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Older adults, cognitively stimulating activities and change in cognitive function

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ABSTRACT

Finding interventions which can address the decline of cognitive function as people get older is of great importance to policy-makers, especially in post-industrial societies with rapidly ageing populations. We examine the impact of several different types of mentally stimulating activities on 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 activities analysed include non-formal learning activities such as education and training courses; informal learning activities such as reading books, newspapers and magazines; and some other types of cognitively stimulating activities including crossword puzzles and playing chess or card games. The cognitive function outcomes under investigation were memory and verbal fluency. Our longitudinal analysis of data on these older adults show that all the activities constituted 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 their age.

KEYWORDS

Ageing; cognitive decline; informal learning; non-formal learning

Introduction

Throughout the developed world, populations are ageing rapidly as fertility rates drop, and life expectancy rises. One of the significant implications of ageing is cognitive decline. Age-associated cognitive ageing is an essential human experience which broadly refers to the progressive deterioration in cognitive abilities which occur as people get older. This condition affects all people, albeit to varying degrees, and not just those who experience neurological disorders such as dementia.

This decline in individual cognitive function is a significant concern as it is associated with an increased risk of mortality, disability, and lower quality of life (Batty et al., 2016; Plassman et al., 2010). Moreover, 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). In addition, cognitive functioning is also crucial for decision-making as it influences an individual's ability to process information and make logical choices. Declining cognitive function can impact key daily living activities, such as driving, banking or the administering of medication (Harada et al., 2013).

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Finding treatments which can slow down, or ameliorate the effects, of age-related cognitive decline is therefore of considerable utility. The research reported in this paper investigates whether cognitively stimulating activities, including participation in certain types of learning, have an effect on cognitive decline among adults aged 50 and over. The authors utilise a rich, multi-country European dataset to address this issue.

Conceptual framework and literature review

According to the famous model developed by Cattel (1971, 1987), it is possible to distinguish between two types of cognitive abilities, namely fluid and 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 & 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.

As Desjardins and Warnke stressed in their detailed paper (Desjardins & Warnke, 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 & Noll, 1997; Lindenberger & Baltes, 1997), and longitudinal designs (Baltes & Mayer, 1999; Schaie & 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 & Jeste, 2006; Yaffe et al., 2009).

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 (Lachman et al., 2010). In particular, more cognitively complex activities, such as reading and involvement in clubs or organisations (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 addresses 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, including participation in education and training courses, and more informal types of learning such as reading books, magazines or newspapers; as well as some other mentally stimulating activities – for example, playing board games (such as chess), or doing word or number games (i.e. sudoku, crosswords and puzzles)., It is important for the models to control also for behavioural risk factors (drinking, the extent of physical inactivity etc.) as well as social engagement in old age.

This study contributes to the debate on the role of engagement in learning and other activities 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.

Methodology

Data source

Data are from the Survey of Health, Ageing and Retirement in Europe (SHARE). SHARE is a multidisciplinary and cross-national bi-annual household panel survey. 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 (Bergmann et al., 2019). The first wave of SHARE was launched in 2004/05 in 11 Continental European countries (Börsch-Supan & Jürges, 2005). Since then, it has been conducted biannually and by the eighth wave in 2020 27 European countries plus Israel were participating in it. The data collection is done according to strict quality standards and with ex-ante harmonised interviews across the participating countries.

Selecting the sample

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 the cognitively stimulating activities (CSAs) which are the focus of this research. 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. Our final sample includes data from twelve selected European countries: Austria, Belgium, Czech Republic, Denmark, Estonia, France, Germany, Italy, Slovenia, Spain, Sweden and Switzerland. These countries were selected mainly because they had data in all three waves, from Wave 4 to Wave 6. We were keen to include some countries from eastern Europe and not just focus on western Europe.

We confine attention to individuals participating in at least two of the three waves and stipulate that they must have participated in Wave 6 (so as to ensure that we can measure change over time in cognitive function). 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. The research therefore focuses on normal cognitive ageing processes. The final sample is therefore an unbalanced panel and includes some 114,974 observations on 43,687 individuals.

Measures of cognitive ageing

Cognitive ageing is a multidimensional phenomenon, and several aspects of the respondent's cognitive functioning are assessed in SHARE. We focus on verbal fluency and memory. 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 & 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 & Stern, 2009). In the verbal fluency task, the participant is asked to name as many items meeting a given criterion as they can in a minute. 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 & 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 (Wagnon et al., 2019). 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. 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 (Banks & Mazzonna, 2012; Bonsang et al., 2012; Rohwedder & Willis, 2010), 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. 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.

Engagement in learning, and other cognitively stimulating activities (CSA)

Our key independent variables are measures of various cognitively stimulating activities (CSAs) including engagement in learning. These 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 certain leisure activities 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).

We have, then, four distinct activities here. Each of them is self-directed, since they are all part of 'leisure', and two of them are types of engagement in learning. The first, as it involves attendance at a course, may be best regarded as non-formal education. The second, reading books, magazines or newspapers, falls within the spectrum of informal learning. Then we have mentally stimulating activities which would not usually be regarded as part of learning. The third item on the list encompasses solitary puzzle-solving such as crosswords and Sudoku, while the fourth activity covers social game playing, for example, chess or cards.

The activities are not mutually exclusive; respondents might participate in none of the activities through to all four of them. We created dichotomous variables for each activity taking the value one when respondents had done the activity and zero otherwise; a further binary variable assessing whether they had engaged in any of them in the 12 months before the interview, was also created.

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 assigned to one of three levels, low, medium or high based on the widely-used ISCED measure of education (Eurostat, 2016). 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. Both social network variables are time-varying. The health control variables included in the current analysis are the engagement in vigorous or moderate activities, and drinking habits – all of these are also time-varying.

Analyses

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). 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.

Descriptive findings

Figures 1 and 2 provide the first insights into the cognitive functioning measures used in this study. They display the cross-sectional average age profile of two different cognitive test scores in SHARE (memory and verbal fluency). Three findings are apparent. Firstly, 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. Secondly, average test scores remain relatively stable until 60 years of age but decrease rapidly at older ages. Thirdly, the age-related cognitive decline varies for the different cognitive domains, with the measure of episodic memory displaying the most notable degree of age-related decline. That is not surprising. As Bingöl et al. (2016) state, the memory test is a measure of pure fluid intelligence, so reflects the functioning of neurological structures which increase until the cessation of neural maturation, generally during adolescence, and then go into decline. 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 is 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 (T. 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 3–6 then show the age distribution of the averages of verbal fluency and memory scores by different CSAs. 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 seems 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).

The patterns showed in these descriptive statistics suggest 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

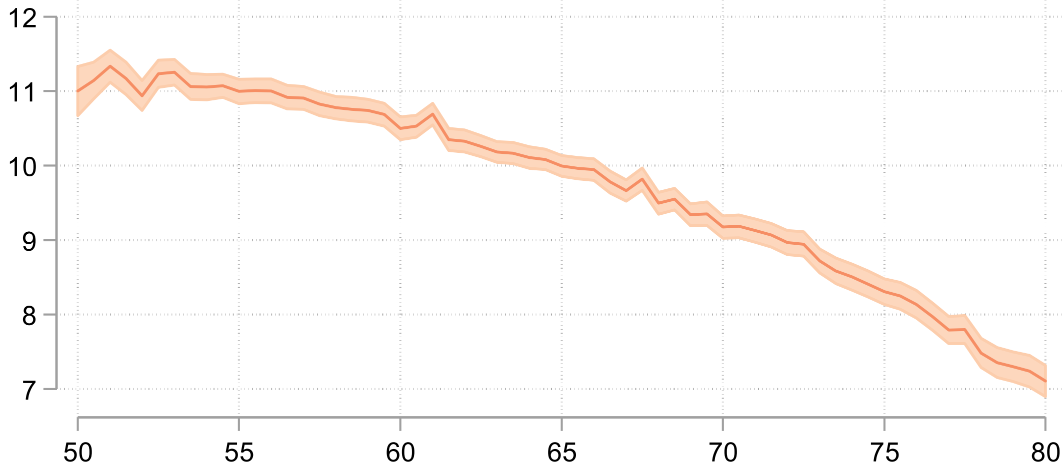

Figure 1. Age profiles of average memory score.

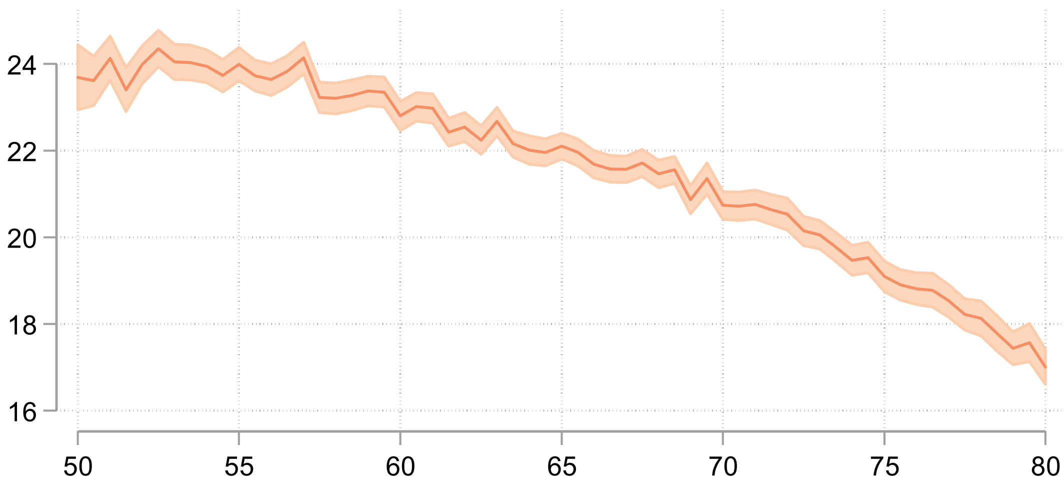

Figure 2. Age profiles of average verbal fluency score.

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 within a regression modelling framework.

Regression analysis

Hence fixed effects regression models 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. Tables 1 and 2 summarise the FE regression estimation results for 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.

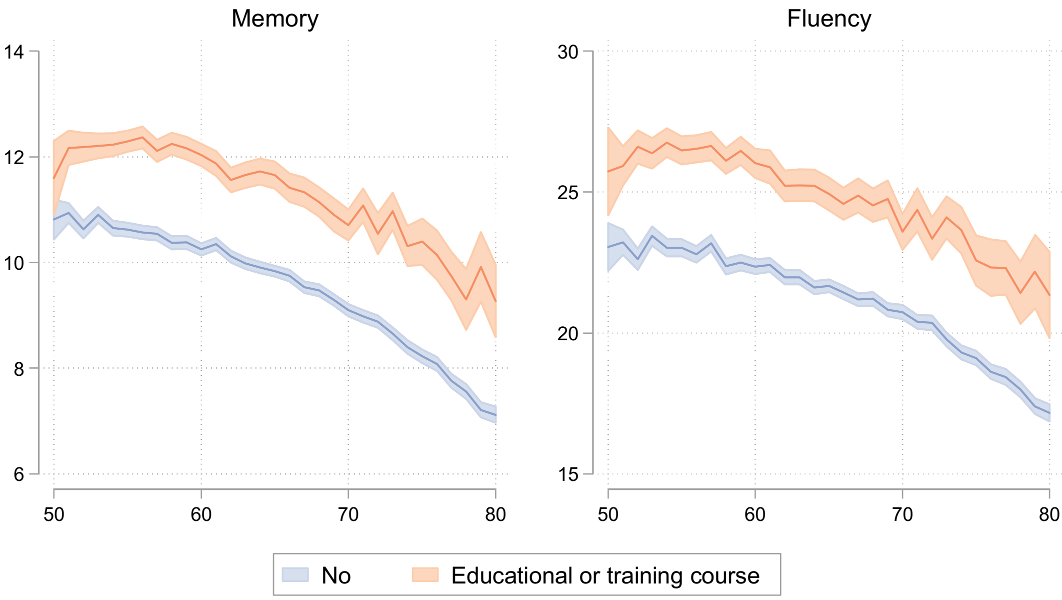

Figure 3. Age profiles of average test scores by engagement in cognitively stimulating activities: attending training or educational courses.

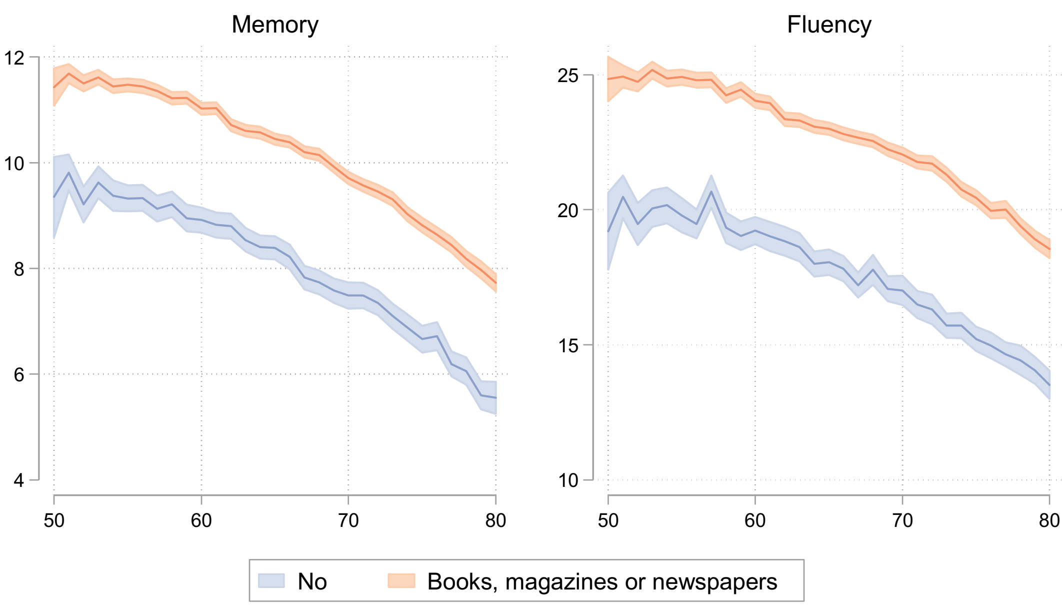

Figure 4. Age profiles of average test scores by engagement in cognitively stimulating activities: reading books, magazines or newspapers.

These results show that CSAs were positively, and significantly, associated with both of the measures of cognitive functioning. Our estimates imply that engaging in reading would increase the memory score by about 0.080 SDs, and 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

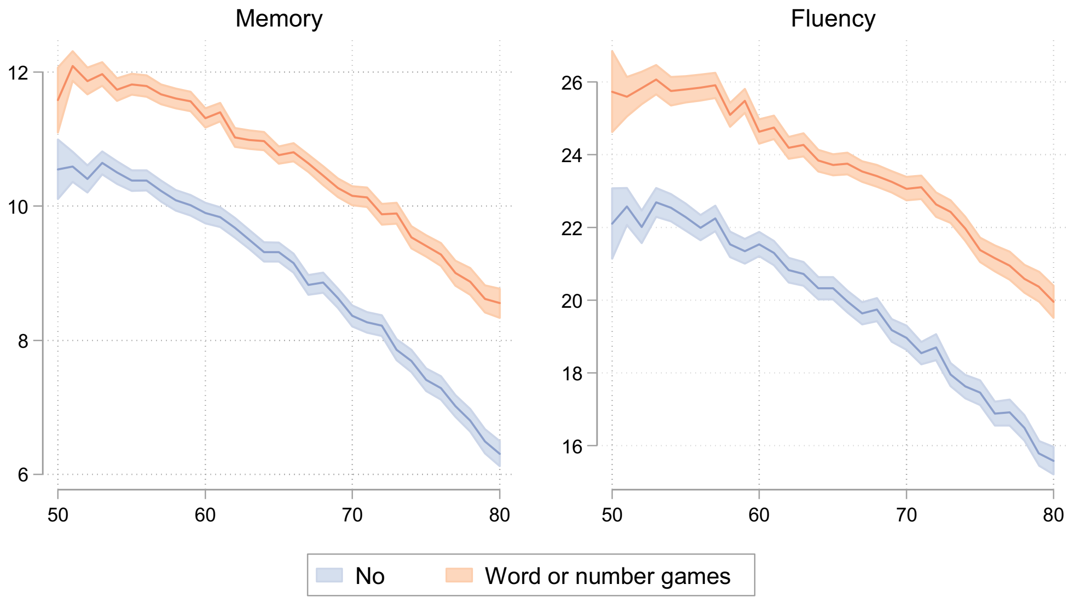

Figure 5. Age profiles of average test scores by engagement in cognitively stimulating activities: playing word or number games (crossword puzzles/Sudoku . . .).

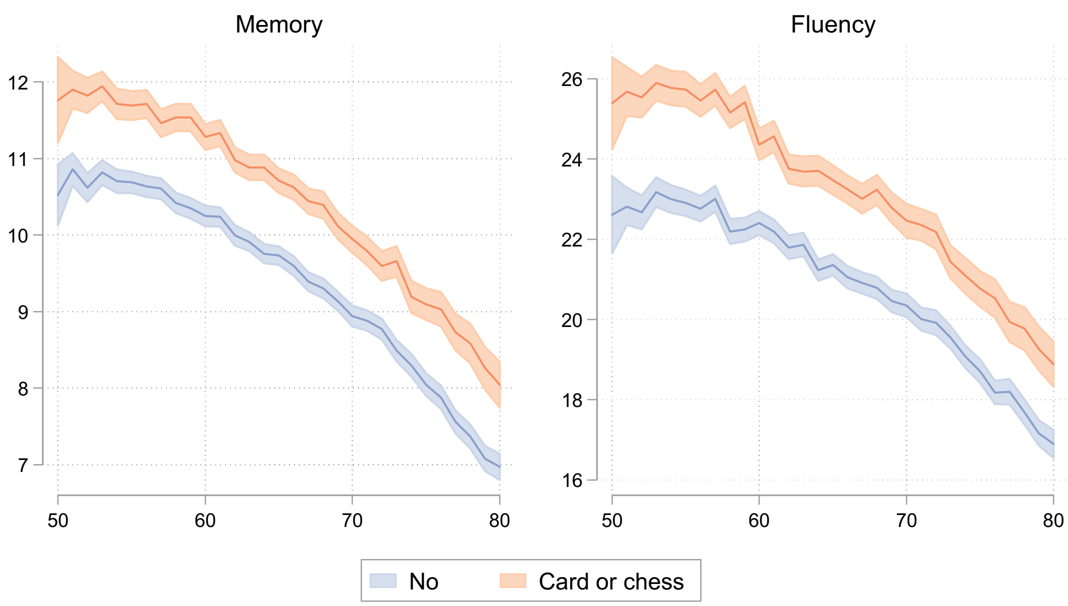

Figure 6. Age profiles of average test scores by engagement in cognitively stimulating activities: playing cards or games such as chess.

(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 effects on memory score (respectively 0.069 SDs and 0.026 SDs).

Table 1. Fixed effects: regression of memory test scores (standardised) on CSA activities.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Model I	Model II	Model III	Model IV	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

Note: All models also include a quadratic in age as well as controls for employment status, partnership status, and health (participation in moderate or vigorous physical activities and drinking habits).
Robust standard errors in parentheses *** p < 0.01, ** p < 0.05, * p < 0.1

Table 2. Fixed effects: regression of verbal fluency test scores (standardised) on CSAs.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Model VI	Model VII	Model VII	Model IX	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

Note: All models also include a quadratic in age as well as controls for employment status, partnership status, and health (participation in moderate or vigorous physical activities and drinking habits).
Robust standard errors in parentheses *** p < 0.01, ** p < 0.05, * p < 0.1

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 effect of CSAs 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 3 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 4.

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, 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

Table 3. Memory test scores: heterogeneity across sub-samples.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Education/ Training	Reading	Word/Number games	Chess/Cards	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)

Note: All models also include a quadratic in age as well as controls for employment status, partnership status, and health (participation in moderate or vigorous physical activities and drinking habits).
Robust standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1

Table 4. Verbal test scores: heterogeneity across sub-samples.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Education/ Training	Reading	Word/Number games	Chess/Cards	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)

Note: All models also include a quadratic in age as well as controls for employment status, partnership status, and health (participation in moderate or vigorous physical activities and drinking habits).
Robust standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1

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, or lack of cultural capital, 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 less participation may occur. 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 an upper secondary school diploma. The only exception to this trend was found for reading as both Tables 3 and 4 show that highly educated individuals (holding a bachelor's degree or higher qualifications) 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 sizeable 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.

Discussion and limitations

Cognitive decline with age is a major challenge both at individual and societal level. This paper focuses on two cognitive functioning measures: 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 (Anderson & Craik, 2000; Souchay et al., 2000). The 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).

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 later life (Lachman et al., 2010; Litwin et al., 2017). 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 availability of data for many countries in the SHARE survey, which improves the findings' generalisability. 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). 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 (T.A. Salthouse, 2010). This could mean that there is some tendency for age-ability estimates to be biased upwards (Hertzog et al., 2008).

Conclusion

Our results, the finding of a strong relationship between cognitively stimulating activities (CSAs) and the delay of cognitive decline in older adults, are important. 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 because it promises to enhance quality of life in old age.

Cognitively stimulating 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.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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