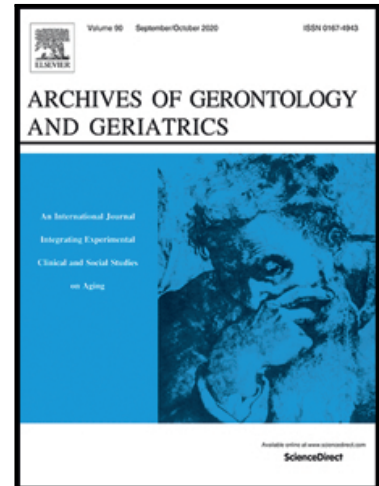


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The Association between Subjective Cognitive Decline and Trajectories of Objective Cognitive Decline: Do Social Relationships Matter?

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Highlights

- Subjective cognitive decline is predictive of objective cognitive decline over time
- A wider social network is associated with a slower objective cognitive decline
- Negative social support is associated with a faster objective cognitive decline
- Social factors do not moderate subjective and objective cognitive decline association

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Abstract

Objectives: We examine the association between subjective cognitive decline (SCD) and the trajectories of objective cognitive decline (OCD); and the extent to which this association is moderated by social relationships.

Methods: Data come from waves 10 (2010) through 14 (2018) of the Health and Retirement Study, a nationally representative panel survey of individuals aged 50 and above in the United States. OCD is measured using episodic memory, and overall cognition. SCD is assessed using a baseline measure of self-rated memory. Social relationships are measured by social network size and perceived positive and negative social support. Growth curve models estimate the longitudinal link between SCD and subsequent OCD trajectories and the interactions between SCD and social relationship variables on OCD.

Results: SCD is associated with subsequent OCD. A wider social network and lower perceived negative support are linked to slower decline in memory, and overall cognition. None of the social relationship variables, however, moderate the link between SCD and future OCD.

Conclusion: Knowing that SCD is linked to subsequent OCD is useful because at SCD stage, deficits are more manageable relative to those at subsequent stages of OCD. Future work on SCD and OCD should consider additional dimensions of social relationships.

Keywords: Subjective Cognitive Decline; Objective Cognitive Functioning; Social Relationships; Health and Retirement Study; Cognitive Aging

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1. Introduction

Subjective cognitive decline (SCD), characterized by everyday memory lapses and complaints about cognition, refers to the perception, not an objective assessment, of cognitive decline (Mitchell et al., 2014). The prevalence of SCD, which is approximately 11.7% in individuals aged 65 and older in the US, increases with advancing age (Alzheimer's Association, 2018; Centers for Disease Control [CDC], 2019). While some studies have found SCD to be inconsequential, according to the CDC, it is a type of cognitive impairment and an early forewarning of objective cognitive decline (OCD), including Alzheimer's disease and other forms of dementia (Alzheimer's Association, 2018; Jessen et al., 2014; Mitchell & Shiri-Feshki, 2009; Mitchell et al., 2014; Reid & Maclullich, 2006). Understanding the linkage between SCD and OCD could help detect individuals at risk for subsequent cognitive deterioration (Brailean et al., 2019). Moreover, early identification of the processes and factors that lead to a differential path from SCD to OCD could prove crucial to creating interventions aimed at improving the prognosis of cognitive decline for persons with SCD.

We contribute to this end in two ways. First, we use waves 10 (2010) through 14 (2018) of the Health and Retirement Study (HRS), a nationally representative panel survey of individuals aged 50 and above in the United States, to examine the association between SCD and subsequent trajectories of OCD. And second, we assess the extent to which the association between SCD and subsequent OCD is moderated by social relationships as reflected by the size of older adults' social network and their perceptions of both, positive and negative social support.

2. Background

2.1 *The connection between subjective and objective decline*

The last decade has witnessed an increasing number of studies on the connection between SCD and OCD. However, most of this work has been cross-sectional and according to meta-analytic evidence, the cross-sectional associations between SCD and OCD are modest (Beaudoin & Desrichard, 2011; Brailean et al., 2019; Crumley et al., 2014). There is some speculation that older adults may resort to varying standards to gauge their current cognitive performance, which may lead to less than reliable reports of cognitive health (Brailean et al., 2019; Mascherek & Zimprich, 2011; Parisi et al., 2011; Zimprich et al., 2003). The inconsistent finding in the literature on the connection between SCD and OCD also may reflect the compromised acuity into cognitive performance among individuals with compromised

cognition (Brailean et al., 2019; Jorm et al., 2001; Galeone et al., 2011; Vogel et al., 2004; Snitz et al., 2015).

While longitudinal examinations of the link between SCD and OCD are on the rise, the findings from these studies remain mixed. One recent study, based on a 25-year follow-up period, found that respondents' objective cognitive deficits were neither cross-sectionally nor longitudinally linked to their SCD (Topiwala et al., 2021). Likewise, Gustavson and colleagues (2021) found no evidence of a link between SCD and OCD after adjusting for mild cognitive impairment (MCI) status at baseline. In contrast, based on an 8-year observation period, Jorm and colleagues (2001) discovered that perceptions of memory loss were negatively associated with subsequent deficits in OCD. Similarly, another recent study reported that persons with SCD are likely to develop cognitive impairment at approximately 28% faster speed, though this finding varied across race and ethnic groups (Ferraro et al., 2022). Consistent with the conceptualization presented by the Subjective Cognitive Decline Initiative working group (SCDI-WG), this suggests that perceptions of impaired memory may represent early indications of subsequent OCD (Jessen et al., 2014). Majority of existing longitudinal research, however, has focused on MCI to assess the progression of SCD to OCD.

In the present study, we measure OCD using a continuous measure of cognitive decline over time, which we believe renders a more informed understanding of the early association between SCD and OCD. More longitudinal studies with larger sample sizes and wider age ranges in both men and women, across race and ethnic groups are needed to understand the interplay between subjective cognitive complaints and subsequent cognitive deficits among the general aging population. Further, we argue that in order to create interventions for those with SCD, we need to identify the social processes that lead to a differential path from SCD to subsequent cognitive decline. In particular, the efforts to manage SCD and either prevent or prolong subsequent cognitive deficits must consider social assets and resources of an older adult.

2.2 Social Relationships as Potential Moderator

Conceptually there are reasons to assume that the strength of the association between SCD and OCD varies based on social relationships factors, such as social network and social support. Social network facilitates social engagement, interactions, and support (Glei et al., 2005; for review, see Costa-Cordella, Arevalo-Romero, & Parada, 2021). And although the size of a network does not equate to the quality of the ties within it, having a wider network may ensure diversity of social contacts, diverse sources of support, and more access to varied

forms of information (Rainie & Wellman, 2012). Social interactions, which accompany social network, include sensory and cognitive stimulation (Henderson et al., 2022; Prior et al., 2022), thus improving cognitive outcomes by preserving cognitive reserve (Scarmeas & Stern, 2003). Social cohesion, which also manifests out of social networks and interactions (Chuang et al., 2013) and reflects a sense of reciprocity of support within the larger community (Cramm & Nieboer, 2015) may be consequential for the relationship between SCD and OCD over time. In fact, recent research discovered that older adults with higher perceived social cohesion report better sleep quality, which in turn, is positively associated with their cognitive health (Wang et al., 2021). Likewise, social support, which grows out of social interactions, in particular, is found to benefit cognitive health via its buffering effect on stress (Cohen & Wills, 1985). Supportive others, be it kin or non-kin, also are beneficial for cognitive health as they are likely to act as a form of social control by discouraging risky health behaviors and motivating positive health activities (Umberson & Montez, 2010; Umberson, 1987).

Alternatively, social relationships also possess a dark side to them where conflict and negative social interactions, which may include impeding the expression of self, being constantly critical, invading privacy, constantly offering unsolicited support and consult, being excessively meddlesome, or/and failing to provide promised help (Croezen et al., 2012; Lincoln, 2000; Rook, 2014), may become stressors for cognitive health. Moreover, it is worth noting that even when they have a large social network and supportive significant others, older adults who discern memory lapses may disengage socially to protect themselves from frustration and embarrassment, not to mention stigma that often accompanies cognitive impairment (Kim et al., 2019). Disengaging socially, consequently, could further deteriorate cognitive capacities over time. Yet much remains undiscovered about the extent to which social relationships either prevent, delay or accelerate the progression from SCD to OCD.

2.3 Study Rationale

More research on SCD is needed because at SCD stage, the deficits can be more easily managed relative to that of subsequent stages of cognitive decline. SCD research can set in motion efforts to help older adults manage those areas of their lives that may be affected by symptoms of SCD, such as memory lapse. Further, such research can be utilized to steer persons with SCD to cognitive therapy or behavioral interventions, which may assist both, in coping with present symptoms of SCD and subsequent OCD (Fyock & Hampstead, 2015). As such, in the present study, we draw on data from HRS over eight years of follow-up and employ growth curve models to assess (1) the relationship over time between SCD, measured by

baseline self-rated memory, and the trajectories of OCD assessed using episodic memory and a composite score of cognitive functioning; and (2) the extent to which the link between SCD and trajectories of OCD are moderated by social relationships as measured by social network size and perceptions of both, positive and negative social support.

3. Material and methods

3.1 Data and Sample

Data are from the Health and Retirement Study (HRS). HRS is a nationally representative longitudinal panel survey of approximately 20,000 individuals aged 50 and above in the US (Sonnegg et al., 2014). It is supported by the National Institute on Aging (NIA U01AG009740) and the Social Security Administration (SSA). This cohort was first interviewed in 1992 (response rate is 81.6%) and subsequently every two years since then. The subcohorts were added at different stages of the HRS, including the Initial HRS cohort (born 1931 to 1941), AHEAD (born before 1924), CODA (born 1924 to 1930), War Baby (born 1942 to 1947), and Early, Mid and Late Baby Boomer (born after 1947).

We used data from wave 10 (2010; as baseline wave) to wave 14 (2018) of HRS to ensure that most of the subcohorts of the HRS were included (all subcohorts except for the Late Baby Boomer). Meanwhile, 2010 was also the first year when HRS asked respondents to self-report whether having dementia/Alzheimer's disease. We excluded any person who were non-respondents, deceased, or living in a nursing home at the time of the interview (baseline sampling weight equal to zero), self-reported dementia/Alzheimer's disease at baseline, did not participate in the baseline wave, and had missing data on main exposures, outcomes and covariates at baseline. The final sample size included for analysis was 18,316 for objective one. Further, we selected a subsample (i.e., subsample 'A', N=3957) for data analysis of the objective two when involving variables for socialrelationships, as the HRS only collected longitudinal psychosocial data (once per four years) in two randomly selected subsamples 'A' (began in 2006) and 'B' (began in 2008) (Smith et al., 2013). See Appendix Figure A1 for the procedure of sample selection in detail.

3.2 Exposure–Subjective Cognitive Decline (SCD)

The main exposure variable is self-rated memory at baseline (time-invariant variable). Results are collected by asking participants about their present self-rated memory: “How would you rate your memory at present? Would you say it is excellent, very good, good, fair, or poor?”

3.3 Outcomes–Objective Cognitive Decline (OCD)

For OCD, this study had two outcomes (a) episodic memory and (b) a composite score of cognitive functioning. Both are time-varying variables. Episodic memory is measured via immediate and delayed word recall tests, where participants are asked to remember ten words and recall as many as possible. After five minutes, participants are asked to repeat these words. The total number of words recalled from both immediate and delayed tests are collected (0–20), and higher scores reflect a higher level of cognitive functioning. Likewise, the composite cognitive scores are calculated from the results of three different cognitive tests, including the immediate and delayed tests, the serial 7s subtraction test (subtracting 7 from 100 and continue subtracting each subsequent number for five trials), and the counting backward tests (counting backwards for 10 continuous numbers beginning with 20). The composite score ranges from 0 to 27, where a higher score reflects higher cognitive functioning (Crimmins et al., 2011).

3.4 Covariates

We included a series of conceptually relevant covariates in the analysis (Byrne, Ghaiumy, & Anaraky, 2022; Nkwata et al., 2022; Shin et al., 2022; Zhu et al., 2022). All covariates were measured at baseline (wave 10). Demographic covariates include gender, race, and birth year. Socioeconomic factors include assigned marital status, the highest education level, labor force status, and deciles of household wealth (Daly et al., 2002; Robert & House, 1996; Simandan, 2010, 2018). Household wealth is the sum of all wealth components minus the sum of all debts (Daly et al., 2002; Robert & House, 1996). Variables indicative of health status include self-rated health, and presented stroke, hypertension, heart problems and lung diseases, and the score of the Center for Epidemiologic Studies Depression Scale (CES-D). Health behavior covariates include smoking status, frequent vigorous activity, and alcohol consumption.

3.5 Potential Effect Modifiers

Potential effect modifiers included in this study are baseline social network and perceived social support (time-invariant variables). Social network is measured by asking questions about frequencies of connections to friends, children, and family members. Social support are measured by asking questions on the perceived support from their spouses, children, family, and friends. Based on participants' answers, three composite scores were derived for assessing social network and perceived social support. For social network, the composite score ranges from 0 to 18, where a higher score reflects a wider social network. For perceived social support, the composite scores range from 0 to 12 for both positive and negative perceived social support, where a higher score reflects more positive or negative perceived

social support respectively (Smith et al., 2013) See Appendix Method: Derivation of Social Factors for detailed introduction of deriving each composite score in detail.

3.6 Statistical Methods

For objective 1, growth curve models (including both random slopes and intercepts) are applied to estimate the longitudinal associations between self-rated memory (baseline, wave 10), and outcomes, measured by episodic memory (wave 11–14) and composite cognitive scores (wave 11–14) over age. Self-rated memory is categorical, with the excellent self-rated memory group used as the reference group. Episodic memory and composite cognitive scores are used as two continuous outcomes. Age is centered by its minimum value (50 years) for interpretation. Centered age and the quadratic term of the centered age were both modelled to reflect the non-linear decline of episodic memory and cognitive functioning.

We also adjusted for baseline objectively measured episodic memory for all models. The first model controlled for demographic covariates (gender, year of birth, and race) only. In the fully adjusted model, all covariates were adjusted for. Predicted trajectories of episodic memory and the composite score of cognitive functioning across participants' self-rated memory based on the fully adjusted model are shown using margin effects with centered age as the time scale (Pai et al., 2021).

For objective 2, interaction terms (between self-rated memory and social network, between self-rated memory and perceived positive social support, and between self-rated memory and perceived negative social support) are added to the fully adjusted models. If there is no interaction effect, we will include social relationship variables as independent variables (without interactions) to test how social relationship variables are associated with OCD.

A sensitivity analysis is carried out to test the robustness of the results. Analyses for objective 1 are repeated using the smaller sample ($n=3,957$) that was used for objective 2.

All analyses are performed using Stata version 17.

4. Results

Table 1 describes baseline sample characteristics. The mean age in our sample was 66 years old. We had 10% more females than males. Most participants were White/Caucasian (83.5%), married (66.8%) and ex-/non-smokers (around 90%), had upper secondary education or above (around 90%), consumed alcohol <3 days per week (nearly 80%), and rated their health status as good or higher (over 90%). Over one-third of the participants were employed or working full-time, while another one-third were retired. Over half reported no frequent vigorous physical activity. For health conditions, 4.1%, 19.2 % and 8.3% of participants had

stroke, heart problems and lung diseases, respectively, and over half had hypertension. The mean CES-D score was 1.32 (SE=0.02). 22% of the participants self-rated their memory as fair or poor. The mean scores of episodic memory and cognitive functioning were 10.2 (standard error [SE]=0.10) and 15.9 (SE=0.10), respectively. For social relationships, the mean scores of social network and perceived positive and negative social support were 7.8 (SE=0.10), 7.3 (SE=0.05) and 7.4 (SE=0.03), respectively. Except for perceived negative social support, all other covariates were associated with episodic memory, cognitive functioning, and self-rated memory.

Table 1. Baseline sample characteristics (n=18,316)^a

Characteristics	%	Association with composite cognitive scores (coefficient)^b	Association with episodic memory (coefficient)^b	Association with self-rated memory (OR)^c
Gender		p<0.001	p<0.001	p<0.001
Male	44.7	ref	ref	ref
Female	55.3	0.46	0.71	1.18
Race		p<0.001	p<0.001	p<0.001
White/Caucasian	83.5	ref	ref	ref
Black/African American	10.3	-2.70	-1.57	1.32
Other	6.2	-1.67	-0.97	1.16
Marital status		p<0.001	p<0.001	p<0.001
Married or partnered	66.8	ref	ref	ref
Separated, divorced, single or spouse absent	22.0	-0.71	-0.51	0.97
Widowed	11.2	-2.30	-1.23	1.64
Education level		p<0.001	p<0.001	p<0.001
First stage of tertiary education or above	36.6	ref	ref	ref
Upper secondary education	51.2	-2.17	-1.57	1.87
Lower secondary education	8.5	-5.23	-3.54	4.11
Primary education or below	3.6	-6.05	-4.11	4.82
Labour force status		p<0.001	p<0.001	p<0.001
Work full-time and (or) fully-employed	35.6	ref	ref	ref
Work part-time/partly retired	15.2	-0.68	-0.50	1.50
Unemployed	4.4	-1.06	-0.75	1.07
Retired	38.1	-2.51	-2.15	2.67
Disabled	1.8	-3.07	-2.08	3.51
Not in labour force	4.8	-1.35	-1.12	2.18

Self-rated health status		p<0.001	p<0.001	p<0.001
Excellent	57.0	ref	ref	ref
Very good	23.6	-0.47	-0.39	1.31
Good	13.9	-1.28	-1.00	1.94
Fair	4.4	-1.59	-1.03	2.58
Poor	1.1	-2.16	-1.49	3.56
Stroke		p<0.001	p<0.001	p<0.001
No	95.9	ref	ref	ref
Yes	4.1	-2.44	-1.87	2.16
Hypertension		p<0.001	p<0.001	p<0.001
No	46.4	ref	ref	ref
Yes	53.6	-1.29	-1.08	1.59
Heart problem		p<0.001	p<0.001	p<0.001
No	80.8	ref	ref	ref
Yes	19.2	-1.21	-1.08	1.75
Lung diseases		p<0.001	p<0.001	p<0.001
No	91.7	ref	ref	ref
Yes	8.3	-1.32	-1.06	2.12
Smoking status		p<0.001	p<0.001	p<0.001
Never smoke	44.7	ref	ref	ref
Ever smoke, now no smoke	40.5	-0.49	-0.46	1.22
Smoke	14.8	-1.19	-0.79	1.23
Frequent vigorous activity		p<0.001	p<0.001	p<0.001
No	51.4	ref	ref	ref
Yes	48.6	-1.25	-0.97	1.93
Alcohol consumption		p<0.001	p<0.001	p<0.001
Under 3 days per week	79.7	ref	ref	ref
3-5 days per week	12.2	1.34	0.96	0.74
5-7 days per week	8.1	0.87	0.49	0.81
Self-rated memory		p<0.001	p<0.001	--
Excellent	7.0	ref	ref	--
Very good	28.9	-0.47	-0.39	--
Good	42.4	-1.28	-1.00	--
Fair	18.5	-1.59	-1.03	--
Poor	3.2	-2.16	-1.49	--
Age	66	p<0.001	p<0.001	p<0.001
	(0.20) ^d	-0.13	-0.12	1.03
Year of birth	1946	p<0.001	p<0.001	p<0.001
	(0.30) ^d	0.13	0.12	0.97
Deciles of wealth	6	p<0.001	p<0.001	p<0.001
	(0.10) ^d	0.35	0.23	0.92
CES-D score	1.3	p<0.001	p<0.001	p<0.001
	(0.02) ^d	-0.35	-0.25	1.25
Self-rated memory		p<0.001	p<0.001	--
Excellent	7.0	ref	ref	--
Very good	28.9	-0.47	-0.39	--
Good	42.4	-1.28	-1.00	--
Fair	18.5	-1.59	-1.03	--
Poor	3.2	-2.16	-1.49	--
Episodic memory	10.2	p<0.001	--	p<0.001

	(0.10) ^d	1.15	--	0.89
Composite score of cognitive functioning	15.9	--	p<0.001	p<0.001
	(0.10) ^d	--	0.72	0.90
Social network	7.8	p<0.001	p<0.001	p<0.001
	(0.10) ^d	0.24	0.20	0.95
Perceived positive social support	7.3	p<0.001	p<0.001	p=0.01
	(0.05) ^d	0.17	0.15	0.95
Perceived negative social support	7.4	p=0.92	p=0.10	p=1.00
	(0.03) ^d	-0.08	-0.01	1.00

^a P values are the overall p value from Wald test. Results are bivariate associations without adjusting for other variables. n=3957 for social relationship variables

^b Results from linear regression

^c Results from ordered logistic regression

^d Mean (SE)

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Table 2 presents the results of longitudinal associations between baseline self-rated memory and composite scores of cognitive functioning. For Model 1, coefficients of cognitive functioning trajectories showed significant differences for good (coefficient=-0.22, $p=0.02$), fair (coefficient=-1.56, $p<0.001$), and poor (coefficient=-1.76, $p<0.001$) compared to excellent self-rated memory group, which means individuals with better self-rated memory also have a better level of objective composite scores of cognitive function over time. The association between baseline self-rated memory and cognitive functioning became weaker in the fully adjusted model, but groups with fair (coefficient=-0.52, $p<0.001$) and poor (coefficient=-0.83, $p<0.001$) self-rated memory still had significantly worse cognitive functioning over time than those with excellent self-rated memory. For covariates, overall, individuals with better baseline episodic memory, advantaged socioeconomic status, better health status and healthier behaviors, and those who self-identified as white/caucasian, had better cognitive functioning over time.

Table 2 also presents the results of longitudinal associations between baseline self-rated memory and episodic memory. Similar to results for composite scores of cognitive functioning, individuals with fair or poor self-rated memory reported worsened episodic memory trajectories over time compared to those with excellent self-rated memory. This observation remained consistent in the fully adjusted model (-0.60, $p<0.001$ and -0.37, $p<0.001$ for poor and fair self-rated memory respectively).

Appendix Figure A2 and A3 show predicted trajectories of cognitive functioning and episodic memory with increased age by baseline self-rated memory. Due to non-linear effects of age on outcomes, with increased age, all of the cognitive and memory trajectories declined faster. The gradient in the trajectories was clear between those with excellent self-rated memory and those with poor/fair self-rated memory.

Table 2. Longitudinal associations of baseline self-rated memory with composite scores of cognitive functioning and episodic memory (n=18,316)

	Composite scores of cognitive functioning				Episodic memory			
	Model 1		Full model		Model 1		Full model	
	Coef. (95% CI)	P-value	Coef. (95% CI)	P-value	Coef. (95% CI)	P-value	Coef. (95% CI)	P-value
Self-rated memory								
Excellent	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Very good	0.16 (-0.03, 0.35)	0.10	0.06 (-0.11, -0.24)	0.48	0.05 (-0.08, 0.19)	0.44	0.01 (-0.12, 0.14)	0.90
Good	-0.22 (-0.40, -0.03)	0.02	-0.11 (-0.28, 0.06)	0.20	-0.18 (-0.31, -0.04)	0.01	-0.10 (-0.23, 0.03)	0.20
Fair	-1.56 (-1.86, -0.91)	<0.001	-0.52 (-0.71, -0.33)	<0.001	-0.73 (-0.87, -0.59)	<0.001	-0.37 (-0.51, -0.24)	<0.001
Poor	-1.76 (-2.01, -1.47)	<0.001	-0.83 (-1.14, -0.58)	<0.001	-1.15 (-1.36, -0.94)	<0.001	-0.60 (-0.81, -0.40)	<0.001
Centred age	0.01 (-0.01, 0.03)	0.27	0.01 (-0.01, 0.02)	0.46	0.05 (0.03, 0.06)	<0.001	0.001 (-0.01, 0.01)	0.10
Centred age square	-0.002 (-0.003, -0.002)	<0.001	-0.003 (-0.002, -0.003)	<0.001	-0.001 (-0.002, 0.003)	<0.001	0.07 (0.05, 0.08)	<0.001
Baseline episodic memory	0.60 (0.59, 0.62)	<0.001	0.48 (0.47, 0.50)	<0.001	0.47 (0.45, 0.48)	<0.001	0.40 (0.39, 0.41)	<0.001
Gender								
Male	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Female	-0.04 (-0.13, 0.05)	0.41	0.30 (0.20, 0.39)	<0.001	0.45 (0.38, 0.51)	<0.001	0.66 (0.59, 0.73)	<0.001
Race								
White/Caucasian	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Black/African American	-1.85	<0.001	-1.43	<0.001	-0.85	<0.001	-0.59	<0.001

Other	(-1.97, -1.74)		(-0.55, -1.31)		(-0.94, -0.77)		(-0.68, -0.51)	
	-1.33	<0.001	-0.78	<0.001	-0.62	<0.001	-0.33	<0.001
	(-1.50, -1.17)		(-0.94, -0.62)		(-0.74, -0.50)		(-0.45, -0.10)	
Year of birth	-0.04	<0.001	-0.05	<0.001	0.01	0.28	-0.06	<0.001
	(-0.05, -0.02)		(-0.06, -0.03)		(-0.002, 0.02)		(-0.08, -0.05)	
Marital status								
Married or partnered			Ref.	Ref.			Ref.	Ref.
Separated, divorced, single or spouse absent			0.001	0.1			-0.05	0.27
			(-0.11, 0.11)				(-0.13, 0.04)	
Widowed			-0.03	0.63			-0.05	0.35
			(-0.17, 0.10)				(-0.15, 0.05)	
Education level								
First stage of tertiary education or above			Ref.	Ref.			Ref.	Ref.
Upper secondary education			-0.88	<0.001			-0.50	<0.001
			(-0.98, -0.78)				(-0.58, -0.43)	
Lower secondary education			-2.27	<0.001			-1.15	<0.001
			(-2.43, -2.11)				(-1.27, -1.03)	
Primary education or below			-3.03	<0.001			-1.48	<0.001
			(-3.25, -2.81)				(-1.64, -1.32)	
Labour force status								
Work full-time and (or) fully-employed			Ref.	Ref.			Ref.	Ref.
Work part-time and (or) partly retired			-0.28	<0.001			-0.16	<0.05
			(-0.42, -0.15)				(-0.26, -0.05)	
Unemployed			-0.17	0.11			-0.12	0.14
			(-0.38, 0.04)				(-0.28, 0.04)	
Retired			-0.52	<0.001			-0.39	<0.001
			(-0.65, -0.40)				(-0.48, -0.29)	
Disabled			-0.66	<0.001			-0.44	<0.001
			(-0.95, -0.38)				(-0.65, -0.22)	
Not in labour force			-0.36	<0.001			-0.32	<0.001

		(-0.57, -0.15)		(-0.48, -0.17)
Self-rated health status				
Excellent	Ref.	Ref.	Ref.	Ref.
Very good	-0.05 (-0.15, 0.05)	0.29	-0.54 (-0.13, 0.03)	0.19
Good	-0.13 (-0.25, -0.01)	0.04	-0.07 (-0.16, 0.02)	0.13
Fair	-0.12 (-0.31, 0.08)	0.25	0.01 (-0.12, 0.16)	0.81
Poor	-0.26 (-0.62, 0.10)	0.16	-0.08 (-0.34, 0.19)	0.58
Wealth	0.12 (0.10, 0.14)	<0.001	0.07 (0.05, 0.08)	<0.001
Stroke				
No	Ref.	Ref.	Ref.	Ref.
Yes	-0.62 (-0.82, -0.43)	<0.001	-0.37 (-0.52, -0.23)	<0.001
Hypertension				
No	Ref.	Ref.	Ref.	Ref.
Yes	-0.13 (-0.22, -0.04)	<0.05	-0.11 (-0.17, -0.03)	<0.001
Heart problem				
No	0.09 (-0.1, 0.20)	0.09	0.04 (-0.04, 0.12)	0.34
Yes	Ref.	Ref.	Ref.	Ref.
Lung problems				
No	Ref.	Ref.	Ref.	Ref.
Yes	-0.12 (-0.27, 0.03)	0.13	-0.12 (-0.24, 0.01)	0.03
CES-D score	-0.10 (-0.12, -0.08)	<0.001	-0.06 (-0.08, -0.05)	<0.001

Smoking status

Never smoke	Ref.	Ref.	Ref.	Ref.
Ever smoke, now no smoke	-0.005 (-0.14, 0.04)	0.32	-0.08 (-0.15, -0.01)	0.02
Smoke	-0.29 (-0.42, -0.16)	<0.001	-0.27 (-0.37, -0.18)	<0.001

Frequent vigorous activity

Yes	Ref.	Ref.	-0.06 (-0.12, 0.01)	0.09
No	0.002 (-0.08, 0.09)	0.94	Ref.	Ref.

Alcohol consumption

Under 3 days per week	Ref.	Ref.	Ref.	Ref.
3-5 days per week	0.18 (0.05, 0.32)	0.01	0.12 (0.02, 0.22)	0.02
5-7 days per week	0.23 (0.07, 0.39)	0.01	0.17 (0.05, 0.30)	0.01

Random-effects parameters (Estimate 95% CI)

Slope variance	0.02 (0.01, 0.04)	0.02 (0.01, 0.04)	0.02 (0.02, 0.03)	0.02 (0.01-0.03)
Intercept variance	2.25 (2.20, 2.31)	1.99 (2.03, 2.14)	1.58 (1.53, 1.62)	1.44 (1.40, 1.48)
Individual-level variance	2.76 (2.74, 2.78)	2.76 (2.73, 2.78)	2.33 (2.32, 2.35)	2.33 (2.32, 2.35)

Model 1: Adjusted for demographic covariates; Fully adjusted model additionally adjusted for socioeconomic status, health status and health behaviors. Coef.: coefficient. CI: confidence interval. Ref.: reference

Table 3 and 4 show results for interactions between each of the three social relationship variables (i.e., social network size; perceived positive support; and perceived negative support) and baseline self-rated memory. In both Table 3 and 4, interactions were non-significant with one exception – fair self-rated memory has a borderline significance for the interaction (P-value = 0.048). However, when testing the overall P-value of interaction, none of the interaction terms is significant (Appendix Table A1). Non-significant interaction terms suggested that social relationships did not moderate the associations of self-rated memory with cognitive functioning and episodic memory respectively. But better social networking and more perceived negative social support were related to better and worse cognitive functioning trajectories over time respectively (Appendix Table A2 to A3).

Trajectories of cognitive functioning and episodic memory showed consistent results from the analytical sample, when using the smaller sample (n=3,957) after excluding missingness of social relationship variables (Appendix Table A4).

Table 3. Longitudinal associations between baseline self-rated memory and composite scores of cognitive functioning, considering interaction with social relationships (n=3,957)

	Considering interaction with social network		Considering interaction with perceived positive social support		Considering interaction with perceived negative social support	
	Coef. (95% CI)	P-value	Coef. (95% CI)	P-value	Coef. (95% CI)	P-value
Centred age	-0.10 (-0.04, 0.2)	0.49	-0.01 (-0.04, -0.02)	0.51	-0.1 (-0.04, 0.02)	0.51
Centred age square	-0.002 (-0.003, -0.001)	<0.001	-0.002 (-0.003, -0.001)	<0.001	-0.003 (-0.003, -0.002)	<0.001
Self-rated memory						
Excellent	Ref.		Ref.		Ref.	
Very good	0.34 (-0.71, 1.38)	0.53	0.16 (-0.95, 1.27)	0.78	-0.24 (-0.80, 0.32)	0.40
Good	0.00 (-1.00, 1.01)	0.99	-0.20 (-1.27, 0.88)	0.72	-0.77 (-1.31, -0.23)	0.01
Fair	0.00 (-1.08, 1.09)	0.99	-0.52 (-1.67, 0.63)	0.38	-1.15 (-1.76, -0.55)	<0.001
Poor	0.14 (-1.46, 1.74)	0.87	-0.21 (-2.01, 1.59)	0.82	-0.83 (-1.80, 0.14)	0.09
Social network	0.12 (0.01, 0.23)	0.03				
Positive social support			0.04 (-0.08, 0.16)	0.51		
Negative social support					-0.17 (-0.32, -0.01)	0.03
Interaction: Social relationship x Self-reported memory						
Excellent	Ref.		Ref.		Ref.	
Very good	-0.06 (-0.18, 0.07)	0.30	-0.05 (-0.19, 0.10)	0.50	0.01 (-0.17, 0.19)	0.93
Good	-0.04 (-0.16, 0.08)	0.38	-0.03 (-0.17, 0.10)	0.64	0.13 (-0.03, 0.31)	0.13
Fair	-0.08 (-0.22, 0.05)	0.17	-0.03 (-0.17, 0.12)	0.72	0.17(-0.02, 0.36)	0.08
Poor	-0.15 (-0.37, 0.06)	0.15	-0.11 (-0.36, 0.13)	0.35	-0.08 (-0.39, 0.22)	0.60

Random-effects parameters (Estimate 95% CI)

Slope variance	0.02 (0.01, 0.04)	0.02 (0.01, 0.04)	0.02 (0.01, 0.05)
Intercept variance	1.91 (1.81, 2.01)	1.92 (1.82, 2.02)	1.91 (1.82, 2.01)
Individual-level variance	2.76 (2.71, 2.80)	2.76 (2.71, 2.80)	2.76 (2.71, 2.80)

Coef.: Coefficient. CI: Confidence interval. Ref.: Reference. Fully adjusted models adjusted for demographic characteristics, socioeconomic status, health status and health behaviors.

Table 4. Longitudinal associations between baseline self-rated memory and episodic memory, considering interaction with social relationships (n=3,957)

	Considering interaction with social network		Considering interaction with perceived positive social support		Considering interaction with perceived negative social support	
	Coef. (95% CI)	P-value	Coef. (95% CI)	P-value	Coef. (95% CI)	P-value
Centred age	0.04 (0.01, 0.06)	<0.05	0.04 (0.01, 0.06)	0.002	0.04 (0.01, 0.06)	0.002
Centred age square	-0.001 (-0.003, -0.002)	<0.001	-0.002 (-0.003, -0.002)	<0.001	-0.002 (-0.003, -0.002)	<0.001
Self-rated memory						
Excellent	Ref.		Ref.		Ref.	
Very good	0.44 (-0.34, 1.22)	0.27	0.11 (-0.73, 0.94)	0.80	-0.17 (-0.59, 0.25)	0.43
Good	0.26 (-0.50, 1.01)	0.5	-0.01 (-0.81, 0.79)	0.98	-0.50 (-0.91, -0.10)	0.02
Fair	0.03 (-0.77, 0.83)	0.94	-0.53 (-1.39, 0.32)	0.22	-0.83 (-1.28, -0.38)	<0.001
Poor	0.03 (-1.14, 1.21)	0.96	-0.40 (-1.72, 0.93)	0.56	-0.63 (-1.35, 0.08)	0.08
Social network	0.10 (0.01, 0.18)	0.02				
Positive social support			0.02 (-0.07, 0.11)	0.64		
Negative social support					-0.12 (-0.24, -0.002)	0.04
Interaction: Social relationship x Self-reported memory						
Excellent	Ref.		Ref.		Ref.	
Very good	-0.07 (-0.16, 0.02)	0.14	-0.03 (-0.13, 0.08)	0.60	0.02 (-0.12, 0.15)	0.80
Good	-0.07 (-0.16, 0.02)	0.15	-0.03 (-0.13, 0.07)	0.52	0.09 (-0.04, 0.22)	0.16
Fair	-0.06 (-0.15, 0.04)	0.22	0.01 (-0.09, 0.12)	0.80	0.14 (0.002, 0.28)	0.048

Poor	-0.10 (-0.26, 0.05)	0.2	-0.04 (-0.22, 0.13)	0.61	-0.04 (-0.27, 0.18)	0.71
<i>Random-effects parameters (Estimate 95% CI)</i>						
Slope variance	0.01 (0.002, 0.04)		0.01 (0.002, 0.04)		0.01 (0.002, 0.04)	
Intercept variance	1.38 (1.30, 1.46)		1.38 (1.30, 1.46)		1.38 (1.30, 1.46)	
Individual-level variance	2.34 (2.31, 2.37)		2.34 (2.31, 2.37)		2.34 (2.31, 2.37)	

Coef.: Coefficient. CI: Confidence interval. Ref.: Reference. Fully adjusted models adjusted for demographic characteristics, socioeconomic status, health status and health behaviors.

5. Discussion

5.1 Summary

In the present study, we assessed the association between SCD and the trajectories of OCD. We also examined the extent to which the association between SCD and trajectories of OCD is moderated by social relationships as measured by social network size and perceptions of positive and negative social support. Data reveal that SCD is predictive of OCD over time. We also find that a wider social network and lower levels of negative social support are associated with a slower decline both, in memory and overall cognitive functioning over time. However, contrary to expectation, none of the social relationship variables moderate the association between SCD and subsequent OCD. Below we interpret these findings.

5.2 SCD and Trajectories of OCD

As expected, we do find that persons with SCD at baseline are at a greater risk of subsequent OCD, as they do report a faster decline in cognitive functioning over time. That is, relative to those with excellent self-rated memory at baseline, participants with poor self-rated memory report unfavorable trajectories of episodic memory and cognitive functioning. Our finding mirrors those in some of the longitudinal studies that show that SCD is associated with an increased risk of subsequent cognitive decline (Kaup et al., 2015; Koppa et al., 2015) or conversion to MCI or Alzheimer's disease (Jessen et al., 2010; Jessen et al., 2014; Mitchell et al., 2014; Reisberg et al., 2010; Rönnlund et al., 2015). This finding is important from a practice point of view because those in the early stage of cognitive decline may be more malleable to adopting new ways of living and coping with changes in their lives (Flood & Buckwalter, 2009). As such, families, friends, and health care providers may be in a better position to help older adults with SCD learn new strategies to maintain a physically and socially active lifestyle, which may help prolong the progression to subsequent OCD.

5.3 Social Relationships and the Association between SCD and Subsequent OCD

Contrary to expectation, none of the social relationship variables moderate the association between SCD and subsequent OCD. We speculate that although there is a broad range of social support scores, the average level of support within this sample of older adults is high and therefore, the distribution of scores on this variable is skewed. It is possible that older adults who experience SCD are more likely to report higher perceived support from significant others. This assumption is grounded in existing research showing that close family members and friends rally around and support older relatives who have health problems (Ha & Pai, 2018; Hank, 2007; Silverstein & Bengtson, 1997). For instance, adult offsprings are likely

to maintain frequent contact with older parents when the latter are faced with chronic physical conditions (Ha & Pai, 2018; Hank, 2007). That said, future scholarship should consider reassessing the links between SCD, OCD, and social support in a sample with greater variability in social support. It may also be worthwhile to explore additional layers of social relationships, namely social networks. For instance, future studies replicating our work may find it valuable to investigate the cognitive health effects of “cross-generational” interactions, namely those with non-kin, given that cross-age interactions represent the “bridging” of social capital (Krzeczkowska et al., 2021; Murayama et al., 2019), which carries important consequences for health (Chen & Meng, 2015).

Despite the null moderation findings, the size of social network still is associated with with a slower decline both, in memory and overall cognitive functioning over time. On one hand, this is not surprising given that social network facilitates engagement in social activities and access to social support. The cognitive health benefits of a larger social network could reflect that more individuals mean more information. It also may mean more diversity in social ties and in consequence, diverse sources of support. Different members of a network (colleagues, neighbors, acquaintances vs. family and close friends) provide different types of support (informational vs. instrumental) (Thoits, 2011). On the other hand, our finding questions otherwise empirically supported fact that with age, older adults prune what they believe to be less valuable portions of their social network prioritizing quality over quantity of social relationships (English & Carstensen, 2014). We speculate that although the larger size of one’s social circle does not ensure the quality of social ties, even weak ties may be advantageous for one’s sense of self and well-being (Granovetter, 1973), ultimately improving cognitive health.

In addition to social network, we also found that older adults who perceive lower levels of negative social support report slower decline in memory and overall cognitive health. This finding reflects the reality that although social support is supposed to be good for one’s health, social relationships can become sources of stress. While paradoxical to think of a negative side of social support, network ties may serve as potential sources of stress (Lincoln, 2000). However, well-intentioned, social support can be mentally distressing when it is unsought, unwelcome, at odds with what the recipient needs or wants, and offered with the intention of exchange or expectation of compliance (Lincoln, 2000). Our finding suggests that older adults who perceive lower levels of negative support do better cognitively over time. The intriguing implication of this finding also is that merely having lower negative support does not

necessarily translate into cognitive benefits of positive social support. In fact, in the present study, positive support remains unrelated to cognitive health outcomes. Given that the positive and negative perceptions of support might have a differential effect on cognitive health, these findings support disentangling the various facets of social support as opposed to relying on the composite measure of it.

5.4 Limitations and Future Directions

While the findings of our study contribute to the literature on cognitive aging, we caution readers to review them within the context of some important limitations. *First*, social relationships are a complex web of intricate social patterns and networks linking individuals with a variety of tangible and non-tangible resources, which shape health and well-being, including but not limited to cognition (Piolatto et al., 2022). As such, despite the lack of moderating role of social networks and support in the present study, the role of social relationships in the association between SCD and subsequent OCD requires further investigation. Research should continue to focus on identifying circumstances under which SCD either prevents, delays, or accelerates OCD. One approach would be to understand the composition and stability of social networks when replicating the present study. Guided by the social convoy model (Antonucci, 2001), recent research found that a greater proportion of family within one's social network is linked with memory decline over time and that this is mediated by the less frequent interactions with friends (Sharifian et al., 2019). Similarly, while it may be difficult to disentangle the reverse causality issue between SCD and changes in social networks, social network stability is a factor worth exploring to further investigate the association between SCD and OCD over time. This is especially important because given losses associated with normal aging, older adults may taken on new social activities, cultivate new friendships, or/and simply renew long lost relationships for the purposes of companionship and support (e.g., Atchley, 1989; Donnelly & Hinterlong, 2010; Zettel & Rook, 2004). Understanding how network gains and losses condition the association between SCD and objective cognitive health may prove crucial to crafting policies aimed at improving the health of persons with SCD.

Second, SCD in HRS is measured with one question of self-rated memory (acqui et al., 2017). However, vast heterogeneity is revealed between studies due to variations in designed questions, target population, timeframe duration, and response options. One review in 2015 showed that only a 25% overlap of measuring items was presented among 19 concurrent questionnaires assessing SCD (Sun et al., 2015). Relatedly, the HRS does allow for the

objective assessment of cognitive functioning and with the use of the serial 7's subtraction test, it permits the assessment of working memory, which is a subset of executive function. However, it may be worthwhile for those replicating our study to rely on other widely used neuropsychological tests (e.g., Trail Making Test (TMT); Clock Drawing Test (CDT); Digits Forward and Backward subtests; Wisconsin Card Sorting Test (WCST), and the Stroop Test) to evaluate the relevance of executive function among older adults (Faria et al., 2015). Given that executive function, which comprises inhibition, self-monitoring, self-regulation, and initiation, as well as attention to detail and planning, constitutes the ability to adapt to external demands of one's social and physical environment (Goldstein & Naglieri, 2014; Harvey, 2019), further research is needed to explore the relevance of SCD and social relationships for cognitive functioning as measured by distinctive components, such as the executive function.

Third, many measures within the study are self-reported (e.g., income or physical activity). The use of self-reported data introduces the possibility of discrepancies between participants' reported and actual behaviors. For example, participants may over-report their physical activity level. *Fourth*, a more significant concern in cognitive decline may be predisposed by those with a family history of dementia (Tanzi, 2012). However, HRS does not provide information on the family history of dementia. *Finally*, despite the exhaustive range of covariates in our study, the problem of residual confounding due to unmeasured variables lingers. For instance, higher childhood intelligence is linked to higher cognitive functioning throughout the life course (Cadar et al., 2020; Lyons et al., 2017). Higher intelligence also may facilitate cognitive operations by promoting cognitive reserve (Stern, 2002), which recruits extant and/or new and alternative neural networks to counteract and compensate for the neuropathological processes (Li et al., 2009; Park & Reuter-Lorenz, 2009; Stern, 2021). As such, future research may be well advised to assess not just the additive but interactive effects of intelligence and social relationship variables on the onset of SCD and the progression from SCD to subsequent OCD.

Notwithstanding these limitations, our study has several strengths. *First*, this study includes a relatively large sample size. Though some samples were excluded at baseline due to missingness and exclusion criteria, a final sample size of 18,316 was included and proceeded to data analysis for objective one. While the large sample size may increase the likelihood of statistically significant results that are not clinically significant, given that SCD is still an under researched area, even small effect sizes may be of interest as they may generate new hypotheses and advance our understanding of SCD. *Second*, this study has a relatively long follow-up

period. Considering that fewer than five years of follow-up may lead to failure in observing meaningful results (Rabin et al., 2015), this study includes an 8-year follow-up period, starting from 2010. *Third*, we relied on a complex modeling approach to investigate the relationships between SCD, OCD, and social relationships. Different models were applied for adjusting different confounders, while fully adjusted models were also run to observe overall effects.

Moving forward, we recommend continuing to assess the links between SCD, OCD, and social relationships by introducing individual-level resources, such as personality traits. While social relationships are essential for health, certain individual-level pre-dispositions may render some older adults better prepared to build and sustain relationships, which are essential for cognitive health. For instance, highly conscientious older adults by the virtue of being disciplined, diligent, orderly, and planful (McCrae & Costa 1987; McCrae & John 1992), may be particularly successful at preserving social network and consequently, support. In contrast, neuroticism, a trait characterized by denial, self-blame, rumination, and retreat (Bolger & Zuckerman 1995; Nolen-Hoeksema et al., 1994), may prevent older adults from optimizing social relationships and social support, which consequently could compromise their cognitive functioning. Future research, as such, may consider adopting a more nuanced approach to examining social relationship factors by considering individual pre-dispositions in the context of SCD and subsequent cognitive impairment.

6. Conclusions

Our study finds that among older adults in the US, SCD is predictive of OCD over time. This finding underscores the fact that older adults' self-reported memory losses should be carefully considered, despite concerns that memory loss alone is non-specific and poorly predictive of OCD. We also find that a wider social network and lower levels of negative social support are associated with a slower decline both, in memory and overall, cognitive functioning over time. However, contrary to expectation, none of the social relationship variables moderates the association between SCD and subsequent OCD. This suggests the need for future research to consider the complexity associated with social relationships, including inspecting the potential pathways that link the varying dimensions of social networks and social support to cognitive function and decline.

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Appendix

Figure A1. Procedure of sample selection

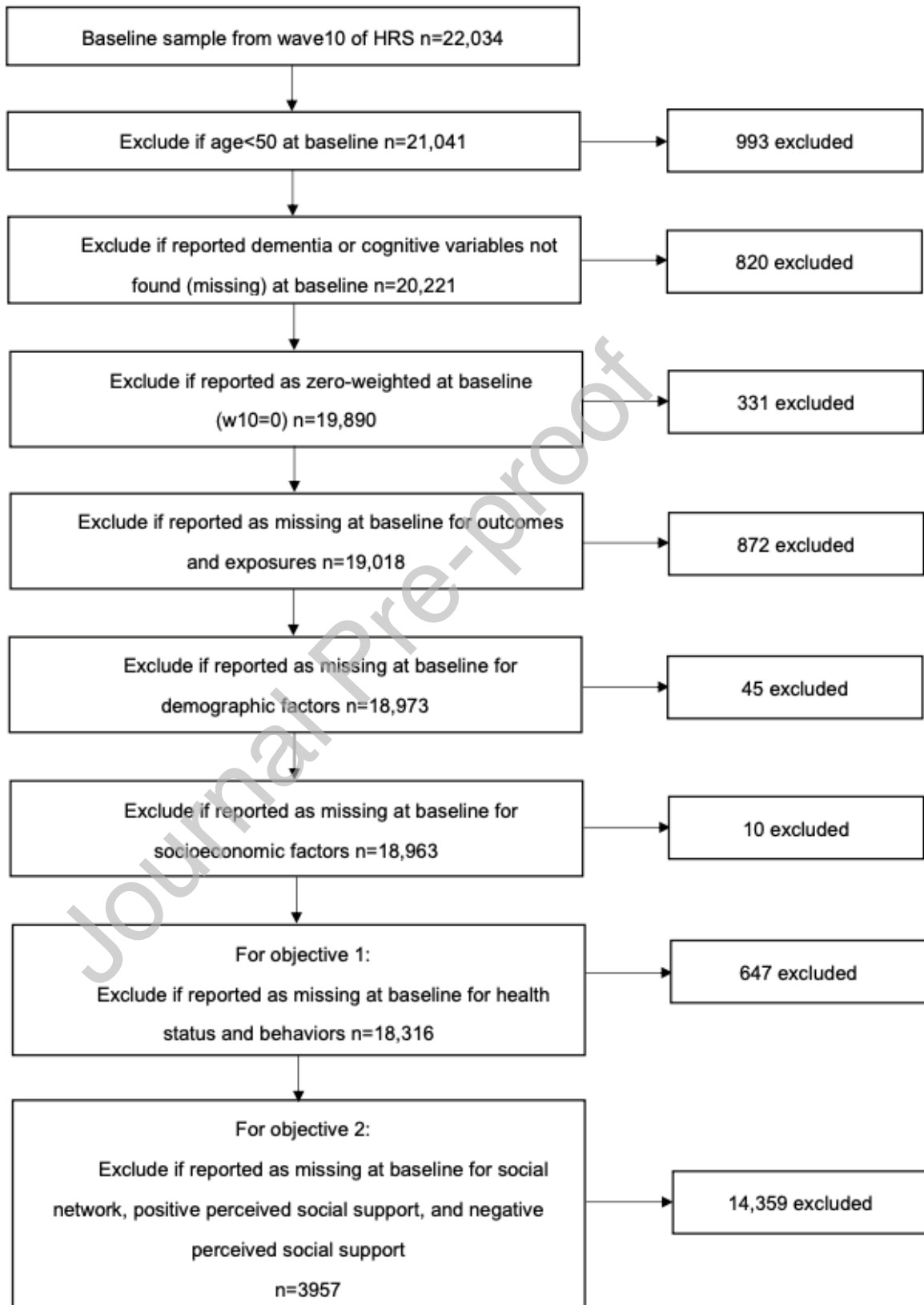


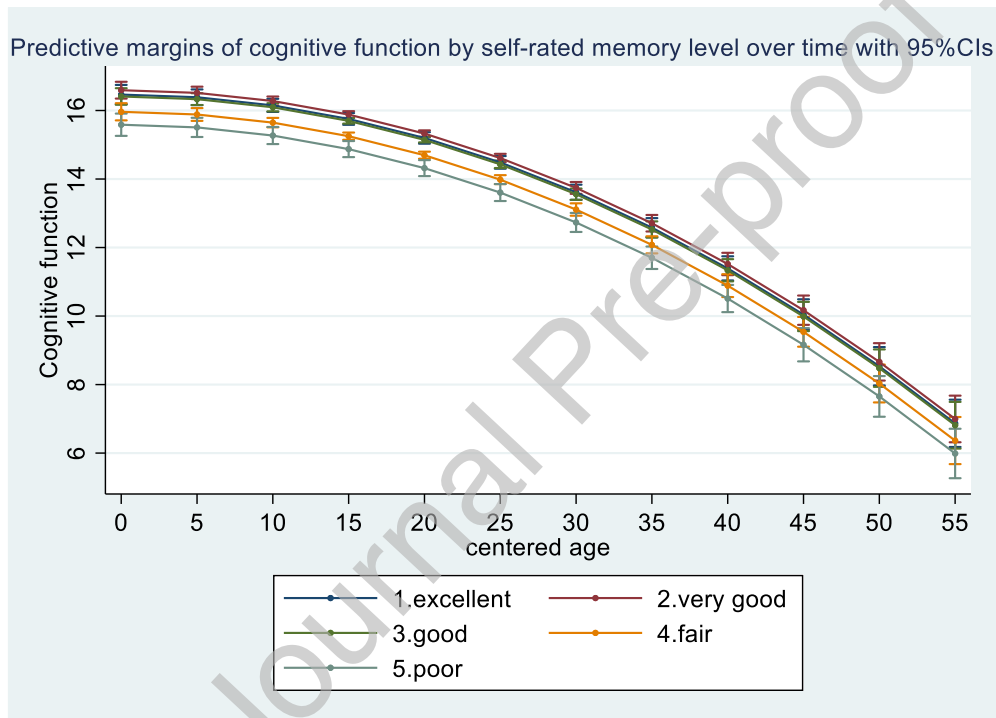
Figure A2. Predicted Trajectories of composite score of cognition with centred age by baseline self-rated memory level

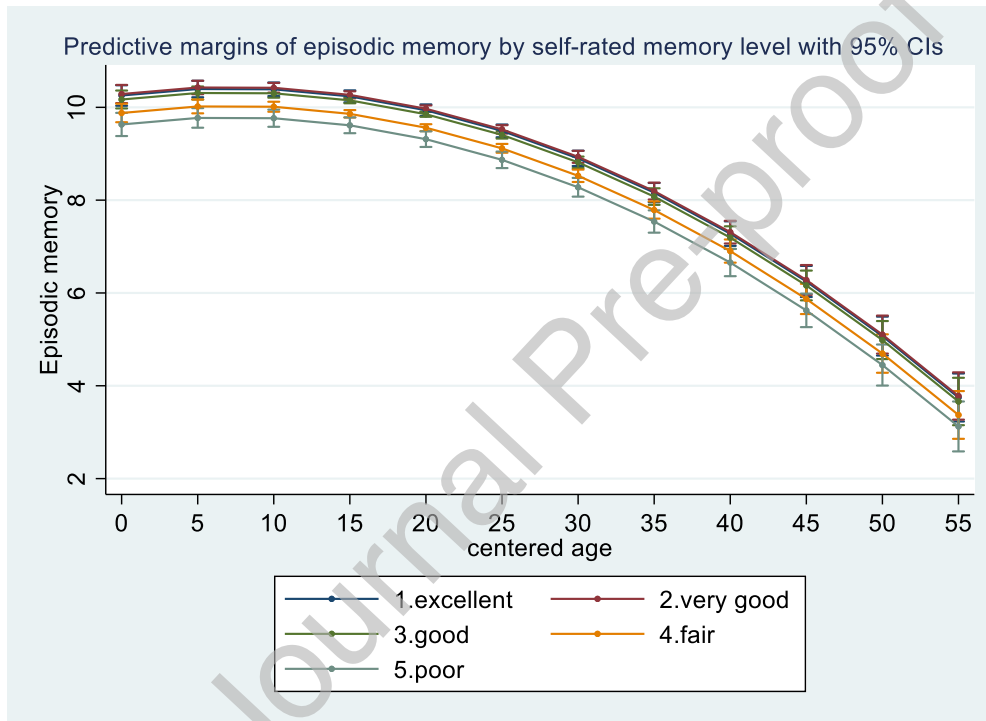
Figure A3. Predicted Trajectories of episodic memory with centred age by baseline self-rated memory level

Table A1. Results of the overall p-value for the interaction term between self-rated memory and social relationship factors (n=3,957)

	Composite scores of cognitive functioning outcome	Episodic memory outcome
	P value of interaction	P value of interaction
Interaction between self rated memory and social network	0.356	0.402
Interaction between self rated memory and positive social support	0.638	0.684
Interaction between self rated memory and negative social support	0.134	0.134

P value from Wald tests

Table A2. Associations between self-rated memory and composite scores of cognitive functioning by social relationships without interaction (n=3,957)

Variables	Fully adjusted model with social network	model with	Fully adjusted model with perceived positive social support	Fully adjusted model with perceived negative social support
	Coef. (95% CI)	P-value	Coef. (95% CI)	Coef. (95% CI)
Social network	0.06 (0.03, 0.09)	<0.001		
Perceived positive social support			0.01 (-0.03, 0.05)	0.75
Perceived negative social support				-0.08 (-0.13, -0.03) 0.003
<i>Random-effects parameters (Estimate 95% CI)</i>				
Slope variance	0.02 (0.01, 0.05)		0.02 (0.01, 0.05)	0.02 (0.01, 0.05)
Intercept variance	1.92 (1.81, 2.01)		1.92 (1.82, 2.02)	1.92 (1.82, 2.02)
Individual-level variance	2.76 (2.71, 2.80)		2.76 (2.71, 2.80)	2.76 (2.72, 2.80)

Coef.: coefficient. C.I.: confidence interval. Ref.: reference. SD: standard deviation.

Table A3. Associations between self-rated memory and episodic memory by social relationships without interaction (n=3,957)

Variables	Fully adjusted model with social network		Fully adjusted model with perceived positive social support		Fully adjusted model with perceived negative social support	
	Coef. (95% CI)	P-value	Coef. (95% CI)	P-value	Coef. (95% CI)	P-value
Social network	0.10 (0.01, 0.06)	0.003				
Perceived positive social support			0.01 (-0.02, 0.04)	0.62		
Perceived negative social support					-0.05 (-0.09, -0.01)	0.01
<i>Random-effects parameters (Estimate 95% CI)</i>						
Slope variance	0.01 (0.003, 0.04)		0.01 (0.004, 0.04)		0.01 (0.002, 0.04)	
Intercept variance	1.38 (1.30, 1.46)		1.38 (1.30, 1.46)		1.38 (1.30, 1.46)	
Individual-level variance	2.33 (2.31, 2.37)		2.34 (2.31, 2.37)		2.34 (2.31, 2.37)	

Coef.: coefficient. C.I.: confidence interval. Ref.: reference. SD: standard deviation.

Table A4. Fully adjusted models for composite score of cognition and episodic memory using smaller sample sizes among those with social relationship information (n=3,957)

Variables	Composite score of cognitive functioning		Episodic memory	
	Coef. (95% CI)	P-value	Coef. (95% CI)	P-value
Self-rated memory				
Excellent	Ref.	Ref.	Ref.	Ref.
Very good	-0.20 (-0.54, 0.14)	0.25	-0.11 (-0.37, 0.14)	0.39
Good	-0.43 (-0.77, -0.10)	0.01	-0.27 (-0.52, -0.02)	0.03
Fair	-0.72 (-1.09, -0.35)	<0.001	-0.46 (-0.74, -0.19)	<0.001
Poor	-1.02 (-1.61, -0.42)	<0.001	-0.74 (-1.18, -0.30)	<0.001
Baseline memory	0.53 (0.51 -0.57)	<0.001	0.45 (0.43 -0.47)	<0.001
Gender				
Male	Ref.	Ref.	Ref.	Ref.
Female	0.29 (0.10, 0.47)	0.003	0.67 (0.53, 0.81)	<0.001
Race				
White/Caucasian	Ref.	Ref.	Ref.	Ref.
Black/African American	-1.31 (-1.55, -1.07)	<0.001	-0.52 (-0.70, -0.35)	<0.001
Other	-0.72 (-1.05, -0.39)	<0.001	-0.30 (-0.54, -0.05)	0.02
Marriage status				
Married or partnered	Ref.	Ref.	Ref.	Ref.
Separated, divorced, single or spouse absent	-0.10 (-0.31, 0.18)	0.37	-0.13 (-0.29, 0.03)	0.12
Widowed	-0.14 (-0.46, 0.17)	0.36	-0.08 (-0.32, 0.15)	0.49
Education level				
First stage of tertiary education or above	Ref.	Ref.	Ref.	Ref.
Upper secondary education	-0.64 (-0.83, -0.44)	<0.001	-0.28 (-0.42, -0.13)	<0.001
Lower secondary education	-1.97 (-2.34, -1.61)	<0.001	-0.87 (-1.14, -0.61)	<0.001

Primary education or below	-1.34 (-2.85, -1.82)	<0.001	-0.95 (-1.33, -0.58)	<0.001
Labour force status				
Work full-time and (or) fully-employed	Ref.	Ref.	Ref.	Ref.
Work part-time and (or) partly retired	-0.20 (-0.46, -0.06)	0.14	-0.12 (-0.32, -0.07)	0.22
Unemployed	-0.19 (-0.55, 0.17)	0.3	-0.13 (-0.40, 0.14)	0.33
Retired	-0.48 (-0.72, -0.24)	<0.001	-0.37 (-0.55, -0.19)	<0.001
Disabled	-0.77 (-1.37, -0.17)	0.01	-0.52 (-0.96, -0.08)	0.02
Not in labour force	-0.67 (-1.14, -0.19)	0.01	-0.43 (-0.76, -0.08)	0.02
Self-rated health status				
Excellent	Ref.	Ref.	Ref.	Ref.
Very good	-0.05 (-0.25, 0.15)	0.62	-0.08 (-0.24, 0.07)	0.28
Good	-0.12 (-0.38, 0.13)	0.34	-0.09 (-0.28, 0.10)	0.34
Fair	0.01 (-0.12, 0.16)	0.07	-0.11 (-0.41, 0.20)	0.5
Poor	-0.08 (-0.34 -0.19)	0.81	0.02 (-0.52, 0.56)	0.95
Stroke				
No	Ref.	Ref.	Ref.	Ref.
Yes	-0.51 (-0.94, -0.08)	0.02	-0.37 (-0.68, -0.05)	0.02
Hypertension				
No	Ref.	Ref.	Ref.	Ref.
Yes	-0.15 (-0.33, -0.03)	0.1	-0.09 (-0.23, 0.05)	0.20
Heart problem				
No	Ref.	Ref.	Ref.	Ref.
Yes	-0.04 (-0.28 - 0.18)	0.67	-0.02 (-0.19, 0.15)	0.85
Lung diseases				
No	Ref.	Ref.	Ref.	Ref.
Yes	-0.28 (-0.24, 0.03)	0.08	-0.21 (-0.45, 0.02)	0.08

Smoking status				
Never smoke	Ref.	Ref.	Ref.	Ref.
Ever smoke, now no smoke	-0.23 (-0.42, -0.04)	0.02	-0.21 (-0.35, -0.07)	0.003
Smoke	-0.31 (-0.58, -0.05)	0.02	-0.29 (-0.49, -0.09)	0.004
Frequent vigorous activity				
Yes	Ref.	Ref.	Ref.	Ref.
No	-0.16 (-0.34, 0.02)	0.07	-0.12 (-0.26, 0.01)	0.07
Alcohol consumption				
Under 3 days per week	Ref.	Ref.	Ref.	Ref.
3-5 days per week	0.18 (-0.08, 0.44)	0.18	0.12 (-0.08, 0.32)	0.23
5-7 days per week	0.36 (0.03 -0.70)	0.03	0.21 (-0.04 -0.46)	0.03
Centred age	-0.01 (-0.04, 0.02)	<0.001	0.04 (0.01, 0.06)	<0.001
Centred age square	-0.002 (-0.003 - -0.002)	<0.001	-0.002 (-0.003, -0.002)	<0.001
Year of birth	-0.04 (-0.07, -0.02)	0.001	0.01 (-0.01, 0.03)	0.34
Wealth	0.11 (0.07, 0.14)	<0.001	0.07 (0.04, 0.10)	<0.001
CES-D score	-0.09 (-0.14, -0.04)	<0.001	-0.06 (-0.09, -0.02)	0.003
<i>Random-effects parameters (Estimate 95% CI)</i>				
Slope variance	0.02 (0.01, 0.05)		0.01 (0.003, 0.04)	
Intercept variance	1.92 (1.82, 2.02)		1.38 (1.31, 1.47)	
Individual-level variance	2.76 (2.71, 2.80)		2.34 (2.31, 2.37)	

Method: Derivation of Social Factors

Social network is calculated by asking questions about frequencies of connections to friends, children, and family members. Participants are asked to answer: “On average, how often do you do each of the following: a. Meet up (include both arranged and chance meetings), b. Speak on the phone, c. Write or email”. Scores from the results are coded as 6 = Three or more times a week, 5 = Once or twice a week, 4 = Once or twice a month, 3 = Every few months, 2 = Once or twice a year, 1 = Less than once a year or never. Sum scores across all related categories are calculated to measure overall contact with the social network. The final score is set to missing if there is more than one item with missing values. The composite score ranges from 0 to 18, where a higher score reflects a wider social network.

For social support, respondents are asked to respond to questions on the perceived support from their spouses, children, family, and friends were asked. For each relationship category, there are three positively worded items (a. How much do they understand the way you feel about things? b. How much can you rely on them if you have a serious problem? c. How much can you open up to them if you need to talk about your worries?) and four negatively worded items (a. How often do they make too many demands on you? b. How much do they criticize you? c. How much do they let you down when you are counting on them? d. How much do they get on your nerves?). Both scores of positive and negative perceived support from the results were coded as 4 = A lot, 3 = Some, 2 = A little, 1 = Not at all. Then the average score within each dimension is calculated. If there are more than two missing values on the negative social support scale or more than one missing value on the positive social support scale, the final score is set to missing. The composite scores range from 0 to 12 for both positive and negative perceived social support, where a higher score reflects more positive or negative perceived social support respectively.

Declaration of interests

The authors declare that they have no known competing financial interests or

personal relationships that could have appeared to influence the work reported in this paper.

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

None

Credit Author Statement

Manacy Pai: Conceptualization, Writing- Original draft preparation

Wentian Lu: Conceptualization, Methodology, Data analysis

Miaoqi Chen: Methodology, Data analysis

Baowen Xue: Conceptualization, Methodology, Writing- Reviewing and Editing

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