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ARTICLE

The interrelationship between social connectedness and social engagement and its relation with cognition: a study using SHARE data

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Abstract

Understanding how psychosocial factors can promote better cognition in mid- and later life is important for making recommendations regarding policies and intervention programmes. This study focuses on two psychosocial aspects (social connectedness and social engagement) in order to assess their independent contribution to explaining cognition, but also how their interrelationship acts on cognition. We hypothesised that each of the factors is positively associated with cognition, but also that a combination of both factors contributes more to cognition than each of the factors independently. Our sample comprises 66,504 individuals who participated in the Survey of Health, Ageing and Retirement in Europe (SHARE). Multilevel linear regression analyses were performed. The results show that higher levels of social engagement and social connectedness are associated with improved cognition. When studying the interaction of social engagement and social connectedness and its association with cognitive function, the analysis shows that better cognitive scores are found in individuals having high levels of both social engagement and social connectedness. Moreover, when one of these aspects is lacking, the other plays a role in cognition protection. This study indicates the importance of social connectedness and social engagement for preserving/developing cognition, which greatly contributes to the quality of life of middle-aged and older adults.

Keywords: ageing; cognition; social connectedness; social engagement; Survey of HealthAgeing and Retirement in Europe (SHARE)

Introduction

Previous research states that cognitive functioning is a critical aspect of older adults' overall wellbeing (Holt-Lunstad *et al.*, 2010; Schwartz and Litwin, 2019) since lower

levels of cognition are associated with reduced quality of life, functional dependence and even mortality (Pavlik *et al.*, 2003; Ishizaki *et al.*, 2006; Johansson *et al.*, 2012).

Several studies stress that the level of cognitive functioning is characterised by high heterogeneity across older adults (Aartsen *et al.*, 2019). Most individuals experience subtle cognitive changes at older ages, such as variations in memory, executive function, attention, reasoning and spatial abilities (Rog and Fink, 2013; Blazer *et al.*, 2015), which do not interfere negatively with their daily activities (Dobrowolski, 2014). However, some may suffer a decline greater than would be expected for their age (Petersen *et al.*, 2001). These variations across individuals are explained not only by genetic or biological traits, but also by different lifestyle choices, education, and social and economic factors during their lifespan (Leist *et al.*, 2014; Blazer *et al.*, 2015).

The evidence suggests that maintaining a socially integrated lifestyle helps preserve cognition and mental health in later life. Two important aspects of a socially integrated lifestyle that promote better cognition in middle and older age are social connectedness and social engagement (Fratiglioni *et al.*, 2004).

Social connectedness indicates the presence of social ties and is included in the notion of social capital proposed by Gray (2009), meaning the cluster of social contacts that provides individuals with social, emotional and practical support. The complexity of an individual's social connections is difficult to capture, with the literature suggesting a multidimensional approach to the topic and its different aspects which play different roles in the individual's life (Fiori *et al.*, 2007; Evans, 2019; Fratiglioni *et al.*, 2020). Previous research has identified several dimensions of social connections (Antonucci and Kahn, 1980; Victor *et al.*, 2000). For example, Antonucci and Kahn (1980) identified three dimensions of social connections based on the broad concept of social networks: structure, function and subjective evaluations of quality. The structure includes network size, proximity and frequency of contact; function refers to the exchange of different kinds of support between network members and subjective evaluations of quality provide an insight into the individuals' experiences of their networks (Fiori *et al.*, 2007). Other authors (Zunzunegui *et al.*, 2003; Wilson *et al.*, 2015) refer to social networks as the number of people within the social network, including family and friends.

The second aspect of a socially integrated lifestyle that helps promote better cognition in middle and older age is social engagement. This is defined as being involved and/or being engaged in formal and informal social activities (Jenkins *et al.*, 2002; Litwin, 2010), such as church attendance, volunteering and work, on the one hand, and getting together with friends and family, and group recreation (Bourassa *et al.*, 2017; Poey *et al.*, 2017), on the other. Therefore, social engagement is frequently studied through the type and the frequency of activity participation (H-X Wang *et al.*, 2002; Zunzunegui *et al.*, 2003; Wilson *et al.*, 2015).

Social connectedness and cognition

Several studies highlight that cognition can be influenced in several ways by social connections. For instance, Berkman and Glass (2000) note that the dissemination of knowledge and information through an individual's social network will influence their lifestyle choices, which are sustained through informal social control and

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protect against poor cognition. In fact, there is strong evidence to suggest that maintaining meaningful social relationships and social ties can play a protective role against pathological decline in later life (Fratiglioni *et al.*, 2004; Schwartz and Litwin, 2019). Maintaining good social connections and social networks will require cognitive strategies to monitor, create, maintain and modify interactions and contacts within the social network of the individual, which will help build cognitive reserve (Watson and Andrews, 2002) by providing 'cognitive exercise' and stimulation, act as a buffer against stressful situations and promote healthy behaviours (Cohen and Wills, 1985; House, 1987; Kelly *et al.*, 2017). Kuiper *et al.* (2016) found, in a meta-analysis, that even though there is greater heterogeneity in the methodology used to measure the concept of social relationships, the outcome is the same: poor structural and functional aspects of social relationships are associated with poor cognition. Less consensus seems to exist when the association between the characteristics of social networks and cognitive function is considered. In fact, while some studies show that a larger social network size and increased frequency of social contact are better for cognitive function (Scarmeas *et al.*, 2001; Saczynski *et al.*, 2006; Crooks *et al.*, 2008; Gureje *et al.*, 2011), others conclude that social network size is not strongly related to the level of cognition in old age (Glei *et al.*, 2005; Hughes *et al.*, 2008). This might be due to the fact that satisfaction with social relationships within one's network is more important than the number of social connections (Krueger *et al.*, 2009).

Social engagement and cognition

Participating in social activities plays a meaningful social and economic role that may promote a useful, competent self-concept and a sense of self-efficacy that has been linked to a variety of positive health outcomes in middle-aged and older adults (H-X Wang *et al.*, 2002). In fact, several authors suggest that more frequent social participation results in better cognitive function (Zunzunegui *et al.*, 2003; Krueger *et al.*, 2009; Middleton and Yaffe, 2010). In the same vein, in a study conducted by Haslam *et al.* (2015), the authors estimate that an individual of 80 years of age who participates in social groups has their cognitive age reduced by 9.5 years.

The interrelationship between social connectedness and social engagement and its relationship with cognition

The interrelationship between social connectedness and social engagement can have an impact on cognition through psychosocial mechanisms since people who have frequent contact with their connections also have more opportunities to engage socially with others (Berkman and Glass, 2000). If an individual is socially engaged in a cognitively stimulating activity during social interactions, this will indirectly contribute to building up a reserve and protecting cognition (Toepoel, 2013). A longitudinal study by Zunzunegui *et al.* (2003) suggested a possible interaction between social engagement and social connectedness. In fact, the effects of social connections through individuals' social networks can be partially explained by social engagement, because the association of social connections with cognition

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has an increased effect when social engagement is considered. In another piece of research by Litwin and Shiovitz-Ezra (2006), the authors also studied the association between social connectedness and social engagement and found that the quality of social contacts matters more than engagement in social activities as a predictor of good old age (Litwin and Shiovitz-Ezra, 2006). Along the same lines, another more recent study, conducted by Litwin and Stoeckel (2014), found that individuals who lack meaningful social ties can benefit most from engagement in a greater diversity of activities, while those with a greater number of social ties experience fewer advantages for their wellbeing from participating in activities. A study by Litwin and Stoeckel (2016) showed that activity participation yielded stronger positive associations with word recall and self-rated memory than social connectedness. However, when the authors analysed the interrelationship between the two factors (activity participation and social connectedness) and word recall, on the one hand, and self-rated memory, on the other, they concluded that the interactions indicate that the strength of activity participation lessened as social connectedness increased, for both the objective and subjective cognitive outcome measures.

Research aim

With this in mind, in this study, we are going to build upon evidence stating that social engagement and social connectedness play a crucial role in cognition, and importantly, we will focus on how their interrelationship acts on cognitive function. Based on the literature review, we hypothesise that both social connectedness and social engagement are positively related to cognition in mid- and later life, but when the interrelationship between the two is considered, we hypothesise that both aspects are critical for high cognition scores.

We aimed to complement and refine the main idea underlying Litwin and Stoeckel (2016) by using a global cognitive score and focusing on formal social activities, excluding intellectually stimulating activities that could result in bias.

Data and methods

Study population

The current study uses data from the Survey of Health, Ageing and Retirement in Europe (SHARE), Wave 6, release 7.0.0 (N = 50,428). SHARE is a multidisciplinary and cross-national biennial panel survey that provides data on the health, socio-economic status, and social and family networks of more than 140,000 individuals aged 50 years and older, covering 27 European countries and Israel. Wave 6 of SHARE was conducted in 2015 in a total of 18 SHARE countries (Austria, Germany, Sweden, Spain, Italy, France, Denmark, Greece, Switzerland, Belgium, Czech Republic, Poland, Luxembourg, Portugal, Slovenia, Estonia, Croatia and Israel). Samples from each country are based on a probability sample that is representative of the non-institutionalised population aged 50+ (Malter and Börsch-Supan, 2017).

Interviews are conducted face-to-face in the respondent's household, using a computer-assisted personal interviewing program (CAPI) (Malter and Börsch-Supan, 2017). All interviewers are trained in order to ensure the reliability,

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consistency, generalisation and comparability of results across countries (Alcser and Benson, 2005).

More specific details of the SHARE study are available elsewhere (Börsch-Supan *et al.*, 2013; Malter and Börsch-Supan, 2017).

Our sample is made up of Europeans and Israelis aged 50 years and older, who were not working at the time of the interview. We restricted our sample to the non-working population, as research has shown that engagement in demanding activities produces changes in the brain that may also facilitate brain health and optimal cognitive functioning (Park *et al.*, 2014; Vance *et al.*, 2016).

Study variables

Dependent variable

The dependent variable, *cognitive function*, is measured using five different objective cognitive tests that focus on: verbal fluency (naming as many animal names as possible in one minute); immediate recall (immediately recalling as many words as possible from a ten-word list that has been previously read out loud once by the interviewer); delayed recall (recalling the same words, after a standardised period of time); numeracy (performing a series of subtraction tasks, based on the Serial Seven Test); and orientation (giving the correct day of the month, day of the week, month and year). Following the procedures in Leist *et al.* (2013, 2014), a summary score of cognitive function was built by averaging the z-scores of these five tests. The score ranges from 12.53 to 40.84, with higher values indicating better cognitive function.

Interest variables

The interest variables of this study are *social connectedness* and *social engagement*.

Social connectedness is assessed using a composite measure scale created and validated by Litwin and Stoeckel (2014) based on the subjective mapping process of older adults' personal social networks. The social network data were obtained through a name generator technique, where the respondents were asked to identify up to six people with whom they discussed important personal matters and to identify an additional person who was important to them for any other reason (Litwin and Stoeckel, 2014). This technique also enables the collection of additional information about each person mentioned, such as the nature of the relationship, geographic proximity, frequency of contact and degree of emotional closeness (Litwin *et al.*, 2013).

The social connectedness scale, therefore, combines the five main characteristics of the social network into one composite measure: (a) the number of persons cited (network size); (b) the number of cited social network members living within 25 kilometres (proximity); (c) the number of cited persons with weekly or more contact (contact frequency); (d) the number of cited persons with very or extremely close emotional ties (support); and (e) the number of different types of relationships present within the network (diversity). The fifth characteristic reflects the number of different relationship categories (spouse; other family, including children; friend; other) that were present in the network. The respondents who did not identify any social network members were scored as zero (Litwin and Stoeckel, 2014). According to Litwin and Stoeckel (2014), having a higher social network score in each category is representative of stronger network resources.

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Respondents without social connectedness were defined as those who did not name anyone. For more details, *see* Litwin and Stoeckel (2014).

SHARE does not have a unified social engagement scale. Therefore, we built a *social engagement* measure, similar to a previous social participation scale employed by Bourassa *et al.* (2017). This indicator includes a question regarding whether respondents had participated in three common types of social activities over the past 12 months (voluntary or charity work; sports, social or other kind of club; political or community organisation) and a subsequent question about the frequency of participation in each activity (almost daily, almost every week, almost every month, less often). The two questions were gathered creating a continuous variable ranging from 0 to 9, with higher scores indicating more social engagement. Since the higher categories of this continuous variable had small frequencies, the variable was then rearranged into four categories (0, 1, 2, 3 or more). As in the study by Bourassa *et al.* (2017), we did not include attending an educational or training course, since it might comprise a cognitive feature and deviate our focus from the social component. Moreover, unlike the Bourassa *et al.* (2017) scale, our indicator does not include participation in a religious organisation, as this activity was not considered in the Wave 6 questionnaire.

Control variables

Several sociodemographic, economic and health variables are controlled in our model.

Sociodemographic variables include age at the time of the interview; gender (female and male); living alone (living with one or more people, and living alone); and educational level, which is measured by the International Standard Classification of Education (ISCED-97) and divided into three categories: primary schooling or less, secondary education and post-secondary education (Litwin *et al.*, 2014).

Economic variables include the financial situation of the respondent and his or her self-perception of financial distress. To assess the financial situation of the respondent, the total household net income adjusted for purchasing power parity and household size square root was used and classified into tertiles (low, medium, high). The self-perception of financial distress was considered, using a single item probing respondent's ease of 'making ends meet'. 'Making ends meet' was grouped as follows: 'great difficulty' and 'some difficulty', on the one hand, and 'easily' and 'very easily', on the other.

Health characteristics include physical and mental health. Physical health was assessed using a latent continuous physical health measure based on the procedures of Ploubidis and Grundy (2011) and Di Gessa *et al.* (2016). This measure comprehends one objective health indicator (maximum grip strength) and six subjective ones, namely self-perceived health, the presence of a long-term illness, limited activities due to poor health, and three health conditions, namely having had a heart attack, stroke and chronic lung disease. According to Ploubidis and Grundy (2011), this indicator is less prone to measurement error and has greater repeatability and reliability compared to individual health indicators used separately. The score ranges from 1.43 to 4.77, with higher scores indicating better health. To build this variable, Mplus, version 7, WLSMV estimator was used. This physical

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health indicator revealed a good model fit: Root Mean Square Error of Approximation = 0.03; Comparative Fit Index = 0.98 and Tucker–Lewis Index = 0.97.

Mental health was measured using the EURO-D scale that consists of a sum of 12 depressive symptoms over the last month: feelings of depression, pessimism, wishing death, guilt, irritability, tearfulness, fatigue, sleeping troubles, loss of interest, loss of appetite, reduction in concentration and loss of enjoyment (Prince *et al.*, 1999). This scale ranges from 0 to 12, with scores greater than 3 indicating clinically significant depression symptoms (1) and scores equal or lower than three denoting no clinically significant depression symptoms (0) (Dewey and Prince, 2005).

We also controlled for any previous form of cognitive deterioration, such as Alzheimer's disease, dementia or senility.

Analytical approach

Statistical analyses were conducted using R software, version 4.0.2. In this analysis, all variables were centred. This study was carried out in two stages. Firstly, in order to characterise our study population, univariate descriptive statistics were applied using calibrated individual weights, since the SHARE survey does not have a uniform sample design.

Secondly, multilevel linear regressions, with individuals as Level 1 and countries as Level 2, were performed in order to examine the association between social engagement and social connectedness with cognitive function, while controlling for confounders. Potential interaction between social engagement and social connectedness and its relation to cognition was also tested.

As a first step, the null model (Model 0) was assessed as a means to determine the variance of cognitive function that is explained by country differences, without controlling for any confounders. The Interclass Correlation Coefficient (ICC) of the null model is 11 per cent, meaning that 11 per cent of the variance of cognitive function is explained by country characteristics. Considering that the ICC of our null model is higher than the recommended cut-point of 5 per cent (LeBreton and Senter, 2008), it is necessary to use multilevel modelling in our analysis. As a second step, Model 1 was adjusted only for the control variables (gender, age, living alone, education, income, financial distress, physical health, mental health, Alzheimer's disease/dementia or senility). In Model 2, social engagement and social connectedness were added to the previous model. Model 3 further adjusts for the interaction between social engagement and social connectedness in order to consider if and how social engagement and social connectedness interact with each other to alter the respective associations with cognitive function in later life.

Results

The characteristics of the study population are displayed in Table 1. The results show that the mean score of cognitive function is 28.46 (standard deviation (SD) = 3.51) on a scale ranging from 12.53 to 40.84. The mean score of social connectedness is 1.97 (SD = 0.85) on a scale ranging from 0 to 4, indicating a moderate level of social connectedness resources. More than half the respondents (69.37%) never engaged in any social activity (voluntary or charity work; going to a sports, social or other kind of club; taking part in a political or community organisation).

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Table 1. Descriptive statistics of the study sample

	Minimum	Maximum	%	Mean	SD
Demographic and socio-economic characteristics:					
Age	50	105		70.1	10.01
Gender (male)			43.12		
Education:					
Primary or less			50.11		
Secondary			31.99		
Post-secondary			17.9		
Income per capita:					
Low			36.41		
Medium			33.6		
High			29.99		
Financial distress (yes)			41.77		
Live alone (yes)			28.86		
Health characteristics:					
Physical health	1.43	4.77		3.18	0.71
Mental health (yes)			34.29		
Alzheimer's, dementia or senility (yes)			2.80		
Social connectedness	0	4		1.97	0.85
Social engagement:					
Level 0			69.37		
Level 1			7.64		
Level 2			12.76		
Level 3 or more			10.23		
Cognitive function	12.53	40.84		28.46	3.51

Notes: Weighted data. N (unweighted) = 50,428. SD: standard deviation.
Source: Survey of Health, Ageing and Retirement in Europe (SHARE), Wave 6, release 7.0.0.

Furthermore, the participants have a mean age of 70.10 years (SD = 10.01) and men constitute 43.12 per cent of the sample. In addition, 28.86 per cent of respondents live alone. Furthermore, 50.11 per cent completed primary education or less, 31.99 per cent completed secondary education and 17.90 per cent completed post-secondary education.

Our findings also highlight that the household income tertiles are mostly evenly distributed across the study sample and that 41.77 per cent of the respondents reported having difficulties 'making ends meet'.

In terms of health, the respondents scored a mean of 3.18 (SD = 0.71) on a scale from 1.43 to 4.77 on physical health, and 34.29 per cent reported symptoms of

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clinically significant depression; 2.80 per cent of the respondents reported having been diagnosed with Alzheimer's disease/dementia or senility.

Table 2 presents the results of the multilevel linear regressions. When comparing Model 1 with the null model, the deviance lowered, which means that, by adding the control variables, the model increased its quality (233,910.1, $p < 0.001$). Decreases in deviance were also observed in Models 2 and 3 (208,982.9, $p < 0.001$ and 208,965.6, $p < 0.001$, respectively).

The final model (Model 3) shows that, for each additional year of age, cognitive function scores decrease 1.01 points ($\beta = -1.01$; standard error (SE) = 0.01; $p < 0.001$) and that, on average, men score lower on cognitive function than women ($\beta = -0.29$; SE = 0.03; $p < 0.001$).

A statistically significant relationship between the interest variables and cognitive function was found. In fact, for each score on the social connectedness scale, cognitive function increased, on average, 0.23 points ($\beta = 0.23$; SE = 0.02; $p < 0.001$). This means that when individuals score higher on the social connectedness scale, they also achieve greater values on the cognition measure. In addition, individuals with a higher level of social engagement (Level 3 or more) score 0.83 points more on the cognitive function scale than the individuals with no social engagement (Level 0) ($\beta = 0.83$; SE = 0.05; $p < 0.001$).

According to Figure 1, individuals with the lowest level of cognition are the ones with no social engagement and no social connectedness. Furthermore, individuals with the highest cognition score are the ones with a higher level of social engagement and a higher level of social connectedness. Our results also suggest that the level of cognition is similar for individuals with no social engagement but higher levels of social connectedness, and for those with no social connectedness but a higher level of social engagement.

Although higher levels of social engagement and social connectedness are independently associated with better cognition scores, the association between social connectedness and cognitive function assumes a greater importance for individuals who have no social engagement. In addition, Figure 1 shows that individuals with no social connectedness benefit their cognition by engaging socially.

Furthermore, regarding the results of the control variables, we found that individuals who live alone also scored less on the cognitive function measure than individuals who do not live alone ($\beta = -0.20$; SE = 0.03; $p < 0.001$). When compared to individuals with primary education or less, respondents with secondary education score 0.93 units more on cognitive function, and respondents with post-secondary education score 1.59 units more ($\beta = 0.93$; SE = 0.03; $p < 0.001$ and $\beta = 1.59$; SE = 0.04; $p < 0.001$, respectively).

With regard to income, when compared to respondents with a low income, middle-income individuals present, on average, 0.32 score units more on cognition measures and individuals with high income present, on average, 0.64 score units more ($\beta = 0.32$; SE = 0.03; $p < 0.001$ and $\beta = 0.64$; SE = 0.04; $p < 0.001$, respectively). In addition, respondents who reported difficulty making ends meet scored 0.19 points less on cognitive function than the respondents who make ends meet somewhat easily ($\beta = -0.19$; SE = 0.03; $p < 0.001$).

Results also suggest that individuals with better physical health achieve better cognitive scores. More specifically, for each point on the physical

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Table 2. Results of the multilevel linear regression analysis

	Model 0 (N = 48,017)			Model 1 (N = 47,997)			Model 2 (N = 43,180)			Model 3 (N = 43,180)		
	β	SE	*p*	β	SE	*p*	β	SE	*p*	β	SE	*p*
Fixed parts:												
Intercept	−0.53	0.27	0.053	−1.07	0.22	<0.001	−1.21	0.20	<0.001	−1.21	0.20	<0.001
Gender (male)				−0.33	0.03	<0.001	−0.28	0.03	<0.001	−0.29	0.03	<0.001
Age				−1.00	0.01	<0.001	−1.01	0.01	<0.001	−1.01	0.01	<0.001
Live alone (yes)				−0.26	0.03	<0.001	−0.20	0.03	<0.001	−0.20	0.03	<0.001
Education (Ref. Primary or less):												
Secondary				1.01	0.03	<0.001	0.93	0.03	<0.001	0.93	0.03	<0.001
Post-secondary				1.76	0.04	<0.001	1.59	0.04	<0.001	1.59	0.04	<0.001
Income per capita (Ref. Low):												
Medium				0.39	0.03	<0.001	0.32	0.03	<0.001	0.32	0.03	<0.001
High				0.74	0.03	<0.001	0.64	0.04	<0.001	0.64	0.04	<0.001
Financial distress (yes)				−0.27	0.03	<0.001	−0.20	0.03	<0.001	−0.19	0.03	<0.001
Physical health				0.41	0.01	<0.001	0.35	0.02	<0.001	0.35	0.02	<0.001
Mental health (four or more symptoms)				−0.76	0.03	<0.001	−0.76	0.03	<0.001	−0.76	0.03	<0.001
Alzheimer's, dementia or senility				−3.94	0.10	<0.001	−3.56	0.11	<0.001	−3.56	0.11	<0.001
Social connectedness							0.19	0.01	<0.001	0.23	0.02	<0.001

Social engagement (Ref. Level 0):									
Level 1				0.56	0.05	<0.001	0.58	0.05	<0.001
Level 2				0.65	0.04	<0.001	0.66	0.04	<0.001
Level 3 or more				0.82	0.05	<0.001	0.83	0.05	<0.001
Social connectedness × Social engagement Level 1							−0.15	0.05	0.001
Social connectedness × Social engagement Level 2							−0.11	0.04	0.005
Social connectedness × Social engagement Level 3+							−0.08	0.04	0.057
Random parts:									
ICC (country)	0.112	0.097		0.085			0.085		
Between-country variation	1.345	0.822		0.687			0.688		
Deviance	249,814.4	233,910.1		208,982.9			208,965.6		
N (country)	18	18		18			18		

Notes: Unweighted data. SE: standard error. Ref.: reference category. ICC: Interclass Correlation Coefficient.
Source: Survey of Health, Ageing and Retirement in Europe (SHARE), Wave 6, release 7.0.0.
Significance level: $p < 0.05$.

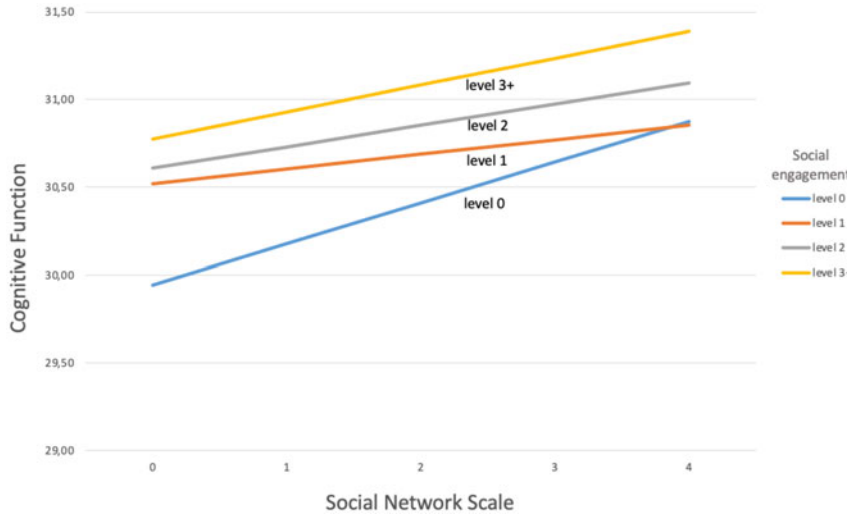

Figure 1. Interaction between social engagement and social connectedness and its relationship with cognitive function.
Source: Survey of Health, Ageing and Retirement in Europe (SHARE), Wave 6, release 7.0.0.

health scale, cognitive function increases, on average, 0.35 score units ($\beta = 0.35$; SE = 0.02; $p < 0.001$). On the other hand, individuals with symptoms of clinically significant depression scored fewer points in cognitive function than individuals with no depression symptoms ($\beta = -0.76$; SE = 0.03; $p < 0.001$). Individuals with a diagnosis of Alzheimer's disease, dementia or senility score, on average, 3.56 points less on the cognition measure ($\beta = -3.56$; SE = 0.11; $p < 0.001$).

Discussion

In this research, we aimed to study the independent contribution of social connectedness and of social engagement to explaining the cognitive function of Europeans and Israelis aged 50 years and older who were not working at the time of the interview, but also how the interrelationship between social connectedness and social engagement acts on cognition.

When analysing the prominent role of social engagement and social connectedness in cognitive health, we found that higher levels on both the social engagement and social connectedness scales were independently associated with higher cognition scores. These results are in line with a previous longitudinal study where social connectedness and social engagement had a positive effect on memory performance and acted as a protective factor against cognitive decline, helping to preserve mental functioning in community-dwelling older adults (H-X Wang *et al.*, 2002).

When analysing the interaction of social engagement and social connectedness and its association with cognitive function in our sample, we found that individuals with the highest cognition score have a higher level of social engagement and also a higher level of social connectedness. This means that both social engagement and social connectedness play a protective role in cognition. Moreover, for individuals

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with no social engagement but with high levels of social connectedness, and for individuals with no social connectedness but high levels of social engagement, the cognition score is relatively the same. This means that one aspect does not have more benefits for cognition than the other, but rather, in the absence of one, the other assumes a protective role. Thus, our study complements the previous literature (Litwin and Shiovitz-Ezra, 2006; Litwin and Stoeckel, 2014, 2016) which attributes a higher importance to social connectedness for cognition and wellbeing in later life, as well as research (Zunzunegui *et al*., 2003) concluding that the association of social connections with cognition has a more marked effect when social engagement is taken into account.

Several mechanisms can explain our findings. Psychological factors associated with participation in social activities help individuals fulfil productive and meaningful social roles, maintain and support their sense of usefulness and competence and their self-appraisal, and this in turn might benefit cognition (Herzog *et al*., 1998). The self-concept of usefulness and competence has been found to be a protective factor in several health outcomes, including cognition, in middle-aged and older adults (Orth-Gomér *et al*., 1993; de Leon *et al*., 1996). Our results also support the theory that, when an individual is socially engaged during social interactions, this indirectly contributes to building reserve and protecting cognition (Toepoel, 2013). Furthermore, people who have frequent contact with their connections also have more opportunities to engage socially with others (Berkman and Glass, 2000).

Moreover, our results are actually in line with previous studies that found age to be negatively associated with cognitive function. This supports the argument that cognition tends to decline with age (Zhu *et al*., 2012; Murman, 2015). This result is consistent with theories of brain ageing and atrophy (Elwan *et al*., 2003). Furthermore, contrary to the study by Laws *et al*. (2016), our results suggest that men aged 50+ have worse cognitive function than women. In addition, higher levels of education are associated with a better cognitive function score, as was found in the study by Schneeweis *et al*. (2014). Stern (2009) stresses that cognitive reserve can be built through educational level. Thus, the higher the level of education, the better the reserve. This enables a higher degree of protection against cognitive losses by compensating for damage and recruiting alternative neural networks to maintain good cognitive function (Siedlecki *et al*., 2008).

Regarding living alone, our findings differ from previous studies which suggest that living alone is not associated with cognitive function (B Wang *et al*., 2015; Evans *et al*., 2019). Hence, our findings indicate that people who live alone have worse cognitive function scores than people who do not live alone. This might be because living with others may strengthen cognitive function through the stimulation arising from regular social interaction with others (Van Gelder *et al*., 2006).

Furthermore, higher income was found to be associated with better cognitive function scores, results that are consistent with previous studies (Schneeweis *et al*., 2014; Miu *et al*., 2016). One possible explanation is that people with a higher income formerly had jobs that required a higher educational level and might have more cognitive demand tasks in their jobs, which enhances their cognitive reserve.

Regarding physical health, our findings support other studies which concluded that people with poor physical health also had lower levels of cognitive function

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(Tilvis *et al.*, 2004). A negative influence of depressive symptoms on cognitive functioning was also found. This is consistent with other studies (Cohrdes and Bretschneider, 2018; Faramarzi *et al.*, 2018) which found that individuals with depression present worse performance in measures of cognitive functioning.

Limitations and strengths

The findings of this research need to be interpreted within a framework sensitive to the limitations of the study. Since this study uses a cross-sectional design, we cannot assume causality. Another limitation is the fact that we were not able to include more domains of cognitive function, such as visual-spatial skills, in our global cognition score.

One strength of our study is the choice of social connectedness scale that was addressed in this analysis. While some studies consider the functional characteristics of social networks, such as provided or perceived available support, as important aspects of social connectedness, in our opinion, provided support is a potentially ambivalent variable because not everyone needs support at a specific time. For this reason, we chose to focus on the social connectedness scale proposed by Litwin and Stoeckel (2014). Most of the literature focuses on the influence of network size on cognition and overlooks the importance that the quality of the relationships maintained might have on cognitive function. Litwin and Stoeckel (2014) note that it is not enough to focus only on the quantitative aspect of social networks, one also needs to examine the quality aspect of the relationships of older adults in order to provide insight into meaningful relationships of older adults and this way help to identify successfully possible isolated older adults in the population (Litwin and Stoeckel, 2014). The choice of the social connectedness scale makes it possible to consider both quantitative and qualitative aspects of older people's relationships in a single measure.

We were able to complement the literature by not only using a global cognitive score but also by focusing on formal social activities, while excluding intellectually stimulating activities that could result in bias.

Conclusion

The purpose of this study is to analyse the association between social engagement and social connectedness with cognitive function in a large sample of non-working individuals aged 50 and older, living in Europe and Israel.

Since cognitive health is crucial for older adults' quality of life, understanding the social factors that promote better cognitive function is of the utmost importance. Even though genetic and biological traits influence an individual's cognitive capabilities, psychosocial factors such as social connectedness and social engagement also play an important role. It is therefore crucial to focus the research on understanding the role and relationship between these factors and cognition in order to help modify some risk factors and behaviours in healthy older adults (Fratiglioni *et al.*, 2004, 2020).

Hence, this research was able to show that, when analysing the interaction of social engagement and social connectedness, and its association with cognitive function, when one of the aspects is lacking, the other has a greater influence

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and also plays a protective role. This research can serve as a bridge for intervention studies, in order to provide individuals with low social connectedness with opportunities to enhance their cognitive function, as being socially engaged benefits not only cognition but can also help form social ties.

For future research, many questions still need to be answered. What is the role of personality, genes and different sociocultural environments in cognition? Can social connectedness and social engagement play a long-term role in protecting cognition?

With this study, we are able to highlight the important role of both social connectedness and social engagement in cognition by concluding that, together, they can enhance the best cognitive function and that, in the absence of one, the other assumes a protective role.

Data. SHARE data is available through individual user registration. All details about the application and registration process can be found at http://www.share-project.org/data-access/user-registration.html.

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Author contributions. AFP, CC and ADM designed the study. AFP, CC, GV and ADM analysed the data. AFP, CC and ADM wrote the manuscript. AFP, CC and ADM participated in the critical review of the manuscript. All authors read and approved the final manuscript.

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Conflict of interest. The authors declare no conflicts of interest.

Ethical standards. The SHARE study is guided by international research ethics principles, such as the Respect Code of Practice for Socio-Economic Research and the Declaration of Helsinki. SHARE Wave 6 was reviewed and approved by the Ethics Council of the Max Planck Society for the Advancement of Science, and by the Ethics Committees of the SHARE participating countries.

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