results remained the same. When we performed the FE-IV estimation, however, we found that the *C* test for the exogeneity of social activities could not reject the null of no endogeneity. This result implies that once the possible correlation of the social activities variable with a_i is taken care of through the FE estimation, there is no correlation of this variable with the time varying unobservable w_{it}.

There are two important implications of the results of the C-test test in the FE-IV model: i) the endogeneity of variable denoting the number social activities in the IV specification is due to its correlation with a_i, but not with w_{it}; ii) one need not use FE-IV because FE estimation suffices for taking care of the endogeneity of social activities.

The one remaining issue is whether one should prefer IV to FE or vice versa. We opt for FE over IV for the following reasons: i) FE controls for the correlation of all regressors with a_i and not just the correlation corresponding to the variable denoting social activities; ii) the FE model does not need any instruments; iii) the FE results are much closer to the OLS ones, and they are also smaller (as expected), while the IV ones are considerably larger. Therefore, the FE results represent conservative estimates of the impact of social activities on cognition.

One additional formal way to choose between FE and IV estimation is to perform a Hausman (1978) specification test. Under the null, only the variable denoting social activities is correlated with a_i and the IV estimates are consistent. On the other hand, if the null is rejected, then there are additional variables that are correlated with a_i, and thus one needs to perform FE estimation. The results from the Hausman test strongly reject the null; therefore, the IV model estimates are likely inconsistent and one needs to use the FE specification.

Next, we experimented with a FE specification that includes not only the number of narrowly defined social activities but also, as a separate variable, the number of the remaining three social activities. We found that the results for the number of the narrowly defined social activities are not affected by this change.

As already discussed, we addressed the issue of the nonlinearity of the effect of social activities on cognition by trying polynomials up to the third degree in the number of activities (and choosing between them using the AIC). One other way to address the same issue is to use dummy variables denoting various numbers of activities. To that effect, we estimated a FE specification that includes a dummy denoting one activity performed, as well as a second dummy denoting two or more activities performed.[24] Results are shown in Table 4, and we note that they are consistent with the FE results derived from the polynomial specifications in the number of activities (shown in Table 2). This consistency is present not only for the whole sample, but also for the two samples split by sex. The exceptions consist of the non-significance of the dummy denoting two or more activities in the equation for delayed recall, and of the corresponding dummy in the equation of immediate recall for females. When we compare, however, the values of the AIC in Table 4 to those from the polynomial specifications (shown in Table A.1), we found that the AIC clearly denoted the latter specifications as preferable. Therefore, we chose to use polynomials in the number of activities in order to derive our baseline results.

We then wanted to check the robustness of our results when we include in our specification not the total number of social activities, but rather each activity separately as a dummy variable. Obviously, this makes our specification much more flexible. On the other hand, there are a couple of reasons why including each activity separately might not be advisable. First, as shown in Table 1, the vast majority of respondents do not engage in any of

[24] We did not use a separate dummy for three or four activities performed because only about 0.7% of individuals in our sample engage into this many activities.

these activities. Hence, all of the dummy variables denoting activities will be zero for most respondents, which makes these variables very correlated to one another. Second, some activities could be complementary, e.g. volunteering and participating in a political organization. In fact, about 39% of the respondents engaging in the latter activity engage also in the former. Therefore, including each activity separately will measure the impact of one net of the other, which will not reflect very well how these activities are actually performed in real life. In any case, our FE results are shown in Panel A and B of Table 5, for the narrow and wider definition of activities, respectively. For the narrowly defined activities, it seems that taking part in a political and community-related organization has an impact on numeracy and delayed recall. Fluency, on the other hand, is more affected by volunteering and going to a sport or a club. For the expanded set of activities, the same results hold, but in addition taking part in a religious organization has an impact on fluency and immediate recall. In order to check whether including each activity separately improves the fit of our model compared to when using just the total number of activities, we compared the AIC from both specifications (the values of the AIC for the model with the total number of activities can be found in Table A.1 in the Appendix). For six out of the eight total combinations of cognition and social activities measures, we found that the specification with the total number of activities was preferable to the one that included each activity separately. Hence, we kept the former specification as our baseline one.

We also checked what happens when we weaken our measures of social activities. To this purpose, we considered all social activities, even when respondents report performing them less than once per week. We find that our results are indeed a bit weaker, especially for the fluency and the delayed recall scores. This suggests that what the respondents report is mirrored in our results, and thus the respondents' answers to the questions on the frequency of performed activities are of good quality.

One additional measure of cognition, used by Hu et al. (2012) involves the temporal awareness of the respondents, as measured by whether they report correctly the date, the month and the year in which the interview took place. To that effect, we constructed two measures of temporal awareness: i) one that goes from zero to three, measuring the answers to the aforementioned three questions; ii) one that adds to i) the answer to the question about which day of the week the interview took place in. For both measures we found that both the OLS and the FE results were statistically significant but extremely small in magnitude, typically 30 or more times smaller than the results found for numeracy. We conclude that there is no substantial effect of social activities on measures of temporal awareness.

As already discussed, one could also interpret the numeracy score not as the number of correctly answered questions, but rather as an indicator of the level of numeracy of the respondent. In this case, an appropriate statistical model to use would be an ordered probit, and we show the results from such a model in Table 6. We report the m.e.'s of the number of activities on the probability of reaching the five different levels of numeracy (higher levels indicate higher numeracy). In Panel A of Table 6 we report the results from a simple cross-sectional estimation, and we note the positive effect of the number of social activities (narrowly defined) on the level of numeracy. For example, one more activity decreases the probability of being at the lowest numeracy level by 1.3 pp, while it increases the probability of reaching the highest level by 2 pp. In Panel B we report the m.e.'s from an IV estimation, using once more the number of ADLs and IADLs of the partner as instruments. We use the control function IV method of Rivers and Vuong (1988), in which the residuals from the first stage regression are added as additional regressors in the main equation. As one can see in Panel B, these residuals are strongly statistically significant, which implies that indeed the number of activities is endogenous.[25] The m.e.'s of the number of activities are, as in the

[25] The same result was obtained in the linear IV model through the *C* test for endogeneity.

linear case, considerably stronger in the IV model. For example, one more social activity increases the probability of reaching the highest level of numeracy by 45 pp. All in all, the results from an ordered probit specification are qualitatively quite similar to those from a linear one. This suggests that the latter is a reasonable specification to use in order to model numeracy.

Unfortunately, it is problematic to perform a FE estimation when using the ordered probit model because in this case the fixed effects a_i's have to be estimated, unlike the case of the linear model (in which the a_i's drop out of the estimation). As a result, the ordered probit is affected by the incidental parameters problem (Neymann and Scott, 1948), which leads to inconsistent estimates, especially if one takes into account the fact that the length of our panel is small (Greene, 2004). The inconsistency of the FE estimates in an ordered probit model is the reason why we used a linear specification (as well as a couple of count data ones, see below) to examine the effect of social activities on numeracy.

Finally, given that the number of correct answers to a cognitive test could be considered a count variable, we experimented with Poisson and negative binomial FE specifications. In both cases the incidental parameters problem can be circumvented, as discussed in Hausman et al. (1984, henceforth HHG). In the Poisson case, the conditional mean of the outcome y_{it} is equal to $a_i \exp(\boldsymbol{x}_{it}\boldsymbol{\beta})$, and the fixed effects a_i can be conditioned out of the likelihood function.[26] Therefore, one can obtain consistent estimates of $\boldsymbol{\beta}$, as one does not need to maximize the likelihood function with respect to the a_i's. In order to estimate, however, the m.e.'s of our variable of interest on the conditional mean of y_{it}, we also need an estimate of the a_i's. As Cameron and Trivedi (2005, p. 805) point out, it can be shown that these estimates are equal to $\sum_t \frac{y_{it}}{\Sigma_t [\exp(\boldsymbol{x}]_{it}\boldsymbol{\beta})}$. We can thus calculate the m.e.'s of the Poisson FE

[26] As Cameron and Trivedi (2005, p. 803) show, one can rewrite $a_i \exp(\boldsymbol{x}_{it}\boldsymbol{\beta})$ as $\exp(\gamma_i + \boldsymbol{x}_{it}\boldsymbol{\beta})$. Therefore, the fixed effect a_i absorbs the constant of the linear index $\boldsymbol{x}_{it}\boldsymbol{\beta}$.

model, which we show in Panel A of Table 7, both for the whole sample and for the two sexes separately. We observe that these m.e.'s are a bit smaller than, but otherwise qualitatively very similar to, those obtained from the linear FE model.

In Panel B of Table 7 we show the m.e.'s of the number of social activities using the negative binomial FE model of HHG. In this model the conditional mean of y_{it} is equal to $\frac{a_i \exp(\boldsymbol{x}_{it}\boldsymbol{\beta})}{\varphi}$, where φ is a parameter of the variance function of the negative binomial distribution. As HHG show, a_i and φ cannot be separately identified, and it turns out that both drop out of the estimation. Furthermore, and in contrast to the Poisson case, one cannot obtain estimates of $\frac{a_i}{\varphi}$ from the negative binomial FE model, and thus the m.e.'s refer to the magnitude $\exp(\boldsymbol{x}_{it}\boldsymbol{\beta})$, and not to the conditional mean $\frac{a_i \exp(\boldsymbol{x}_{it}\boldsymbol{\beta})}{\varphi}$. We show the m.e's of the negative binomial FE model in Panel B of Table 7. We immediately note that they are much larger than the corresponding Poisson ones, both for the whole sample as well as for the two sexes. It is quite likely that this disparity is due to the scaling problem induced by the lack of estimates of $\frac{a_i}{\varphi}$. Therefore, and given that there is no known solution to this problem, we will not give any further consideration to the results from the negative binomial FE model.

There is, however, a more general issue that makes the use of both the Poisson and the negative binomial models problematic in our context. A key assumption in both models is that the events modelled (in our case the correct answers to each test) are independent from each other, conditional on $\boldsymbol{x}$, a_i (and φ in the negative binomial case). This assumption is unlikely to hold in the case of answers to cognitive tests. It is easiest to consider this lack of independence in the case of the answers to the immediate and delayed recall questions. In both cases there is a fixed number (ten) of particular words that respondents are asked to recall, and it stands to reason that they first mention the words that come to mind more easily. They are likely, however, to find it progressively more and more difficult to come up with the remaining words, given also the time pressure they are under (the enumeration has to take place in one minute). This should make the distribution of the inter-arrival time of correct answers move to the right as one comes closer to the maximum number of ten. This would be incompatible with the Poisson and negative binomial distributions, for which the inter-arrival time of events has a constant distribution in each sample unit. It is also likely that enumeration is a self-reinforcing process: remembering words with relative ease at the beginning of the enumeration process is likely to make respondents feel more confident and thus make it easier to remember the remaining words, while the opposite is true if respondents stumble at the beginning.[27] Finally, the lack of independence between correct answers is most obvious in the numeracy test, in which some questions are not asked at all if one does not answer correctly a previous question. This lack of independence between successive correct answers to the cognitive tests makes us sceptical about the applicability of both the Poisson and the negative binomial models in our context. Hence, we opt for the linear model as our baseline specification.

5. **Conclusions**

In this paper we investigated the impact of social activities on cognition later in life (as measured by test scores for numeracy, fluency, and immediate and delayed recall), by using representative and harmonized survey data for individuals aged fifty and above from eleven European countries.

We found that social activities have an important effect on cognition, with results differing by sex. Social activities increase cognitive performance in females by affecting their

[27] This should also be true of the fluency questions, even if there is no maximum number of words and one is free to mention any relevant words that come to mind

fluency, and immediate and delayed recall. On the other hand, the improvement in males comes with respect to numeracy and delayed recall. Importantly, we found these effects after addressing the issue of the endogeneity of social activities through the use of panel data and IV methods. As a result, we conclude that social activities have a positive causal impact on cognition in older age.

Given that several studies have demonstrated that higher cognition in older age is associated with significantly better economic outcomes, our findings suggest that having a socially active life in older age can have an important economic impact. Therefore, pursuing policies that target the social involvement of older people can be justified not only on medical but also on economic grounds.

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Table 1. Descriptive Statistics

	Sweden	Denmark	Germany	Netherlands	Belgium	France	Switzerland	Austria	Italy	Spain	Greece	All Countries
Cognitive test scores												
Number of correctly answered numeracy questions	2.58	2.51	2.58	2.58	2.31	2.11	2.75	2.64	1.84	1.45	2.31	2.19
Number of words in fluency test	22.63	21.53	20.19	19.58	19.70	19.31	20.30	21.10	14.25	14.16	14.36	17.98
Number of words recalled immediately	5.20	5.42	5.30	5.17	4.94	4.53	5.29	5.22	4.15	3.54	4.72	4.67
Number of words recalled with a delay	3.93	4.16	3.63	3.81	3.34	3.09	3.88	3.73	2.70	2.33	3.22	3.19
Social activities												
Done voluntary or charity work	0.112	0.124	0.076	0.177	0.110	0.103	0.090	0.041	0.045	0.014	0.013	0.072
Follows an educational/training course	0.066	0.039	0.020	0.044	0.066	0.025	0.074	0.019	0.008	0.018	0.017	0.024
Gone to a sport, social or other kind of club	0.208	0.305	0.162	0.267	0.166	0.157	0.246	0.109	0.053	0.057	0.042	0.132
Taken part in a political or community-related organization	0.020	0.019	0.010	0.016	0.038	0.020	0.025	0.025	0.009	0.005	0.013	0.013
Taken part in a religious organization (including religious attendance)	0.062	0.033	0.057	0.082	0.055	0.043	0.085	0.087	0.048	0.076	0.219	0.063
Cared for a sick or disabled adult	0.065	0.040	0.058	0.070	0.078	0.061	0.065	0.058	0.028	0.022	0.043	0.049
Provided help to family, friends or neighbors	0.247	0.160	0.089	0.142	0.187	0.138	0.129	0.103	0.066	0.032	0.068	0.098
Number of often performed activities (narrow definition)	0.407	0.487	0.267	0.504	0.380	0.305	0.436	0.195	0.116	0.094	0.086	0.240
Number of often performed activities (all)	0.781	0.721	0.471	0.797	0.699	0.547	0.714	0.444	0.257	0.223	0.416	0.450
Other variables												
Age	67.1	66.0	67.1	65.7	66.1	65.7	66.4	67.0	67.9	68.0	67.2	67.0
Female	0.539	0.535	0.553	0.548	0.538	0.550	0.552	0.557	0.566	0.566	0.542	0.555
Has a spouse/partner	0.623	0.661	0.651	0.678	0.735	0.696	0.675	0.616	0.662	0.660	0.681	0.667
Number of children	2.253	2.206	1.898	2.362	2.140	2.253	2.097	1.966	2.039	2.374	1.919	2.104
Post-secondary education	0.211	0.349	0.247	0.215	0.245	0.198	0.107	0.209	0.064	0.085	0.133	0.173
High schoold graduate	0.266	0.411	0.552	0.229	0.255	0.291	0.458	0.481	0.195	0.075	0.226	0.323
Self-reported health fair or bad	0.222	0.255	0.413	0.296	0.283	0.354	0.175	0.320	0.449	0.461	0.299	0.386
Number of limitations in activities of daily living	0.205	0.193	0.245	0.165	0.222	0.224	0.106	0.209	0.269	0.306	0.173	0.241
Lives in a city or in the suburbs	0.357	0.333	0.261	0.448	0.263	0.301	0.179	0.289	0.195	0.318	0.460	0.282
Median household income (PPP-adjusted euros)	24,685	24,589	23,598	28,397	21,662	25,498	31,555	23,617	16,938	13,826	15,001	21,247
Number of observations	5,691	4,123	5,436	5,461	6,688	5,875	2,362	3,168	5,411	4,499	5,701	54,415

Notes: All figures denote weighted averages, unless otherwise noted. Social activities are considered to be performed only if respondents answer that they engage in them at least once a week. Narrowly defined social activities include: i) doing voluntary or charity work; ii) following an educational/training course; iii) going to a sport, social or other kind of club; iv) taking part into a political or community-related organization.

Table 2. The impact of often performed social activities (narrow definition) on cognitive scores, various specifications

Magnitudes	Numeracy			Fluency			Immediate Recall			Delayed Recall		
	Coeff.	Std. Error		Coeff.	Std. Error		Coeff.	Std. Error		Coeff.	Std. Error	
Panel A. OLS												
A1. Whole Sample												
Number of activities	0.102	0.008	***	1.154	0.059	***	0.209	0.013	***	0.243	0.016	***
R^2	0.102			0.318			0.209			0.262		
Number of observations	54,917			54,797			54,894			54,907		
A2. Females												
Number of activities	0.101	0.012	***	1.301	0.077	***	0.263	0.019	***	0.307	0.023	***
R^2	0.286			0.350			0.263			0.287		
Number of observations	30,430			30,398			30,451			30,455		
A3. Males												
Number of activities	0.104	0.011	***	0.978	0.083	***	0.156	0.018	***	0.166	0.020	***
R^2	0.260			0.277			0.258			0.220		
Number of observations	24,487			24,399			24,443			24,452		
Panel B. Panel Fixed Effects												
B1. Whole Sample												
Number of activities	0.034	0.013	***	0.387	0.139	***	0.036	0.022		0.234	0.066	***
R^2	0.069			0.090			0.080			0.080		
Number of observations	36,098			35,996			36,104			36,118		
B2. Females												
Number of activities	0.011	0.018		0.399	0.114	***	0.064	0.031	**	0.247	0.094	***
R^2	0.064			0.085			0.118			0.082		
Number of observations	20,102			20,088			20,138			20,144		
B3. Males												
Number of activities	0.081	0.028	***	0.119	0.123		0.007	0.032		0.225	0.091	**
R^2	0.063			0.069			0.019			0.027		
Number of observations	15,996			15,908			15,966			15,974		

Notes: Marginal effects of the number of activities are shown. When a nonlinear specification in the number of social activities is preferred, the standard errors of the marginal effects are obtained using the delta method. ***,**,* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 3. Instrumental variables results

Magnitudes	Numeracy		Fluency		Immediate Recall		Delayed Recall	
	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error
Panel A. Whole Sample								
Number of activities	1.970	0.517 ***	6.776	3.059 **	2.191	0.712 ***	2.611	0.817 ***
F test for weak instruments from the first stage regression	18.947		19.253		19.129		18.959	
Hansen J-test of overidentifying restrictions	0.034		0.037		0.313		1.409	
Hansen J-test of overidentifying restrictions - P-value	0.853		0.848		0.576		0.235	
C-test of endogeneity	21.447		3.913		9.555		11.105	
C-test of endogeneity - P-value	0.000		0.048		0.002		0.001	
Number of observations	34,027		33,957		34,002		34,011	
Panel B. Females								
Number of activities	1.347	0.598 **	5.280	4.515	2.411	0.996 **	2.330	1.101 **
F test for weak instruments from the first stage regression	13.449		13.531		13.488		13.502	
Hansen J-test of overidentifying restrictions	1.241		1.546		0.060		1.078	
Hansen J-test of overidentifying restrictions - P-value	0.265		0.214		0.806		0.299	
C-test of endogeneity	5.517		0.814		5.671		3.861	
C-test of endogeneity - P-value	0.019		0.367		0.017		0.049	
Number of observations	17,070		17,054		17,079		17,081	
Panel C. Males								
Number of activities	2.702	0.931 ***	8.736	4.041 **	2.039	0.972 **	3.004	1.208 **
F test for weak instruments from the first stage regression	6.980		7.099		7.072		6.924	
Hansen J-test of overidentifying restrictions	0.649		1.339		1.176		0.455	
Hansen J-test of overidentifying restrictions - P-value	0.420		0.247		0.278		0.500	
C-test of endogeneity	18.958		5.050		4.735		9.000	
C-test of endogeneity - P-value	0.000		0.025		0.030		0.003	
Number of observations	16,957		16,903		16,923		16,930	

Notes: ***,**,* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 4. The impact of social activities on cognitive scores when dummies for the number of activities are used in the estimating equation, fixed effects specification

Magnitudes	Numeracy		Fluency		Immediate Recall		Delayed Recall	
	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error
				Panel A. Whole Sample				
One activity	0.041	0.018 **	0.327	0.113 ***	0.039	0.029	0.123	0.033 ***
Two or more activities	0.067	0.031 **	0.545	0.206 ***	0.068	0.056	0.088	0.062
R^2	0.070		0.090		0.080		0.080	
Number of observations	36,098		35,996		36,104		36,118	
Akaike Information Criterion	52,574.54		183,580.05		90,956.52		96,727.61	
				Panel B. Females				
One activity	0.012	0.024	0.488	0.145 ***	0.076	0.039 **	0.114	0.045 **
Two or more activities	0.030	0.042	0.721	0.278 ***	0.106	0.077	0.062	0.085
R^2	0.065		0.087		0.118		0.080	
Number of observations	20,102		20,088		20,138		20,144	
Akaike Information Criterion	29,005.68		101,813.02		50,442.28		54,314.30	
				Panel C. Males				
One activity	0.074	0.026 ***	0.131	0.170	-0.002	0.044	0.134	0.047 ***
Two or more activities	0.108	0.044 **	0.339	0.304	0.026	0.077	0.117	0.087
R^2	0.063		0.071		0.019		0.027	
Number of observations	15,996		15,908		15,966		15,974	
Akaike Information Criterion	23,563.09		81,745.80		40,507.12		42,366.96	

Notes: We display the marginal effects (which are equal to the regression coefficients in this case) of the dummy variables denoting the number of activities on the various cognition scores. ***,**,* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5. The impact of social activities on cognitive scores when each activity enters separately in the estimating equation, fixed effects specification

Magnitudes	Numeracy		Fluency		Immediate Recall		Delayed Recall	
	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error
Panel A. Often performed activities, narrow definition								
Done voluntary or charity work	0.041	0.027	0.443	0.168 ***	-0.007	0.046	0.058	0.053
Taken part in a political or community-related organization	0.065	0.042	-0.185	0.300	0.029	0.089	0.148	0.092
Follows an educational/training course	0.029	0.031	0.131	0.204	0.078	0.052	0.112	0.059 *
Gone to a sport, social or other kind of club	0.025	0.019	0.297	0.126 **	0.046	0.033	0.068	0.036 *
R^2	0.069		0.088		0.080		0.078	
Number of observations	36,098		35,996		36,104		36,118	
Akaike Information Criterion	52,578.64		183,578.83		90,956.72		96,736.23	
Panel B. Often performed activities, all								
Done voluntary or charity work	0.037	0.027	0.402	0.168 **	-0.012	0.046	0.055	0.053
Taken part in a political or community-related organization	0.064	0.042	-0.198	0.300	0.027	0.089	0.147	0.092
Follows an educational/training course	0.028	0.031	0.116	0.204	0.076	0.052	0.111	0.059 *
Gone to a sport, social or other kind of club	0.025	0.019	0.284	0.126 **	0.045	0.033	0.067	0.036 *
Taken part in a religious organization (including religious attendance)	0.062	0.027 **	0.394	0.160 **	0.123	0.048 **	0.035	0.052
Provided help to family, friends or neighbors	-0.006	0.018	0.159	0.117	-0.029	0.031	0.003	0.033
Cared for a sick or disabled adult	0.032	0.026	0.249	0.157	0.018	0.045	0.015	0.050
R^2	0.063		0.089		0.075		0.080	
Number of observations	36,084		35,982		36,090		36,104	
Akaike Information Criterion	52,525.52		183,501.65		90,918.24		96,691.36	

Notes: We display the marginal effects (which are equal to the regression coefficients in this case) of each activity on the various cognition scores. ***,**,* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 6. Ordered probit specification for the numeracy score

Magnitudes	Number of Often Performed Activities		
	Marg. Eff.	Std. Error	
Panel A. Cross-Sectional Estimation without IV			
1st Level of Numeracy	-0.013	0.001	***
2nd Level of Numeracy	-0.013	0.001	***
3d Level of Numeracy	-0.006	0.001	***
4th Level of Numeracy	0.012	0.001	***
5th Level of Numeracy	0.020	0.002	***
Number of observations	54,917		
Panel B. Cross-Sectional Estimation with IV			
1st Level of Numeracy	-0.226	0.049	***
2nd Level of Numeracy	-0.290	0.063	***
3d Level of Numeracy	-0.173	0.038	***
4th Level of Numeracy	0.235	0.051	***
5th Level of Numeracy	0.454	0.098	***
Residual from First Stage Regression	-2.023	0.458	***
Number of observations	34,027		

Notes: Marginal effects of the number of activities on the probability of reaching any given level of numeracy are displayed. Standard errors of the marginal effects are obtained using the delta method. ***,**,* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 7. Results using fixed-effects Poisson and Negative Binomial Models

Magnitudes	Numeracy		Fluency		Immediate Recall		Delayed Recall	
	Marg. Eff.	Std. Error	Marg. Eff.	Std. Error	Marg. Eff.	Std. Error	Marg. Eff.	Std. Error
Panel A. Poisson								
A1. Whole Sample								
Number of activities	0.029	0.011 ***	0.225	0.072 ***	0.030	0.019	0.062	0.020 ***
Number of observations	35,184		35,982		35,996		34,896	
A2. Females								
Number of activities	0.008	0.014	0.321	0.093 ***	0.052	0.026 **	0.053	0.031 *
Number of observations	19,434		20,080		20,084		19,474	
A3. Males								
Number of activities	0.052	0.016 ***	0.106	0.108	0.006	0.029	0.074	0.031 **
Number of observations	15,750		15,902		15,912		15,422	
Panel B. Negative Binomial								
B1. Whole Sample								
Number of activities	1.182	0.163 ***	0.693	0.080 ***	0.837	0.115 ***	1.086	0.141 ***
Number of observations	35,184		35,982		35,996		34,896	
B2. Females								
Number of activities	0.900	0.213 ***	0.806	0.106 ***	0.931	0.161 ***	0.878	0.189 ***
Number of observations	19,434		20,080		20,084		19,474	
B3. Males								
Number of activities	1.505	0.251 ***	0.502	0.110 ***	0.736	0.208 ***	1.044	0.210 ***
Number of observations	15,750		15,902		15,912		15,422	

Notes: We display the marginal effects of the number of activities on the various cognition scores. The standard errors of the marginal effects are obtained using the delta method. ***,**,* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Appendix

Table A1. Values of the Akaike Information Criterion for Various OLS and FE Specifications of the Number of Social Activities

Specifications	Numeracy	Fluency	Immediate Recall	Delayed Recall
		Panel A. OLS		
		A1. Whole Sample		
Linear Specification	150,322.90	356,452.65	203,561.86	217,037.12
Quadratic Specification	**150,313.74**	356,436.75	**203,557.81**	217,035.68
Cubic Specification	150,315.55	**356,436.47**	203,558.48	**217,033.52**
		A2. Females		
Linear Specification	83,702.01	196,590.04	113,137.12	121,162.33
Quadratic Specification	**83,696.53**	**196,578.89**	113,136.94	121,161.32
Cubic Specification	83,698.53	196,580.50	**113,135.60**	**121,155.51**
		A3. Males		
Linear Specification	66,548.25	159,775.84	90,279.31	**95,700.80**
Quadratic Specification	**66,545.91**	159,772.95	**90,278.66**	95,702.52
Cubic Specification	66,547.52	**159,772.93**	90,280.46	95,704.48
		Panel B. Linear Fixed Effects		
		B1. Whole Sample		
Linear Specification	**52,574.10**	183,580.93	**90,954.13**	96,732.68
Quadratic Specification	52,574.76	**183,580.01**	90,956.12	96,733.02
Cubic Specification	52,576.75	183,581.53	90,958.10	**96,724.48**
		B2. Females		
Linear Specification	**29,004.01**	**101,812.48**	**50,439.88**	54,315.78
Quadratic Specification	29,005.91	101,812.91	50,441.82	54,317.60
Cubic Specification	29,007.89	101,814.69	50,443.39	**54,311.45**
		B3. Males		
Linear Specification	23,563.14	**81,744.92**	**40,505.33**	42,369.17
Quadratic Specification	**23,562.94**	81,745.94	40,507.26	42,369.04
Cubic Specification	23,564.94	81,746.07	40,509.14	**42,367.76**

Notes: Lower values of the Akaike criterion denote a better fit. We present in bold letters the values of the criterion for the preferred specifications.

Fig. 1. Means of the four cognitive test scores, by the number of social activities performed