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Quantitative Social Science

Working Paper No. 21-15

April 2021

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Quantitative Social Science

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Engaging in cognitively stimulating activities and change in cognitive function: a cross-country analysis using SHARE

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Abstract

We examine the relationship between different types of cognitively stimulating activities (CSAs) and cognitive function in a sample of community-dwelling Europeans aged 50 and older. The data were drawn from the fourth, fifth and sixth waves of the Survey on Health, Ageing and Retirement in Europe (SHARE). The cognitive activities analysed were: educational and training courses; reading books, newspapers and magazines; word or number games (such as crossword puzzles or Sudoku); and playing chess or cards. The cognitive function outcomes under investigation were memory and verbal fluency. Our longitudinal analysis of changes in cognitive abilities show that CSAs can constitute a potential source for the delay or reduction of cognitive decline, even after a short period - only 4 years - of engagement in such activities and regardless of one's age.

Keywords: ageing, cognitive decline, memory, verbal fluency, cognitively stimulating activities.
JEL Codes: J14, J26, I12, I21

Acknowledgements: We are grateful to Dick Wiggins, Paola Zaninotto and John Jerrim for helpful comments on earlier versions of this paper. We thank the SHARE project (www.share-project.org) for providing access to the data.

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1. Introduction

In many developed countries, the population is ageing rapidly as fertility rates drop, and life expectancy rises. We are not only living longer, but we also have fewer children. According to recent estimates, by 2050, the share of the population aged 65 years or over will more than double worldwide, jumping from the current level of 9.3% to 16.0% (UN, 2020).

One of the significant implications of ageing is cognitive decline. Age-associated cognitive ageing is an essential human experience which broadly refers to the deterioration in cognitive abilities occurring as people get older. This condition affects all people, albeit to varying degrees, and not just those who experience dementia or mild cognitive impairment. For this reason, it is crucial to understand this human process better, as it can affect key daily living activities, such as driving, banking or the administering of medication (Harada et al., 2013).

Although there are clear generalities and shared principles in cognitive decline, the extent of change in age-related cognitive function varies considerably across individuals and cognitive domains.

According to the famous model provided by Cattel (1971, and 1987), it is possible to distinguish between two types of cognitive abilities, namely *fluid* vs *crystallised* intelligence. Thanks to fluid intelligence (usually denoted Gf), we learn or understand things independently of prior knowledge (Baltes, 1993). Gf includes a person's innate ability to process and learn new information, solve problems, and reason about things. It refers to cognitive functioning elements such as attentional capacity, processing speed, reasoning, working memory capacity and spatial ability (Cattel, 1971), it is thought to be primarily determined by genetic and biological factors (Toga and Thompson, 2005). Crystallised intelligence (usually denoted Gc), on the other hand, refers to skills, abilities, and knowledge which is acquired or learned (Baltes, 1993), such as verbal abilities, including vocabulary, information, and comprehension. Gc, which show stability across time, is argued to be primarily socially and culturally determined (Ibidem). It may be useful to consider a computer metaphor, wherein the hard drive represents our fluid abilities and computer software programs represent our crystallised abilities.

As Desjardins and Warnke stressed in their detailed paper (2012), in the early phase of the lifespan, the two intelligence processes go side by side: we expect that Gc rises together with Gf. However, from somewhere in one's mid-twenties - in the third decade of life -, the direction and rate of these processes change significantly: Gf begins to display a declining pattern, whereas Gc continues to rise, eventually levelling off between the ages of 60 and 70.

That explains why older adults tend to perform better at tasks requiring crystallised intelligence than younger adults. Many studies, including both cross-sectional analyses (Horn and Noll, 1997; Lindenberger and Baltes, 1997), and longitudinal designs (Baltes and Mayer, 1999; Schaie and Zanjani 2006), support these predictions.

Nevertheless, the decline of cognitive functioning with age is not inevitable. Nature provides clear examples of older adults who maintain mental vitality, and this may be seen even among the most elderly. Some of them out-perform young people, at least on some cognitive tasks, and others of similar vintage do at least as well as the young. Indeed empirical studies suggest there is considerable variation in individual patterns of cognitive ageing. Depending on biological, behavioural, environmental and social influences, individual trajectories vary considerably (Barnes et al., 2007; Depp and Jeste, 2006; Yaffe et al., 2009).

Due to this phenomenon’s complex nature, its risk factors and consequences are still not fully understood. First, the decline in individual cognitive function is a significant concern as it is associated with an increased risk of mortality, disability, and low quality of life (Batty et al. 2016; Plassman et al., 2010). Secondly, the relationship between cognitive ageing and productivity matters for long-term economic growth. Older individuals learn at a slower pace and have reductions in their memory and reasoning abilities. In particular, senior workers are likely to have difficulties adjusting to new ways of working, especially in roles and skills affected by technological progress (Skirbekk, 2004). Thirdly, cognitive functioning is also crucial for decision-making as it influences an individuals' ability to process information and make logical choices. As people are increasingly required to make complicated financial, health, and long-term care decisions as they age, a reliable cognitive functioning level is precious (Salthouse, 2012).

The concerns and challenges discussed above raise an essential question: can cognitive decline be slowed down or reduced? According to the well-known notions of “use it or lose it” (Small et al., 2007) and “activities enrichment” (Hertzog et al., 2008), leading a lifestyle rich with engaging activities or environmental complexity may provide enhancing effects on the brain and cognitive health. *“The continued deployment of cognitive abilities through activities requiring cognitive effort may have direct effects on the brain, in terms of structure and/or function. This is closely linked to the ‘cognitive reserve’ hypothesis. Individuals who are more cognitively active or engaged may accrue greater ‘reserve capacity’ across the lifecourse, and subsequently delay the onset of age-associated cognitive decline or reduce the impact of this*” (Deary et al., 2009; p. 147). Several studies have already suggested that the participation in activities of a mentally or intellectually stimulating nature can reduce cognitive decline. Most studies have scaled activities by collecting self-reports of specific activities deemed cognitively stimulating, such as reading a book, attending a play, playing chess or cards, and asking people to indicate whether, or how frequently, they participated in each activity during a specified period. More frequent participation in cognitive activities is correlated with better cognitive performance (Gallucci et al., 2009; Lachman et al., 2010; Wilson et al., 2005). In particular, more cognitively complex activities, such as reading and involvement in clubs or organizations (Singh-Manoux et al., 2003), doing crossword puzzles or Sudoku (Litwin et al., 2017) and intellectual activities (Elwood et al., 1999) are associated with better cognitive functioning.

In short, certain small-scale clinical trials and some more extensive cross-sectional studies have inferred that engaging in cognitively stimulating activities (henceforth abbreviated CSAs) may augment cognitive performance, but there is still little reported longitudinal examination of this association using probability samples composed of older adults. The current study will address this gap in the literature.

Based on data from the Survey on Health, Ageing and Retirement in Europe (SHARE), this paper studies the role of some CSAs on cognitive functioning in old age focusing on two measures of mental abilities: memory and verbal fluency. We model cognitive abilities as a function of the self-reported level of engagement with CSAs, such as the participation in adult education and training courses, playing board games (such as cards and chess), doing word or number games (i.e. sudoku, crosswords and puzzles), reading books, magazines or newspapers; plus some behavioural risk factors (i.e. drinking, physical inactivity etc.) as well as social engagement at old age.

This study contributes to the debate on CSAs in counteracting the normative cognitive decline of older individuals in developed countries. It does this, principally, in two ways.

First, different data compared to previous studies on the same topic were used. Although other papers rely on SHARE, all exploit a maximum of the first five waves and not the most recent information. As a result, the studies restrict attention to most Western European countries, and none include respondents from Estonia, the Czech Republic or Slovenia, for example. Second, and most importantly, some sources of heterogeneity in the effect of stimulating intellectual factors on cognition were analysed.

The rest of the paper is arranged as follows: data and variables are discussed in Section 2, and our empirical methodology is set out in section 3. The results are reported in Section 4. In Section 5 we discuss the implications of our findings and draw conclusions.

2. Data

The SHARE survey

Data from the Survey of Health, Ageing and Retirement in Europe (SHARE) were used in this study. SHARE is a multidisciplinary and cross-national bi-annual household panel survey designed to be harmonized with the U.S. Health and Retirement Study (HRS) and the English Longitudinal Study of Ageing (ELSA). It collects data on health, socioeconomic status, and social and family networks for nationally representative samples of older people in the participating countries. The target population consists of individuals aged 50 and above who speak the country's official language and do not live abroad or in an institution, plus their spouses or partners irrespective of age (Bergaman et al., 2019)[3]. The first wave of SHARE was launched in 2004/05 in 11 Continental European countries (Börsch-Supan et al. 2005). Since then, it has been conducted biannually. The seventh wave of this multidisciplinary and cross-national panel database was collected in 27 European countries plus Israel in 2017. With the public release of Wave 7 in 2019, the data available are based on more than 375,000 interviews[4] administered on the nearly 140,000 respondents who participated in the survey so far. The data collection is done according to strict quality standards and with ex-ante harmonized interviews across the participating countries.

Sample selection

The sample used in this paper is from waves 4, 5 and 6 of SHARE. The fourth wave served as the baseline in the current analysis as it was the first time that the SHARE questionnaire specifically measured engagement in CSAs. Pooling data from Waves 4, 5, 6 allowed examining the variables related to baseline cognitive activities and the relationship of such activities to cognitive functioning across different waves.

The empirical analysis is restricted to respondents aged 50 or more. Thus it excluded the partners who, at the time of the interview, were under 50. Furthermore, attention was focused on individuals interviewed in the countries contributing to each of the waves 4, 5 and

[3] Persons were excluded if they were incarcerated, hospitalized, or out of the country during the entire survey period, unable to speak the country's languages, could not be located due to errors in sampling frame (e.g., non-existent address, vacant house), or have moved to an unknown address (see Bergaman et al., 2019).
[4] The interview mode is the Computer Assisted Personal Interview (CAPI). The interviewers conducted face-to-face interviews using a laptop computer on which the CAPI instrument is installed.

6. The final sample includes data from twelve selected European countries: Austria, Belgium, Czech Republic, Denmark, Estonia, France, Germany, Italy, Slovenia, Spain, Sweden and Switzerland.

In this study, the sample consists only of individuals participating in at least two of the three waves. Among these are individuals who participated in Wave 6. Remaining are the respondents who first appear either on wave 4 or 5 and present a common measurement on wave 6. Individuals with disabilities or permanently sick were dropped from the analysis, as well as individuals who indicated that they had ever been diagnosed with a stroke, Parkinson disease, Alzheimer's disease, dementia, or senility, all of which impact cognition. By structuring the sample, the research will focus only on normal cognitive ageing[5].

The final sample is therefore an unbalanced panel and includes some 114,974 observations on 43,687 individuals (see Table 1). Among these, about 63% participated in three waves, 32% in waves 5 and 6, and the remaining 5% participated in waves 4 and 6 only. Wave 6 is thus the wave common to every respondent in our selected sample.

Table 1 – Sample size by European countries participating in Wave 4, 5 and 6

		ORIGINAL SAMPLE		SELECTED SAMPLE	
		(1)	(2)	(4)	(5)
REGION/COUNTRIES	VARIABLES	N	%	N	%
Austria	Country	*5,457*	*7.37*	*3,121*	*7.14*
Belgium	Country	*7,888*	*10.65*	*4,214*	*9.65*
Czech Republic	Country	*7,018*	*9.48*	*4,439*	*10.16*
Denmark	Country	*4,647*	*6.27*	*3,093*	*7.08*
Estonia	Country	*7,563*	*10.21*	*4,557*	*10.43*
France	Country	*6,538*	*8.83*	*3,233*	*7.40*
Germany	Country	*6,176*	*8.34*	*4,007*	*9.17*
Italy	Country	*6,989*	*9.44*	*3,613*	*8.27*
Slovenia	Country	*5,210*	*7.04*	*2,497*	*5.72*
Spain	Country	*7,520*	*10.15*	*4,814*	*11.02*
Sweden	Country	*5,220*	*7.05*	*3,524*	*8.07*
Switzerland	Country	*3,831*	*5.17*	*2,575*	*5.89*
Total		74,057	100.00	43,687	100.00

[5] Normal cognitive ageing is the cognitive decline caused by biological ageing universal to all individuals. In contrast, pathological cognitive decline is caused by age-related neurological conditions such as dementia or Alzheimer's disease (AD) (see Deary et al., 2009).

Cognitive functioning measures

Cognitive ageing is a multidimensional phenomenon, and several aspects of the respondent's cognitive functioning are assessed in SHARE. In particular, SHARE includes four different measures for cognitive functions: orientation in time, verbal fluency, memory and numeracy. These four measures are the outcome of brief tests, included in the CAPI questionnaire, that follow a protocol aimed at minimising the potential influence of the interviewer and the interview process (Mazzonna and Peracchi, 2012).

Orientation as to date, month, year and day of the week is a rather basic cognitive functioning indicator. In the current study, orientation was not included due to its limited variation across waves (more than 80% of the respondents answered correctly the four questions about the interview date - day, month and year - and day of the week in each wave, see Table A2 in the Appendix) and to the fact that it is more appropriate for detecting severe cognitive deficits.

The numeracy measure is based on a Serial Sevens test; respondents are asked to subtract 7 from 100 and then continue subtracting from the given answer four more times. The test is a measure of concentration and essential calculation skills (Karzmark, 2000). Respondents received one point for each correct answer. In cases of mistakes, subsequent responses were counted if they were correct in relation to the previous number (Scholey et al., 2001). The final scores have a narrow range, from 1 (bad) to 5 (good). In the sample under study, variability is very low: 14% of the observations score 4 and more than 60% are a score of 5, the maximum score (see Table A3 in the Appendix). That shows a clear situation of "ceiling effects" since many subjects have maximum scores. Due to this low variability, numeracy is not considered as a possible outcome here.

Verbal fluency is one of the most commonly used tasks in clinical practice to assess semantic memory (Clark et al., 2009; Dal Bianco et al., 2013). Semantic memory stores factual information acquired over a lifetime; it is often not tied to the space or time of learning, and its retrieval is generally prefaced with "I know". It is used when a person provides answers to factual questions, such as naming a state capital. Usually, older adults do not have significant impairments in semantic memory, and typically they perform as well as young adults on tasks testing this type of memory (Craik and Jennings, 1992; Spaniol et al., 2006). An individual's accumulated semantic knowledge and memory increases into the sixth and seventh decades of life, and only a slight decline may be seen subsequently (Brickman and Stern, 2009). In the verbal fluency task, the participant is asked to name as many items meeting a given criterion as they can in 1 min. Typically the criterion will be orthographic (words starting with a given letter, e.g., F) or semantic (words falling into a given semantic category, e.g., animals or vegetables). In SHARE verbal fluency is assessed through a semantic test. It is measured by asking respondents to name as many distinct animals (real or mythical), without repetitions or proper nouns, in 1 minute. The number of distinct animals enumerated among selected respondents – the score of the test – ranges from 0 to 100. The mean is 21.1. Half of the results lie between 16 and 27.

Memory is assessed with a modified version of Rey's Auditory Verbal Learning Test (RAVLT), which tests short-term verbal learning and memory and information retention (Dal Bianco et al., 2013). This test can be used as a measure of episodic memory (Cheke and Clayton, 2013), which refers to memory from personally experienced events in a particular place and at a particular time. This kind of memory allows one to think back through subjective time (the so-called "mental time travel", see Tulving, 2002), and it usually evokes an "I remember" response. It is the most advanced form of memory and is the latest to develop. It also seems the most susceptible to brain damage and the most affected by normal ageing. Thus, it tends to decline with age. The declines are more significant when the task demands are more complex, or few environmental supports or cues are available - e.g., writing a note to oneself about where the car was parked - (Institute of Medicine, 2015). In the modified version of RAVLT used in SHARE, the interviewer reads out a list of 10 words, after which the respondent is asked to recall as many of them as s/he can. After 5–10 minutes, the respondent is asked to recall the words from that list[6]. The CAPI controls the speed at which the words are read out. The values for both memory tests range from 0 to 10. Furthermore, to ensure comparability with previous literature on cognitive decline (Rohwedder and Willis, 2010; Banks and Mazzonna, 2012, Bonsang et al., 2012), in this research we constructed a memory variable, based on the sum of the scores on immediate and delayed recall. The combined memory score ranges from 0 to 20, while for fluency, the raw score was taken.

In common with most of the literature on cognitive decline, this paper focuses on two cognitive functioning measures: the verbal fluency and memory scores. As Bingöl et al. (2016) suggest, the memory test is a measure of fluid intelligence, which typically tends to be significantly affected by ageing (see Anderson and Craik, 2000; Souchay et al., 2000). The

[6] The CAPI randomly assigns one of the following ten-word lists: hotel, river, tree, skin, gold, market, paper, child, king, book - sky, ocean, flag, dollar, wife, machine, home, earth, college, butter -woman, rock, blood, corner, shoes, letter, girl, house, valley, engine - water, church, doctor, palace, fire, garden, sea, village, baby, table.

verbal fluency is a complex cognitive domain composed of both crystallised and fluid cognitive abilities, which also shows decline with ageing (Harada et al., 2013). Moreover, as Bonsang et al. (2012) explain, both the memory and the verbal fluency tests do not suffer from floor and ceiling effects. This contrasts with the orientation in time and numeracy tests that displayed low variability due to ceiling effects. For the empirical analysis in this paper, older adults' cognitive abilities were standardised, separately for each domain, across the 12 countries to have mean zero and standard deviation one.

Cognitively stimulating activities (CSA)

The independent variables are cognitively stimulating activities (CSAs) measures. CSAs are mentally-engaging activities or exercises that challenge a person's ability to think (Global Council on Brain Health, 2017). These activities can help people to maintain their brain and cognitive abilities, such as memory, thinking, attention and reasoning skills as they age.

These variables in SHARE were measured by a single question which asked whether the respondent was engaged in some leisure activity in the 12 months before the interview, including:

i. attending an educational or training course;
ii. reading books, magazines or newspapers;
iii. completing crossword, puzzles or Sudoku;
iv. playing games (e.g. chess and cards).

Another variable, called *csa*, indicating whether an individual was engaged in at least one of these cognitive activities in the 12 months before the interview, was created.

Each of these variables are rated dichotomously as "1" whether the respondents in the twelve months before the interview had done one (or more) of the CSAs mentioned above; or "0" otherwise.

Other control variables

Background variables, health, and social network variables, all of which may be related to cognitive function, were added as control variables.

Background variables include the following: age, gender, education and job situation. Age and job situation are time-varying variables, while gender and education are time-invariant covariates.

Age is clearly essential to include as a control since the ageing process is a prominent cause of cognitive decline. This natural process was modelled using a quadratic polynomial in age.

Education was measured in levels. The International Standard Classification of Education (ISCED) coding was used to account for country specificities in the educational system as generated by the SHARE team. People were separated according to their educational attainment level. Following Eurostat's methodology (2016), three aggregates were created: low, medium, and high education levels. The low category includes ISCED levels 0 to 2: early childhood education (such as early childhood educational development and pre-primary education), primary education and lower secondary education. The medium category includes the ISCED levels 3 and 4: upper secondary education and post-secondary non-tertiary education. The 'high' aggregate level covers the ISCED levels from 5 to 8: short-cycle tertiary education, bachelor or equivalent, master or equivalent and doctoral or equivalent.

Job is a categorical variable, indicating the respondent's job situation at the interview time: retired, working, unemployed or homemaker.

The social network variables included the number of children (0–12) and a dummy variable taking the value one when the respondent is living with a spouse or partner in the same household. Bingöl et al. (2016) called this control "the hearing spouse effect". In reality, its total expected effect is ambiguous. On the one hand, living alone means having less social interactions on average, which is expected to harm cognitive abilities. On the other hand, it might be a cognitive stimulant in that it compels the individual to take care of complex activities related to maintaining the household, on their own. Overall, adding this dummy variable controls for the important change in lifestyle that living alone implies. Both social network variables are time-varying.

The health control variables included in the current analysis are the engagement in *vigorous* and *moderate* activities, and *drinking habits*. All of them are time-varying variables.

The first two variables indicate whether the respondent states to have been engaged in vigorous activities (such as sports, heavy housework or a job that involves physical labour) or activities requiring a moderate level of energy (Deary et al, 2009). If the interviewee has done at least one to three times a month some activities, they were coded as engaged in vigorous/moderate activities. If the respondent answers "less than once a month", he/she is coded as not being engaged in vigorous/moderate activities.

A further independent variable measuring the drinking habits (see Elwood et al., 1999) - based on the number of days a week consumed alcohol in the 3 months preceding the interview - includes three categories: “almost ever or never”, “few times a month” and “often or almost every day”. Appendix A reports summary statistics for the control variables (Table A1).

3. Methodology

The relationship between cognitive abilities and CSAs is examined in this paper using the panel fixed effects (FE) regression method. The underlying purpose of our analyses is to assess how strong is the association with CSAs and whether they persist after controlling for the other relevant factors that influence cognitive abilities. The key advantage of the FE approach is that it overcomes the problem that there may be unobserved characteristics which could influence both the likelihood of engaging in CSA and cognitive functioning. For example, suppose that more curious people are more likely to engage in cognitive activities and also happen to have high scores on memory and verbal fluency. Curiosity was not measured in the dataset, and so could not be included in the analyses and might potentially bias the estimates of the effects of CSA. The correlation between cognitive scores and CSA would be spurious – it has arisen solely because of the unobserved factor, curiosity. A way of addressing this issue is to focus on the change in, rather than the level of, cognitive scores.

As cognitive test scores and CSAs are measured repeatedly in SHARE, it is possible to analyse the change in cognitive functioning between waves of data, and whether there is any association with engagement in CSAs. So long as curiosity is a fixed attribute, then examining the change in cognitive functioning, will eliminate the fixed effect and an unbiased estimate of the effects of CSAs can then be obtained. For these reasons, to deal with this source of endogeneity, we estimate panel models with fixed-effects (FE) whose rationale essentially is of differencing out the effect of both observed and unobserved time-invariant predictors. The FE method focuses on each wave’s deviation from the overall mean on each variable (Allison, 2009).

$$Y_{i,t} = \beta CSA_{i,t} + f\ (age_{i,t}) + \gamma\ X_{i,t} + \mu_i + \varepsilon_{i,t} \qquad (1)$$

This model assumes that cognitive test scores also depend on an error term decomposed into individual specific unobserved time-invariant heterogeneity – μ_i – and idiosyncratic error – $\varepsilon_{i,t}$. Examples of time-invariant unobservables that enter in μ_i include personality traits like intellectual curiosity, motivation and the ease of learning from challenging activities. On the other hand, the time-varying unobservables entering in $\varepsilon_{i,t}$ - the idiosyncratic error – include, for instance, particularly physical health problems or psychological stress.

Via the FE approach the impact of unobserved individual fixed effects was eliminated. However, it should be acknowledged that it does not completely rectify potential issues of endogeneity. This could be present due to omitted variables, measurement errors in the variables or reverse causality (Wooldridge, 2002). The optimal way of solving the endogeneity problem would be to find an instrument correlated with CSA variables and uncorrelated with any other determinants of cognitive scores. That, however, could not be done in our study, since no significant first stage relationship was found for potential instruments we have data for. For all of the models we ran, cluster-robust standard errors (SE) were used, following suggestions of Wooldridge (2003). Standard errors are thus robust to heteroskedasticity and intra-group correlation.

4. Results

Figures 1 and 2 provide the first insight into the cognitive functioning measures used in this study. In particular, they display the cross-sectional average age profile of two different cognitive test scores in SHARE (memory and verbal fluency). Three findings are revealed. First, the figures highlight the negative association between cognitive functioning and age. Except for the early years, between the 50s and 52s, for memory, and between 50s and 55s, for verbal fluency, where the test scores fluctuate a bit, on average, both cognitive measures decrease almost linearly with age. Second, average test scores remain relatively stable until 60 years of age but decrease rapidly at older ages. Third, the age-related cognitive decline varies for the different cognitive domains. Indeed, the measure of episodic memory displays the most considerable degree of age-related decline as it can be seen.

Figure 1 – Age profiles of average memory score

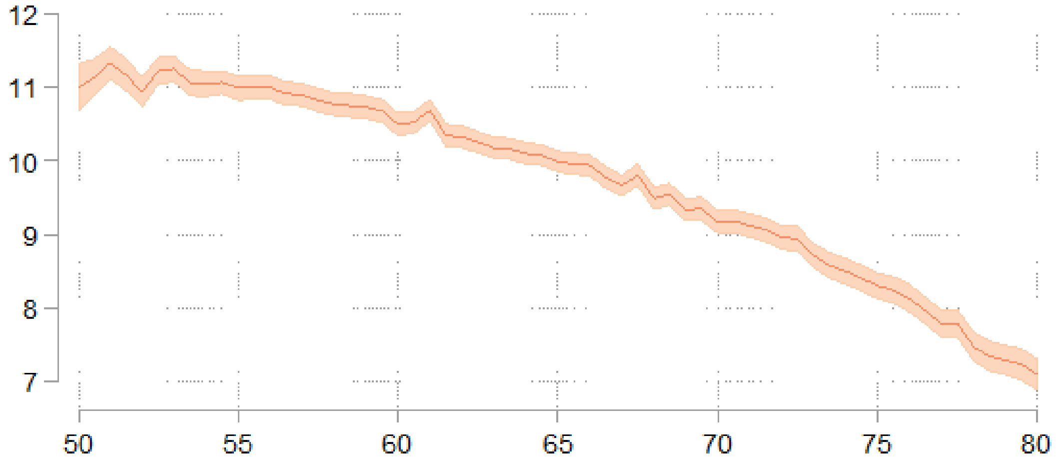
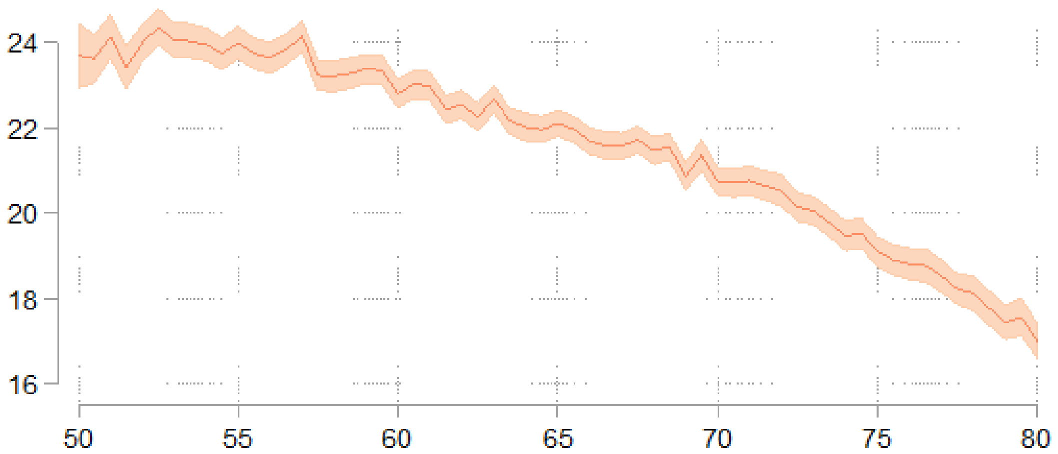


Figure 2 – Age profiles of average verbal fluency score



That is not surprising. Bingöl et al. (2016) pointed out that the memory test is a measure of pure fluid intelligence, purported to reflect the functioning of neurological structures, increases until the cessation of neural maturation, generally during adolescence, and then declines after that. In contrast, the verbal fluency test measures both fluid and crystallised abilities: crystallised intelligence is mainly responsible for knowing about many distinct elements, while fluid intelligence allows one to remember them rapidly (Harada et al. 2013). Crystallised intelligence believed to reflect cultural assimilation. In particular, it seems to be highly influenced by formal and informal educational factors throughout the life-span. Assuming adequate health, crystallised intelligence is presumed to increase steadily across the adult age span, at least until ages 60-70 (Salthouse, 2012). That explains why the decline pattern of verbal fluency seems to be more smooth. Over 30 years, the average memory score declines from 11 at age 50 to almost 7 at age 80; while in the same period, the verbal fluency score decreases from 24 at age 50 to about 17 at 80.

Figures 3 to 6 show the age distribution of the averages of verbal fluency and memory scores by different CSAs. As can be seen, engaging in CSAs allows older adults to mitigate cognitive abilities' physiological decline. In particular, attending educational or training courses seem to have a better effect on both types of cognitive measures (see Figure 3). Conversely, reading books, magazines or newspapers seem to be less effective in counteracting the deterioration over the years of episodic memory (Figure 4); while playing cards or chess is less efficient for verbal fluency (Figure 6).

Figure 3 - Age profiles of average test scores by cognitively stimulating activities engagement: attending training or educational courses

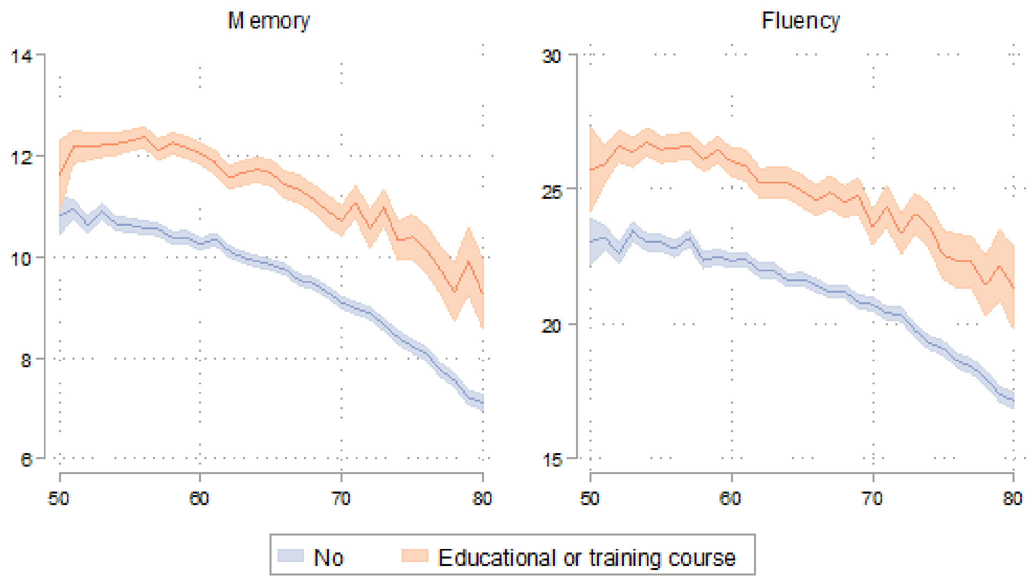


Figure 4 - Age profiles of average test scores by cognitively stimulating activities engagement: reading books, magazines or newspapers

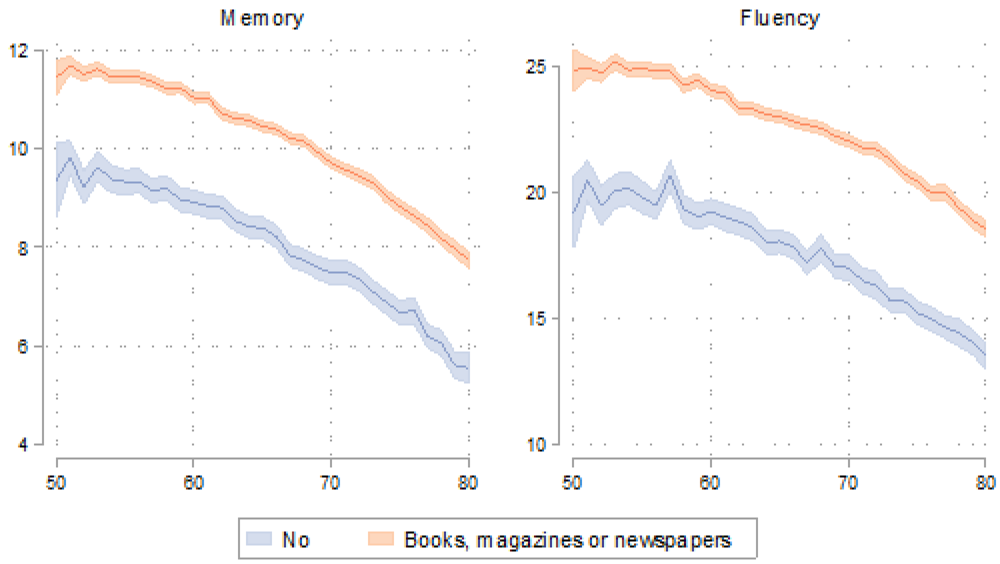


Figure 5 - Age profiles of average test scores by cognitively stimulating activities engagement: playing word or number games (crossword puzzles/Sudoku...)

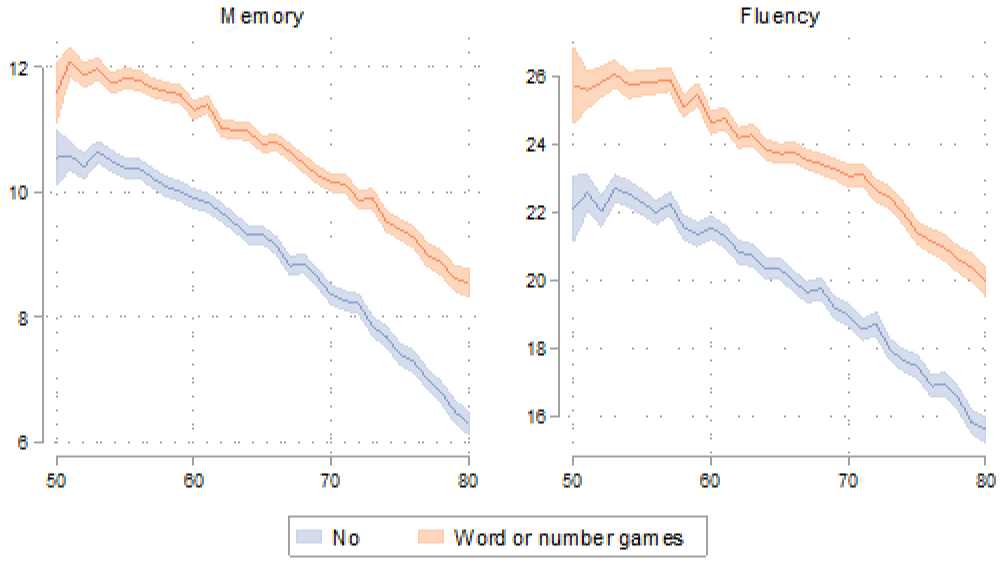
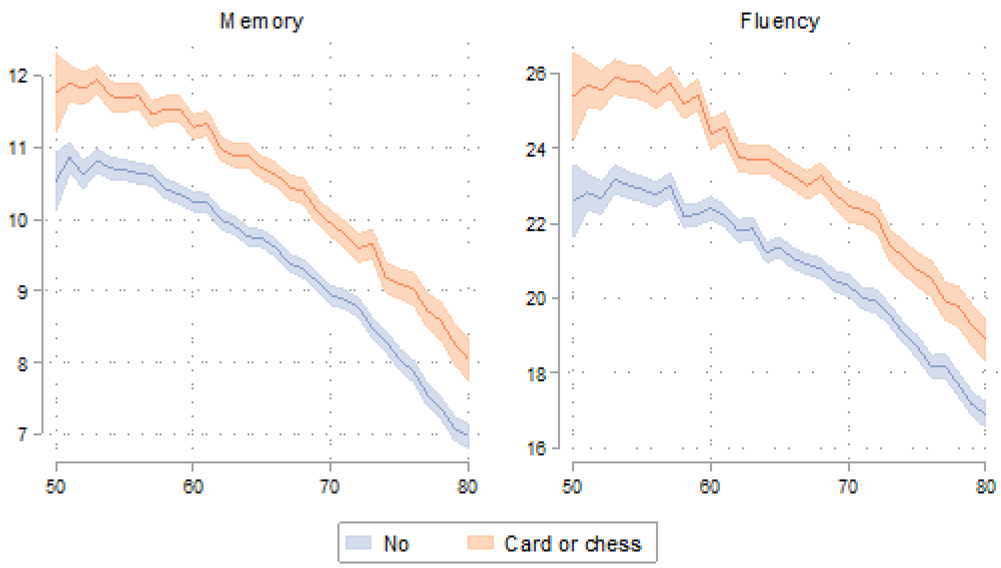


Figure 6 - Age profiles of average test scores by cognitively stimulating activities engagement: playing cards or games such as chess



The patterns showed in these Figures are broadly consistent with the literature on the topic (see section 1): they demonstrate that older age is associated with faster decline in cognitive functioning but, at the same time, engaging in mental activities helps older adults to reduce this physiological process. Nevertheless, the cross-sectional nature of these types of analysis does not allow us to infer a causal relationship since we would observe time, age and cohort effects combined. Accordingly, to understand the link between CSAs and cognitive functioning, we exploit longitudinal information. That allows looking at the change in performance, a superior outcome measure, for it estimates the decline directly.

Hence FE regression models, described in the methodology section, were estimated: cognitive test scores for memory and verbal fluency were regressed on the CSAs – separately for each cognitive activity. In this case, the average effect of CSAs is measured taking account of all the respondents who changed their status, transited from not being involved in some CSA to be engaged on CSA or the other way around, during the sample period[7].

[7] We also performed a random effects (RE) panel estimation, in which one assumes that no control variables (including those denoting CSA) are correlated with the time-invariant error - μ_i. After testing this model against

Tables 2 and 3 summarise the FE regression estimation results for both memory and verbal fluency. It is important to note that in FE models, it is not possible to include time constant variables (such as gender and initial education). Here we focus just on the key coefficients of interest – those for the CSAs) – and the full regression results can be located in Appendix B.

Table 2 – Fixed effects: regression of memory test scores (standardised) on CSA activities

VARIABLES	(1) Model I	(2) Model II	(3) Model III	(4) Model IV	(5) Model V
Education/Training	0.048*** (0.010)				
Reading		0.080*** (0.009)			
Word/Number games			0.069*** (0.008)		
Chess/Cards				0.026*** (0.007)	
Csa					0.082*** (0.010)
No. of observations	110,880	110,880	110,880	110,880	110,880
R-squared	0.025	0.041	0.043	0.024	0.039
No of individuals	45,216	45,216	45,216	45,216	45,216

Notes: Models I, II, III, IV and V include controls variables. See Appendix B for full details (Table B1).
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 3 – Fixed effects: regression of verbal fluency test scores (standardised) on CSAs

VARIABLES	(1) Model VI	(2) Model VII	(3) Model VII	(4) Model IX	(5) Model 1X
Education/Training	0.024*** (0.009)				
Reading		0.069*** (0.008)			
Word/Number games			0.053*** (0.008)		
Chess/Cards				0.037*** (0.007)	
Csa					0.087*** (0.010)
No. of observations	110,881	110,881	110,881	110,881	110,881
R-squared	0.028	0.049	0.048	0.033	0.052
No. of individuals	45,173	45,173	45,173	45,173	45,173

the FE ones using a Hausman specification test, we found that the null hypothesis of no correlation of any variable with μ_i was decisively rejected. As a result, the FE specification was found preferable to the RE one.

Notes: Models VI, VII, VIII, IX and X include controls variables. See Appendix B for full details (Table B2). Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

These results show that CSAs were positively, and significantly, associated with the two measures of cognitive functioning. Our estimates imply that engaging in reading would increase the memory score by about 0.080 SDs the verbal fluency score by about 0.069 SDs. Simultaneously, the positive effect of attending educational or training courses is higher on memory test scores (0.048 SDs) than verbal fluency (0.024 SDs). Finally, doing word or number games (such as crosswords or Sudoku) and playing cards or chess have a similar impact on verbal fluency (respectively 0.053 SDs and 0.038 SDs) but very different on memory score (respectively 0.069 SDs and 0.026 SDs).

Heterogeneity across sub-samples

While the empirical results so far strongly support the hypothesis that engaging in CSAs had a significant positive effect on cognitive abilities, this effect might be heterogeneous across sub-groups within the data. This section explores this question. To investigate the potential heterogeneity of the CSAs effect across individuals, the FE model described above was fitted separately with different sub-samples of the population. As sources of heterogeneity were used the following variables: gender and education level. The estimates of the coefficients of interest (the different types of CSAs) when using only a part of the population to run the regression, are reported in the following tables. Table 4 shows the CSAs coefficients obtained from the FE regressions estimation results of memory, split by gender and education level, and the CSA coefficients of similar FE regressions on verbal fluency are in Table 5.

Table 4 – Memory test scores: heterogeneity across sub-samples

VARIABLES	(1) Education/ Training	(2) Reading	(3) Word/Number games	(4) Chess/Cards	(5) Csa
Gender					
Male	0.045**	0.074**	0.063***	0.017**	0.053**
	(0.014)	(0.012)	(0.010)	(0.011)	(0.014)
Female	0.050**	0.087**	0.074***	0.034***	0.110**
	(0.012)	(0.012)	(0.000)	(0.010)	(0.014)
Education					
Low	0.041**	0.063**	0.090**	0.034**	0.073**
	(0.024)	(0.012)	(0.014)	(0.013)	(0.013)
Medium	0.058**	0.097**	0.080**	0.024**	0.097**
	(0.015)	(0.015)	(0.012)	(0.011)	(0.017)
High	0.040**	0.102**	0.029**	0.014**	0.066**
	(0.015)	(0.025)	(0.016)	(0.014)	(0.031)

Notes: See Appendix B for full details.
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5 – Verbal test scores: heterogeneity across sub-samples

VARIABLES	(1) Education/ Training	(2) Reading	(3) Word/Number games	(4) Chess/Cards	(5) Csa
Gender					
Male	0.004***	0.072***	0.042**	0.019***	0.088***
	(0.014)	(0.012)	(0.012)	(0.011)	(0.014)
Female	0.039***	0.066***	0.062***	0.051***	0.085***
	(0.012)	(0.012)	(0.010)	(0.009)	(0.014)
Education					
Low	0.035	0.065***	0.080***	0.040***	0.084***
	(0.024)	(0.011)	(0.012)	(0.012)	(0.013)
Medium	0.035**	0.068***	0.060***	0.053***	0.093***
	(0.014)	(0.015)	(0.012)	(0.011)	(0.018)
High	0.010	0.076**	0.004	0.004	0.067**
	(0.014)	(0.025)	(0.017)	(0.014)	(0.031)

Notes: See Appendix B for full details of all variables in models.
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

When the models were run separately for men and women, then with regards to memory, the effect of all types of CSAs can be seen to be significant. Moreover, coefficients for males were smaller than those for females women, which were indeed slightly bigger than those found in the previous section for the sample as a whole.

The situation for verbal fluency was broadly similar: all coefficients were significant and, except for reading and the *csa* index, the other coefficients tended to be larger for females. Congruently with the results stressed before, CSAs have larger effects on cognition on women than men. These results, highlighting the crucial role of the gender selection process, may merit further investigation.

Further, when splitting up the sample between lower, medium and higher educated individuals, it was found that engaging in CSAs had a significant positive effect on all groups and for both cognitive test scores. Nevertheless, except reading, the magnitude of these effects for individuals who completed an education programme of upper secondary level (medium level) tends to be higher than those with lower or higher education attainment. The explanation for this is not immediately apparent. On the one hand, perhaps partially due to feelings of inadequacy, people with less education seem reluctant to engage in CSAs (Atchley, 2000). Whereas, individuals who view themselves as more capable and consider an activity more enjoyable are also more likely to select and maintain participation in various social and intellectual activities (Rousseau et al., 2005). Therefore, if an individual does not expect success in an activity, as a result, less participation may occur (Bandura, 1982). That would explain why individuals with a medium level of education may be more likely to select and perform activities that are typically intellectually challenging, compared to people holding primary or lower secondary education diplomas.

On the other hand, there are also indications that cognitive activities moderate education's influence on cognition. Such activities are more beneficial for those with low levels of education. For example, in one study (Lachman et al., 2010) frequent engagement in cognitive activities (reading, writing, doing word games or puzzles, and attending lectures) was found to attenuate the influence of education on episodic memory so that the memory performance of those with lower education who engaged in frequent cognitive activities matched those with higher education. This trend is confirmed in the current analysis, showing that the effect of CSAs on subsequent memory and fluency was more substantial among those with a bachelor's degree or higher qualifications. The only exception to this trend was found for reading as both Table 4 and Table 5 show that highly educated individuals performed better in both types of cognitive domains than individuals with a medium level of education.

All in all, the results obtained using the FE method suggest that CSAs have a sizable impact on both cognitive scores. After splitting the sample by gender and education level, the data showed substantial differences between the sexes, between people with lower and medium levels of education, and between people with upper secondary education and tertiary education.

5. Discussion and Conclusion

The world's population is ageing: many countries face declining fertility rates and constant increases in life expectancy, which will inevitably lead to a steep increase in the share of elderly individuals in their populations. Advancing age is often associated with cognitive decline. Many believe it to be an undeniable part of the ageing process, especially in the latter stages of ever-increasing longevity (Kravitz et al., 2012). From this perspective, understanding whether individuals can at least partly offset the normative age-related cognitive decline is highly relevant to policymakers (Cylus et al, 2019). The reason is that cognitive abilities are fundamental for economic decisions and represent an essential dimension of human capital, along with education, health and non-cognitive skills (Mazzonna and Peracchi, 2018). Furthermore, cognitive decline can be associated with age-related neurological health disorders, including dementia and Alzheimer's disease, representing a substantial challenge to public health and healthcare systems. Unfortunately, very few pharmacological treatments are effective at either delaying the onset of neurodegenerative disorders or in managing the progression of symptoms (Yiannopoulou and Papageorgiou, 2013). It is crucial to identify some strategies that can prevent these pathologies and promote healthy brain ageing.

According to the cognitive enrichment hypothesis, cognitive functioning in old age can be influenced by a wide variety of behaviours and activities (Hertzog et al., 2008). Within this broad outlook, the "use it or lose it" perspective focuses on cognitively stimulating activities (CSAs) and suggests that they stimulate the mind and preserve cognitive functions (Deary et al., 2009). Several empirical studies generally support the argument of a positive association between CSAs and cognitive performance in late life (see Gallucci et al., 2009; Lachman et al., 2010; Wilson et al., 2005; Singh-Manoux et al., 2003; Litwin et al., 2017; Elwood et al., 1999). However, research using longitudinal data from large-scale and representative samples of older adults remains scarce.

The current study was designed to address this gap in the literature. It examined the relationship between different CSAs and cognitive function in a sample of community-dwelling Europeans aged 50 and above across a period of four years, from 2011 to 2015. The data were drawn from the fourth, fifth and sixth waves of SHARE, a valuable source of information on cognitive ageing. The CSAs analysed were: educational and training courses; reading books, newspapers and magazines; word or number games (such as crossword puzzles or Sudoku); chess or cards. The outcomes under investigation were memory and verbal fluency.

As cognitive test scores and CSAs are measured repeatedly in SHARE, our core estimation strategy was to analyse the change in cognitive functioning between waves of data, and whether there was an association with engagement in CSAs. More specifically, we estimated panel models with fixed-effects (FE). We found that CSAs were positively associated with both memory and verbal fluency, after controlling for socioeconomic background, health, and social network variables.

Furthermore, to detect the potential heterogeneity in CSA effects across individuals, we fitted the FE model separately for different sub-samples of the population. We used as sources of heterogeneity two variables: gender and education attainment. Firstly, we found substantial differences between males and females, with the impact of CSAs larger for females than for males in both cognitive abilities. As for education, differences in the magnitude of the effect of CSAs was uncovered – both between people with a medium level of education and individual holding lower education level; and also between people with upper secondary education diploma and people with tertiary education degrees.

The current study has many strengths, including the large sample size and the cross-country dimension of the survey (SHARE), which improves the findings' generalizability. It is also a longitudinal investigation, thus analysing how cognitive decline depends on behavioural and environmental factors while netting out the confounding effects of cohort differences and other time-invariant omitted effects. Observing the same individual over time (not only individuals of different ages in a single wave), allowed us to directly relate cognitive function changes at the individual level to observed behavioural and environmental changes.

Certain limitations also need to be borne in mind. A standard problem with longitudinal surveys is that people tend to drop out over time (non-response), so that the survey may become unrepresentative. The simplest approach would be just to exclude these individuals with missing data. However, estimates obtained from such a ‘complete-case’ (CC) analysis may be biased if the excluded individuals are systematically different from those included. The approach used in this study to correct for the potentially biasing effects of missing data is through Inverse Probability Weighting (IPW) technique (Fitzgerald et al., 1988; Wooldridge, 2002). In this method, complete cases are weighted by the inverse of their probability of being a complete case.

Another well-known issue with studies of this kind is that people could become familiar with the tests used to assess cognitive function. Here when individuals participate in the survey in subsequent waves they may be able to improve or maintain their test scores despite a cognitive decline simply because they have taken similar tests before (in earlier waves of the study) and are therefore more trained at being in a test situation and used to the type of questions that are being asked (Salthouse, 2010). This could mean that there is some tendency for age-ability estimates to be biased upwards (Hertzog et al., 2008).

In regression models reverse causality could be an issue. For example, it is unclear whether cognitive activities protect against cognitive decline or whether people with high cognitive function engage more often in cognitive activities (Hertzog et al., 2008; Singh-Manoux, 2003). We considered, but were not able to find, a suitable instrument, and hence cannot rule out such a possibility.

Nevertheless, we consider that our results, the finding of a strong relationship between CSAs and the delay of cognitive decline in older adults, is an important one. For, as populations age and life expectancies increase, there is growing concern among policymakers, professionals, and the public at large, about the quality of late-life. One key area of worry in this regard is the maintenance of cognitive function. From a societal point of view, prolonging independent functioning is both a desirable goal in itself and a way of deferring costs of long-term care. From the individual’s perspective, maintaining effective cognitive functioning is appealing only because it promises to enhance old age quality.

Consequently, the question as to whether cognitive decline can be slowed down or reduced has important implications for ageing well. The results of the present study document that participating in CSAs can be beneficial for older adults. These activities can constitute a potential source for the delay or reduction of cognitive decline, even after a short period – only 4 years-and regardless of one's age. As such, policymakers should recognise the value of CSAs and encourage both their adoption among the older adult population, as a part of a healthy and active lifestyle, and their expansion in appropriate professional settings. However, this study does not address the protective effects of cognitive activities for incident dementia or Alzheimer's disease. While there is a large body of the literature examining the beneficial effects of cognitive activities in reducing dementia risk, the current investigation data were based on normal cognitive ageing. Individuals with dementia diagnoses were excluded from the present analysis. An extension of this work in populations at significant risk for dementia, or with individuals already diagnosed with neurodegenerative diseases, remains therefore a worthwhile goal.

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Appendix A – Descriptive Statistics and Graphs

Table A1 – Descriptive statistics

	VARIABLES	(1) Obs	(2) %	(3) Mean	(4) Sd
Cognitive abilities					
Numeracy	numeracy_2	113,235		4.108	1.463
Orientation in time	orienti	75,839		3.828	0.546
Verbal fluency	cf010_	112,135		20.789	7.668
Immediate recall	recall_1	112,168		5.316	1.794
Delayed recall	recall_2	112,164		3.964	2.186
Memory	mem_sc	112,024		9.287	3.695
Cognitive stimulating activities					
Educational or training course:	training	14,145	12.56		
Reading book, magazines..	reading	87,771	77.94		
Word or number games	word_number	51,529	45.76		
Cards and chess	cards_chess	34,898	30.99		
Cognitive activities index	Csa	94,058	83.53		
Background					
Gender:	female	114,974		0.565	0.496
Male		*50,061*	43.54		
Female		*64,913*	56.46		
Age	Age	114,974		67.918	9.645
Age squared	age_sqr	114,974		4705.857	1341.840
Education attainment	Educ	113,266		0.828	0.767
Low		*44,676*	39.44		
Medium		*43,340*	38.26		
High		*25,250*	22.29		
Employment status	job_status	113,923		1.555	0.890
Retired		*72,425*	63.57		
Working		*29,106*	25.55		
Unemployed		*3,080*	2.70		
Homemaker		*9,312*	8.17		
Social Network					
Living with spouse/partner	partnerinhh	82,316	71.60		
Children	ch001_	114,570		2.153	1.311
Health					
Drinking habits:	drinking_habits	114,645		1.637	0.796
Hardly ever, or never		*64,629*	56.37		
Few times a month		*26,959*	23.52		
Often or almost every day		*23,057*	20.11		
Moderate activities:	moderate	114,671		0.891	0.312
Hardly ever, or never		*12,555*	10.95		
At least 1/3 times a month		*102,116*	89.05		
Vigorous	vigorous	114,670		0.565	0.496
Hardly ever, or never		*49,881*	43.50		
At least 1/3 times a month		*64,789*	56.50		

As Table A1 reveals, females constituted about 57% of the sample. Only 25% received a tertiary education diploma or more, and the majority of individuals were retired (64%) while just 26% were still at work. Almost three-quarters had a partner. The average number of children was approximately two.

More than 80% of individuals of the sample were engaged in at least one CSA. About thirteen per cent reported to have attended an educational or training course; and 78% read books, newspapers or magazines. On average, 46% of participants were engaged in word or number games; while 31% played cards or chess games.

The mean memory score was about 9 on a scale of 0–20. Average numeracy was high (4.11 out of 5), whereas mean verbal fluency was about 21 on a scale of 0–100. Finally, orientation to time was almost 4 (3.83 out of 5).

Most participants hardly ever or never drank (56.37%). Regarding physical activities: 89.05% of individuals reported to be engaged in moderate activities (at least one or three times a month) and 56.50% in vigorous activities.

Table A2 – Orientation test score by wave

Orientation	(1) wave 4 Freq (Percent)	(2) wave 5 Freq (Percent)	(3) wave 6 Freq (Percent)
Bad	223***	149***	120***
	(1.22)	(1.17)	(0.28)
1	41***	32***	180***
	(0.22)	(0.25)	(0.43)
2	202***	164***	600***
	(1.10)	(1.29)	(1.42)
3	1,711***	1,228***	3,915***
	(9.34)	(9.64)	(9.24)
Good	16,150***	11,170***	37,553***
	(88.12)	(87.66)	(88.64)
N. of inviduals	8,671	8,671	8,671
Total	18,327	12,743	42,368

Table A3 – Numeracy test score by wave

Numeracy	(1) wave 4 Freq (Percent)	(2) wave 5 Freq (Percent)	(3) wave 6 Freq (Percent)
Bad	1,720***	2,083***	1,791***
	(5.79)	(5.06)	(4.23)
1	1,281***	1,639***	1,838***
	(4.31)	(3.98)	(4.34)
2	1,113***	1,578***	1,548***
	(3.75)	(3.84)	(3.65)
3	2,621***	3,585***	3,692***
	(8.82)	(8.71)	(8.71)
4	4,264***	5,988***	6,266***
	(14.36)	(14.55)	(14.78)
Good	18,704***	26,278***	27,246***
	(62.97)	(63.86)	(64.29)
N. of individuals	8,671	8,671	8,671
Total	29,703	41,151	42,381

Figure A1 - Age profiles of average test scores by gender

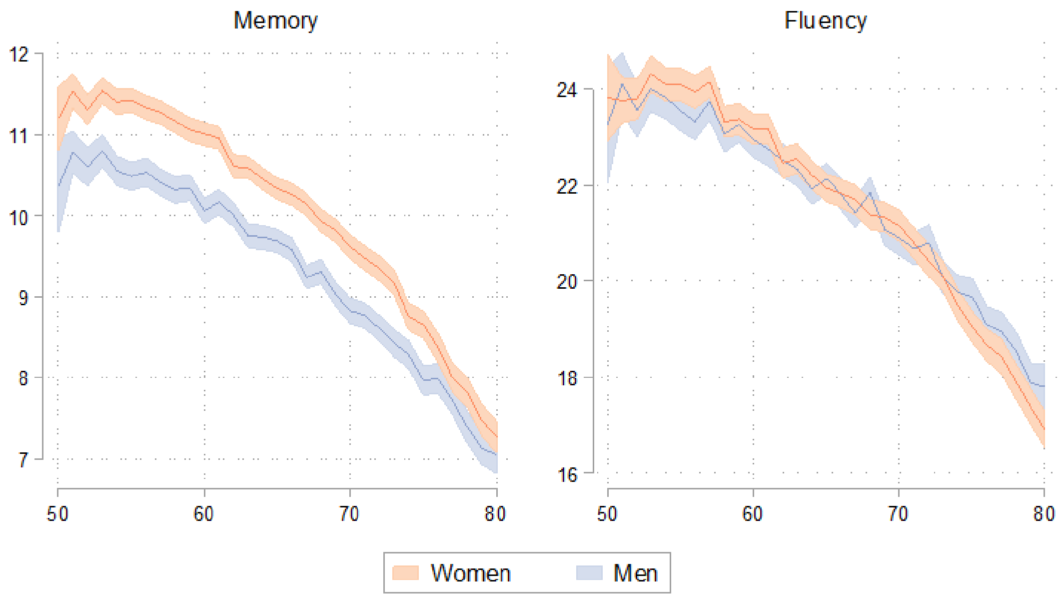
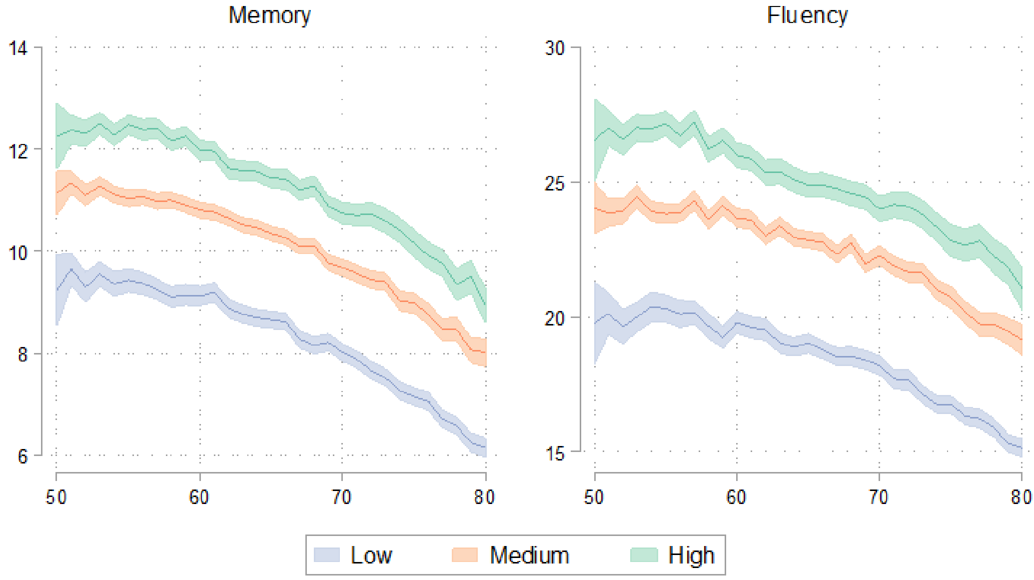


Figure A2 - Age profiles of average test scores by educational attainment



Appendix B – Regression results in full

Table B1 - Fixed effects regression of memory test scores (standardised) on CSAs

VARIABLES	(1) Model I	(2) Model II	(3) Model III	(4) Model IV	(5) Model V
Education/Training	0.048*** (0.010)				
Reading		0.080*** (0.009)			
Words/Number games			0.070*** (0.008)		
Cards/Chess				0.026*** (0.007)	
Csa					0.082*** (0.010)
Age	0.171*** (0.010)	0.168*** (0.010)	0.168*** (0.010)	0.169*** (0.010)	0.168*** (0.010)
Age Squared	-0.001*** (7.23e-05)	-0.001*** (7.22e-05)	-0.001*** (7.22e-05)	-0.001*** (7.23e-05)	-0.001*** (7.22e-05)
Employment status (reference: Retired)					
Working	-0.019** (0.013)	-0.018** (0.013)	-0.016** (0.013)	-0.017*** (0.013)	-0.018** (0.013)
Unemployed	-0.018** (0.028)	-0.015** (0.023)	-0.014** (0.023)	-0.0159** (0.023)	-0.015** (0.023)
Homemaker	-0.051** (0.019)	-0.049** (0.019)	-0.050** (0.019)	-0.050** (0.019)	-0.048** (0.019)
Partnership status (reference: Living alone)					
Living with partner/spouse	-0.001** (0.018)	-0.001** (0.018)	-0.001** (0.018)	-0.001** (0.018)	-0.002** (0.017)
Children	0.005*** (0.006)	0.004*** (0.006)	0.004*** (0.006)	0.005*** (0.006)	0.004*** (0.006)
Vigorous activities (reference: Hardly ever, or never)					
At least 1/3 times a month	0.044*** (0.007)	0.045*** (0.007)	0.044*** (0.007)	0.044*** (0.007)	0.045*** (0.007)
Moderate (reference: Hardly ever, or never)					
At least 1/3 times a month	0.049** (0.011)	0.044** (0.011)	0.047** (0.011)	0.048** (0.011)	0.044** (0.011)
Drinking habits (reference: Hardly ever, or never)					
Few times a month	0.006*** (0.007)	0.006*** (0.007)	0.006*** (0.007)	0.006*** (0.007)	0.005*** (0.007)
Often	-0.012*** (0.008)	-0.013*** (0.008)	-0.013*** (0.008)	-0.012*** (0.008)	-0.014*** (0.008)
Constant	-5.793 (0.347)	-5.724 (0.346)	-5.698 (0.347)	-5.748 (0.347)	-5.734 (0.347)
Observations	110,880	110,880	110,880	110,880	110,880
R-squared	0.007	0.008	0.008	0.007	0.008
Number of individuals	45,216	45,216	45,216	45,216	45,216

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table B2 - Fixed effects regression of verbal fluency test scores (standardised) on CSAs

VARIABLES	(1) Model VI	(2) Model VII	(3) Model VIII	(4) Model IX	(5) Model IX
Education/Training	0.024***				
	(0.009)				
Reading		0.069***			
		(0.008)			
Words/Number games			0.053***		
			(0.008)		
Cards/Chess				0.037***	
				(0.007)	
Csa					0.0868***
					(0.010)
Age	0.142***	0.139***	0.139***	0.140***	0.139***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Age Squared	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(7.05e-05)	(7.05e-05)	(7.04e-05)	(7.05e-05)	(7.05e-05)
Employment status					
(reference: Retired)					
Working	0.023**	0.023**	0.025**	0.024**	0.023**
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Unemployed	0.026**	0.029**	0.029**	0.028**	0.028**
	(0.023)	(0.023)	(0.023)	(0.023)	(0.023)
Homemaker	-0.019**	-0.017**	-0.019**	-0.019**	-0.017**
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Partnership status					
(reference: Living alone)					
Living with partner/spouse	0.010**	0.010**	0.010**	0.010**	0.010**
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
Children	-0.000***	-0.001***	-0.001***	-0.001***	-0.001***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Vigorous activities					
(reference: Hardly ever, or never)					
At least 1/3 times a month	0.038***	0.039***	0.038***	0.038***	0.039***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Moderate					
(reference: Hardly ever, or never)					
At least 1/3 times a month	0.080**	0.076**	0.078**	0.079**	0.075**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Drinking habits					
(reference: Hardly ever, or never)					
Few times a month	-0.007***	-0.008***	-0.008***	-0.008***	-0.009***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Often	-0.001***	-0.002***	-0.002***	-0.002***	-0.003***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Constant	-4.889	-4.839	-4.822	-4.847	-4.840
	(0.345)	(0.345)	(0.345)	(0.345)	(0.344)
Observations	110,881	110,881	110,881	110,881	110,881
R-squared	0.006	0.007	0.006	0.006	0.007
Number of individuals	45,173	45,173	45,173	45,173	45,173

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table B3 - Fixed effects regression of memory test scores (standardised) on CSAs by gender (male)

VARIABLES	(1) Model I	(2) Model II	(3) Model III	(4) Model IV	(5) Model V
Education/Training	0.045**				
	(0.015)				
Reading		0.074**			
		(0.012)			
Words/Number games			0.063**		
			(0.012)		
Cards/Chess				0.017**	
				(0.011)	
Csa					0.053**
					(0.014)
Age	0.169**	0.17**	0.168**	0.169**	0.168**
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Age Squared	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Employment status					
(reference: Retired)					
Working	-0.010**	-0.009**	-0.008**	-0.009**	-0.009**
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
Unemployed	0.009	0.012**	0.012**	0.010**	0.011**
	(0.034)	(0.034)	(0.034)	(0.034)	(0.034)
Homemaker	-0.133*	-0.121*	-0.128*	-0.131*	-0.125*
	(0.082)	(0.082)	(0.082)	(0.082)	(0.082)
Partnership status					
(reference: Living alone)					
Living with partner/spouse	0.021**	0.020**	0.020**	0.021**	0.020**
	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)
Children	0.008**	0.0072***	0.008***	0.008***	0.008***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Vigorous activities					
(reference: Hardly ever, or never)					
At least 1/3 times a month	0.051***	0.051***	0.051***	0.051***	0.0513***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Moderate					
(reference: Hardly ever, or never)					
At least 1/3 times a month	0.044**	0.039**	0.042**	0.044**	0.040**
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Drinking habits					
(reference: Hardly ever, or never)					
Few times a month	0.044**	0.039**	0.042**	0.044**	0.040**
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Often	-0.028**	-0.029**	-0.028**	-0.028**	-0.029**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Constant	-5.738	-5.681	-5.671	-5.709	-5.696
	(0.545)	(0.544)	(0.545)	(0.545)	(0.545)
Observations	48,010	48,010	48,010	48,010	48,010
R-squared	0.007	0.009	0.008	0.007	0.008
Number of individuals	19,697	19,697	19,697	19,697	19,697

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table B4 - Fixed effects regression of memory test scores (standardised) on CSAs by gender (female)

VARIABLES	(1) Model VI	(2) Model VII	(3) Model VIII	(4) Model IX	(5) Model X
Education/Training	0.050**				
	(0.013)				
Reading		0.087**			
		(0.012)			
Words/Number games			0.074**		
			(0.011)		
Cards/Chess				0.034***	
				(0.010)	
Csa					0.109**
					(0.014)
Age	0.170**	0.167**	0.166**	0.168**	0.166**
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Age Squared	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(9.41e-05)	(9.40e-05)	(9.41e-05)	(9.41e-05)	(9.40e-05)
Employment status (reference: Retired)					
Working	-0.031**	-0.030**	-0.027**	-0.028**	-0.030**
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
Unemployed	-0.045**	-0.040**	-0.040**	-0.041**	-0.040**
	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)
Homemaker	-0.050**	-0.047**	-0.049**	-0.049**	-0.047**
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Partnership status (reference: Living alone)					
Living with partner/spouse	-0.011**	-0.011**	-0.010**	-0.011**	-0.011**
	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)
Children	0.002***	0.001***	0.001***	0.002***	0.001***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Vigorous activities (reference: Hardly ever, or never)					
At least 1/3 times a month	0.039***	0.040***	0.040***	0.039***	0.041***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Moderate (reference: Hardly ever, or never)					
At least 1/3 times a month	0.052**	0.047**	0.049**	0.051**	0.046**
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Drinking habits (reference: Hardly ever, or never)					
Few times a month	0.000***	-0.001***	4.35e-05***	0.000***	-0.001***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Often	0.002**	0.002**	0.002**	0.002**	0.001**
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Constant	-5.759	-5.682	-5.644	-5.700	-5.684
	(0.450)	(0.450)	(0.450)	(0.450)	(0.450)
Observations	62,870	62,870	62,870	62,870	62,870
R-squared	0.007	0.008	0.008	0.007	0.009
Number of individuals	25,519	25,519	25,519	25,519	25,519

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table B5 - Fixed effects regression of verbal fluency test scores (standardised) on CSAs by gender (male)

VARIABLES	(1) Model VI	(2) Model VII	(3) Model III	(4) Model IV	(5) Model V
Education/Training	0.004**				
	(0.014)				
Reading		0.072**			
		(0.012)			
Words/Number games			0.042**		
			(0.012)		
Cards/Chess				0.019**	
				(0.011)	
Csa					0.0880**
					(0.014)
Age	0.121**	0.119**	0.120**	0.120**	0.118**
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Age Squared	-0.001***	-0.000***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Employment status					
(reference: Retired)					
Working	0.037**	0.037**	0.038**	0.038**	0.037**
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Unemployed	0.060**	0.062**	0.061**	0.060**	0.060**
	(0.037)	(0.036)	(0.036)	(0.036)	(0.036)
Homemaker	0.120	0.131	0.123	0.121	0.132
	(0.156)	(0.156)	(0.157)	(0.156)	(0.156)
Partnership status					
(reference: Living alone)					
Living with partner/spouse	0.048**	0.048**	0.047**	0.048**	0.047**
	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)
Children	0.003***	0.002***	0.003***	0.003***	0.002***
	(0.009)	(0.009)	(0.009)	(0.008)	(0.009)
Vigorous activities					
(reference: Hardly ever, or never)					
At least 1/3 times a month	0.062***	0.062***	0.061***	0.062***	0.062***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Moderate					
(reference: Hardly ever, or never)					
At least 1/3 times a month	0.112**	0.108**	0.111**	0.112**	0.106**
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Drinking habits					
(reference: Hardly ever, or never)					
Few times a month	0.008**	0.007**	0.008**	0.008**	0.007**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Often	-0.003**	-0.005**	-0.003**	-0.003**	-0.005**
	(0.011)	(0.012)	(0.012)	(0.012)	(0.012)
Constant	-4.414	-4.373	-4.380	-4.401	-4.372
	(0.551)	(0.551)	(0.552)	(0.552)	(0.551)
Observations	47,992	47,992	47,992	47,992	47,992
R-squared	0.006	0.008	0.007	0.007	0.008
Number of individuals	19,668	19,668	19,668	19,668	19,668

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table B6 - Fixed effects regression of verbal fluency test scores (standardised) on CSAs by gender (female)

VARIABLES	(1) Model VI	(2) Model VII	(3) Model VIII	(4) Model IX	(5) Model X
Education/Training	0.039**				
	(0.012)				
Reading		0.066**			
		(0.012)			
Words/Number games			0.062***		
			(0.010)		
Cards/Chess				0.051***	
				(0.009)	
Csa					0.085**
					(0.014)
Age	0.155**	0.152**	0.152**	0.153**	0.152**
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Age Squared	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(8.96e-05)	(8.98e-05)	(8.96e-05)	(8.96e-05)	(8.97e-05)
Employment status					
(reference: Retired)					
Working	0.010**	0.011**	0.014**	0.012**	0.011**
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
Unemployed	0.001**	0.004**	0.005**	0.004**	0.004**
	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)
Homemaker	-0.030**	-0.028**	-0.029**	-0.029**	-0.028**
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Partnership status					
(reference: Living alone)					
Living with partner/spouse	-0.014**	-0.014**	-0.013**	-0.014**	-0.014**
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
Children	-0.004***	-0.004***	-0.005***	-0.004***	-0.004***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Vigorous activities					
(reference: Hardly ever, or never)					
At least 1/3 times a month	0.022***	0.023***	0.023***	0.0226***	0.024***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Moderate					
(reference: Hardly ever, or never)					
At least 1/3 times a month	0.060**	0.056**	0.058**	0.058**	0.056**
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Drinking habits					
(reference: Hardly ever, or never)					
Few times a month	-0.019***	-0.019***	-0.019***	-0.019***	-0.020**
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Often	0.011**	0.010**	0.010**	0.010**	0.009**
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Constant	-5.196	-5.140	-5.102	-5.125	-5.142
	(0.442)	(0.442)	(0.442)	(0.442)	(0.442)
Observations	62,889	62,889	62,889	62,889	62,889
R-squared	0.006	0.007	0.007	0.007	0.007
Number of individuals	25,505	25,505	25,505	25,505	25,505

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table B7 - Fixed effects regression of memory test scores (standardised) on CSAs by education level (low)

VARIABLES	(1) Model I	(2) Model II	(3) Model III	(4) Model IV	(5) Model V
Education/Training	0.041**				
	(0.024)				
Reading		0.063**			
		(0.012)			
Words/Number games			0.090**		
			(0.014)		
Cards/Chess				0.034**	
				(0.013)	
Csa					0.073**
					(0.013)
Age	0.153**	0.149**	0.149**	0.151**	0.148**
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
Age Squared	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Employment status					
(reference: Retired)					
Working	-0.019**	-0.022**	-0.017**	-0.019**	-0.021**
	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)
Unemployed	-0.018**	-0.017**	-0.014**	-0.018**	-0.018**
	(0.036)	(0.036)	(0.035)	(0.036)	(0.035)
Homemaker	-0.068**	-0.067**	-0.065**	-0.068**	-0.066**
	(0.026)	(0.026)	(0.025)	(0.026)	(0.025)
Partnership status					
(reference: Living alone)					
Living with partner/spouse	-0.011**	-0.010**	-0.010**	-0.010**	-0.010**
	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)
Children	0.002***	0.002***	0.001***	0.002***	0.001***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Vigorous activities					
(reference: Hardly ever, or never)					
At least 1/3 times a month	0.064**	0.065**	0.065**	0.065**	0.065**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Moderate					
(reference: Hardly ever, or never)					
At least 1/3 times a month	0.028**	0.024**	0.025**	0.027**	0.023**
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Drinking habits					
(reference: Hardly ever, or never)					
Few times a month	0.018**	0.017**	0.019**	0.018**	0.017**
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Often	-0.004**	-0.006**	-0.004**	-0.005**	-0.006**
	(0.014)	(0.014)	(0.013)	(0.014)	(0.014)
Constant	-5.631	-5.516	-5.505	-5.570	-5.515
	(0.608)	(0.608)	(0.608)	(0.609)	(0.608)
Observations	40,930	40,930	40,930	40,930	40,930
R-squared	0.007	0.008	0.009	0.007	0.008
Number of individuals	17,030	17,030	17,030	17,030	17,030

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table B8 - Fixed effects regression of memory test scores (standardised) on CSAs by education level (medium)

VARIABLES	(1) Model I	(2) Model II	(3) Model III	(4) Model IV	(5) Model V
Education/Training	0.058**				
	(0.015)				
Reading		0.097**			
		(0.015)			
Words/Number games			0.080**		
			(0.012)		
Cards/Chess				0.024**	
				(0.011)	
Csa					0.0965**
					(0.017)
Age	0.157**	0.154**	0.153**	0.156**	0.154**
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Age Squared	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Employment status					
(reference: Retired)					
Working	-0.020**	-0.016**	-0.015**	-0.016**	-0.017**
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
Unemployed	-0.041**	-0.036**	-0.037**	-0.037**	-0.036**
	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)
Homemaker	-0.007**	-0.004**	-0.007**	-0.006**	-0.004**
	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)
Partnership status					
(reference: Living alone)					
Living with partner/spouse	-0.002**	-0.004**	-0.003**	-0.003**	-0.005**
	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)
Children	-0.005***	-0.006***	-0.006***	-0.005***	-0.006***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Vigorous activities					
(reference: Hardly ever, or never)					
At least 1/3 times a month	0.032***	0.034***	0.033***	0.0330***	0.034***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Moderate					
(reference: Hardly ever, or never)					
At least 1/3 times a month	0.060***	0.055**	0.056**	0.0596**	0.055**
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Drinking habits					
(reference: Hardly ever, or never)					
Few times a month	-0.009**	-0.010**	-0.010**	-0.009**	-0.010**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Often	-0.018**	-0.018**	-0.018**	-0.017**	-0.018**
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Constant	-5.121	-5.059	-5.003	-5.079	-5.076
	(0.554)	(0.554)	(0.554)	(0.554)	(0.554)
Observations	42,874	42,874	42,874	42,874	42,874
R-squared	0.006	0.007	0.007	0.006	0.007
Number of individuals	17,318	17,318	17,318	17,318	17,318

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table B9 - Fixed effects regression of memory test scores (standardised) on CSAs by education level (high)

VARIABLES	(1) Model I	(2) Model II	(3) Model III	(4) Model IV	(5) Model V
Education/Training	0.040**				
	(0.015)				
Reading		0.102**			
		(0.025)			
Words/Number games			0.029**		
			(0.016)		
Cards/Chess				0.014**	
				(0.014)	
Csa					0.066**
					(0.031)
Age	0.220**	0.219**	0.220**	0.220**	0.220**
	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)
Age Squared	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Employment status (reference: Retired)					
Working	-0.020**	-0.019**	-0.018**	-0.019**	-0.019**
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
Unemployed	0.032*	0.040*	0.037*	0.036*	0.038*
	(0.054)	(0.054)	(0.054)	(0.054)	(0.054)
Homemaker	-0.0571*	-0.056*	-0.058*	-0.056*	-0.055*
	(0.060)	(0.060)	(0.060)	(0.060)	(0.060)
Partnership status (reference: Living alone)					
Living with partner/spouse	0.005**	0.004**	0.004**	0.005**	0.005**
	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)
Children	0.022**	0.021**	0.022**	0.022**	0.021**
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Vigorous activities (reference: Hardly ever, or never)					
At least 1/3 times a month	0.0280**	0.027**	0.028**	0.028**	0.028**
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Moderate (reference: Hardly ever, or never)					
At least 1/3 times a month	0.095**	0.091**	0.095**	0.096**	0.093**
	(0.031)	(0.032)	(0.032)	(0.032)	(0.032)
Drinking habits (reference: Hardly ever, or never)					
Few times a month	0.013**	0.012**	0.013**	0.013**	0.012**
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Often	-0.019**	-0.021**	-0.019**	-0.020**	-0.021**
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
Constant	-6.974	-6.990	-6.954	-6.958	-6.998
	(0.735)	(0.735)	(0.735)	(0.735)	(0.735)
Observations	25,489	25,489	25,489	25,489	25,489
R-squared	0.011	0.011	0.010	0.010	0.010
Number of individuals	10,290	10,290	10,290	10,290	10,290

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table B10 - Fixed effects regression of verbal fluency test scores (standardised) on CSAs by education level (low)

VARIABLES	(1) Model VI	(2) Model VII	(3) Model VIII	(4) Model IX	(5) Model X
Education/Training	0.035**				
	(0.024)				
Reading		0.065**			
		(0.011)			
Words/Number games			0.080**		
			(0.012)		
Cards/Chess				0.0399**	
				(0.012)	
Csa					0.0840**
					(0.013)
Age	0.139**	0.135**	0.136***	0.137**	0.134**
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
Age Squared	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Employment status (reference: Retired)					
Working	0.027**	0.025**	0.029**	0.027**	0.026**
	(0.027)	(0.028)	(0.028)	(0.028)	(0.028)
Unemployed	-0.029**	-0.028**	-0.026**	-0.028**	-0.028**
	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)
Homemaker	-0.040**	-0.039**	-0.038**	-0.040**	-0.038**
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
Partnership status (reference: Living alone)					
Living with partner/spouse	-0.014**	-0.013**	-0.013**	-0.013**	-0.013**
	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)
Children	-0.006**	-0.007***	-0.007***	-0.006***	-0.007***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Vigorous activities (reference: Hardly ever, or never)					
At least 1/3 times a month	0.044***	0.044***	0.045***	0.044***	0.045***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Moderate (reference: Hardly ever, or never)					
At least 1/3 times a month	0.060**	0.056**	0.058**	0.059**	0.054**
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Drinking habits (reference: Hardly ever, or never)					
Few times a month	-7.70e-05**	-0.002**	0.000**	-0.001**	-0.002**
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Often	-0.001**	-0.003**	-0.001**	-0.002**	-0.003**
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Constant	-5.270	-5.155	-5.160	-5.204	-5.144
	(0.596)	(0.597)	(0.596)	(0.597)	(0.597)
Observations	40,944	40,944	40,944	40,944	40,944
R-squared	0.006	0.008	0.008	0.007	0.008
Number of individuals	17,012	17,012	17,012	17,012	17,012

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table B11 - Fixed effects regression of verbal fluency test scores (standardised) on CSAs by education level (medium)

VARIABLES	(1) Model VI	(2) Model VII	(3) Model VIII	(4) Model IX	(5) Model X
Education/Training	0.035**				
	(0.014)				
Reading		0.068**			
		(0.015)			
Words/Number games			0.0596**		
			(0.012)		
Cards/Chess				0.053**	
				(0.011)	
Csa					0.093**
					(0.018)
Age	0.149**	0.147**	0.146**	0.147**	0.146**
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Age Squared	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Employment status (reference: Retired)					
Working	0.036**	0.039**	0.039**	0.039**	0.038**
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
Unemployed	0.061**	0.064**	0.064**	0.064**	0.064**
	(0.040)	(0.040)	(0.040)	(0.040)	(0.040)
Homemaker	0.021**	0.023**	0.020**	0.022**	0.023**
	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)
Partnership status (reference: Living alone)					
Living with partner/spouse	0.035**	0.033**	0.034**	0.034**	0.032**
	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)
Children	-0.002***	-0.003***	-0.002***	-0.002***	-0.002***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Vigorous activities (reference: Hardly ever, or never)					
At least 1/3 times a month	0.033**	0.0339**	0.033**	0.033**	0.034**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Moderate (reference: Hardly ever, or never)					
At least 1/3 times a month	0.088**	0.084**	0.085**	0.086**	0.083**
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
Drinking habits (reference: Hardly ever, or never)					
Few times a month	-0.008**	-0.008**	-0.009**	-0.008**	-0.009**
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Often	-0.006**	-0.007**	-0.007**	-0.006**	-0.007**
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Constant	-5.121	-5.059	-5.003	-5.079	-5.076
	(0.554)	(0.554)	(0.554)	(0.554)	(0.554)
Observations	42,874	42,874	42,874	42,874	42,874
R-squared	0.006	0.007	0.007	0.006	0.007
Number of individuals	17,318	17,318	17,318	17,318	17,318

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table B12 - Fixed effects regression of verbal fluency test scores (standardised) on CSAs by education level (high)

VARIABLES	(1) Model VI	(2) Model VII	(3) Model VIII	(4) Model IX	(5) Model X
Education/Training	0.010**				
	(0.014)				
Reading		0.076**			
		(0.025)			
Words/Number games			0.004**		
			(0.017)		
Cards/Chess				0.004**	
				(0.014)	
Csa					0.067**
					(0.032)
Age	0.145**	0.144**	0.145**	0.145**	0.145**
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
Age Squared	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Employment status					
(reference: Retired)					
Working	0.008**	0.008**	0.009**	0.009**	0.009**
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
Unemployed	0.085*	0.089*	0.086*	0.086*	0.088*
	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)
Homemaker	-0.059*	-0.059*	-0.059*	-0.059*	-0.058*
	(0.056)	(0.056)	(0.056)	(0.056)	(0.055)
Partnership status					
(reference: Living alone)					
Living with partner/spouse	0.004**	0.003**	0.003**	0.003**	0.004**
	(0.037)	(0.035)	(0.036)	(0.036)	(0.036)
Children	0.009**	0.008**	0.009**	0.009**	0.008**
	(0.012)	(0.012)	(0.020)	(0.012)	(0.012)
Vigorous activities					
(reference: Hardly ever, or never)					
At least 1/3 times a month	0.035**	0.035**	0.036**	0.036**	0.036**
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Moderate					
(reference: Hardly ever, or never)					
At least 1/3 times a month	0.129**	0.126**	0.129**	0.129**	0.126**
	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)
Drinking habits					
(reference: Hardly ever, or never)					
Few times a month	-0.013**	-0.014**	-0.013**	-0.013**	-0.014**
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Often	0.011**	0.010**	0.011**	0.011**	0.010**
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
Constant	-4.591	-4.608	-4.587	-4.586	-4.621
	(0.723)	(0.723)	(0.723)	(0.723)	(0.724)
Observations	25,473	25,473	25,473	25,473	25,473
R-squared	0.006	0.007	0.006	0.006	0.007
Number of individuals	10,284	10,284	10,284	10,284	10,284

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1