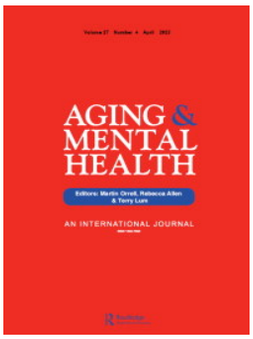

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Social support, social strain and declines in verbal memory: sex-specific associations based on 16-year follow-up of the English Longitudinal Study of Ageing cohort

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ABSTRACT

Objectives: Previous investigations of cognitive aging have mainly focused on structural aspects of social relations (e.g. network size and composition), thereby neglecting the role of qualitative aspects of social relations. The current longitudinal study examined sex-specific differences in verbal memory decline by measures of perceived relationship quality (social support/strain) by relationship type.

Method: In the English Longitudinal Study of Ageing (ELSA), 10,109 participants aged 50–89 years were assessed at wave 1 (baseline: 2002–03) and followed to wave 9 (2017–18). Verbal memory was assessed by immediate and delayed word-recall tasks. Social support/strain was measured by relationship type (spouse; children; family; friends). Random effects within-between (REWB) modelling was used to separate between- and within-person effects. We estimated associations between social support/strain and (1) baseline levels of memory (main effects), and (2) rate of decline in memory (interaction with time-since-baseline).

Results: Longitudinal associations were most prominent for men, specific to relationship type, and showed between- rather than within-person effects. Among men, higher spousal strain was associated with faster memory decline ($\beta_{\text{between-effect}\times\text{time}} = -0.043$; 95% CI [−0.084, −0.002]; $p = .039$), whilst greater support from children was associated with slower decline ($\beta_{\text{between-effect}\times\text{time}} = 0.020$; 95% CI [0.002, 0.039]; $p = .033$). Men with higher strain from friends showed lower baseline memory ($\beta_{\text{between-effect}} = -0.382$; 95% CI [−0.627, −0.137]; $p = .002$) and faster decline ($\beta_{\text{between-effect}\times\text{time}} = -0.047$; 95% CI [−0.095, 0.000]; $p = .051$).

Conclusion: Between-person differences in social support/strain were modestly associated with memory decline, especially among men.

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KEYWORDS
Social support; social strain; memory; cognitive aging; longitudinal; ELSA; age-associated memory problems

Introduction

Identifying modifiable risk or protective factors for cognitive decline in older adults is crucial for preventing or managing clinical outcomes, including Alzheimer's disease and related dementias (Rutter et al., 2020). One such factor is social relations. Social relationships are positively linked to cognitive functioning in older age through the mentally stimulating nature of social interactions and the stress-buffering effects of social support; in contrast, socially strained relations are negatively linked through being a source of chronic stress (Kuiper et al., 2016, 2017).

Using longitudinal data from aging cohorts, previous investigations have mainly focused on structural aspects of social relations (e.g. network size and composition), thereby neglecting the role of perceived relationship quality (i.e. social support and social strain that can coexist in close relationships). Further, few studies have examined whether any social support/strain–cognitive decline associations vary by relationship type (e.g. spousal relationship versus friends), and whether any such relationship-specific associations are sex-dependent. Finally, studies to date have primarily focused on *between-person* differences in levels of perceived relationship quality, and so have not investigated whether change over time in levels of social support/strain *within-persons* (e.g. spousal relationships being more strained than usual) independently associate with age-related cognitive decline.

Our study attempts to fill these gaps in existing evidence. Using models that simultaneously model within- and between-person effects, we estimate sex-specific associations between social support/strain and verbal memory decline separately by relationship type (spouse/partner; children; family; friends).

Theory and literature review

Social relations are a potential modifiable risk or protective factor for cognitive decline in older adults (Kuiper et al., 2016; Kelly et al., 2017). Using the convoy model as a theoretical framework, studies (Zahodne et al., 2019) have explored which dimensions of social relations independently associate with cognitive decline, and whether these associations differ by factors such as relationship type and sex.

A social convoy is an assembly of close relations who surround the individual, serve to socialise and protect, as well as

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be available in times of need (Kahn & Antonucci, 1980; Zahodne et al., 2019). The four basic tenets of this model are as follows (Antonucci et al., 2010). First, social relations are multidimensional: encompassing network structure (observable features, e.g. size, contact frequency, and composition); support exchange (aid, affect, affirmation); and support satisfaction (e.g. positive and negative relationship quality). Second, social convoys are dynamic: changing and adapting over time in some ways but remaining stable in others. Third, convoys are shaped over the life-course by the personal (e.g. age, sex) and situational (e.g. role demands, norms, values) characteristics of individuals; while, fourth, having significant implications for health and well-being.

Distinct mechanisms link two different dimensions of social relations to preserving cognitive functioning in older age (Kuiper et al., 2016; Kelly et al., 2017). Structural aspects (e.g. network size) are linked through the mental stimulation inherent in social interactions (Zahodne et al., 2019). Positive (socially supportive) relations are beneficially linked by buffering the influence of stressful life circumstances (Cohen & Wills, 1985), whilst negative (socially strained) exchanges (e.g. unwanted demands, conflicts, tension) are harmfully linked through functioning as a source of chronic stress (Rook, 2015).

Previous investigations have mainly focused on structural aspects: yet, the number of people with whom one interacts may be less important than the perceived quality of relationships (Amieva et al., 2010). According to the solidarity-conflict model, support and strain can coexist in close relationships (Rook, 1990). To date, mixed evidence has accumulated regarding whether social support/strain independently associate with cognitive decline. In the MacArthur Studies of Successful Aging, a greater frequency of emotionally supportive interactions with a network of social relations assessed at baseline was associated with lower cognitive decline over 7.5 years, adjusting for levels of demands/criticisms (Seeman et al., 2001). In the Midlife in the US (MIDUS) cohort, lower social strain/conflict (but not social support) predicted higher executive function 10-years later; whilst the frequency of social support (but not strain/conflict) was positively associated with episodic memory (Seeman et al., 2011). In a 6-year follow-up of the US Health and Retirement Study (HRS), adjusting for social network structure (marital status, network size, contact frequency), lower social support and social strain at baseline were each independently associated with higher initial episodic memory, but not with subsequent memory decline (Zahodne et al., 2019). In the UK Whitehall II cohort, after adjustment for positive aspects, participants in the top third of cumulative negative aspects of close relationships experienced a faster 10-year decline in executive function than those in the bottom third (Liao et al., 2014).

Drawing on the convoy model, key gaps in scientific understanding remain. First, few studies have examined whether the social support/strain–cognitive decline associations vary by relationship type; yet, the social resources obtained from unique relationships may have differential effects due, for example, to exerting differential stress effects (Zahodne et al., 2019). Among older adults, the spouse is usually the preferred source of support, whilst marriage and kinship connections are more likely to exhibit strain than friendships or extended family members due to their involuntary character (Chen & Feeley, 2014). Hence, a more nuanced understanding requires differentiating social support/strain from various sources, rather than rely on a global measure consisting of support/strain from all providers.

Second, the social ties most relevant to preserving cognitive functioning in older age may be sex-dependent (Béland et al., 2005). Older men provide and receive the majority of their support from their spouses or those they have intimate ties to (Antonucci & Akiyama, 1987); in contrast, older women have larger, denser, and more diverse social networks, and so both benefit from, and are burdened by, providing and receiving support from multiple sources (Fuhrer & Stansfeld, 2002). In light of differences in utilisation and social network composition, a more nuanced understanding requires examining potential sex-dependent effects (Pillemer et al., 2019).

Third, social convoys change over time (Fuller et al., 2020), especially for older adults confronted with significant exits and entrances of network members (Kim & Nesselroade, 2003). However, within-person associations between social relations and cognitive function are not well understood (Hülür, 2021). By assessing social support/strain only at baseline (Seeman et al., 2001, Zahodne et al., 2019; Pillemer et al., 2019) or cumulatively (Seeman et al., 2011; Liao et al., 2014), studies to date have primarily focused on differences between-persons (*inter-individual variability*), and have not investigated whether change over time in levels of social support/strain within-persons (*intra-individual variability*) independently influence cognitive decline. To disentangle these, random effects within-between models (REWB or 'hybrid' models) simultaneously model the within- and between-person effects of a single time-varying independent variable (Twisk & de Vente, 2019).

To fill the evidence gap, we conducted an earlier study based on 8-years follow-up of the English Longitudinal Study of Ageing (ELSA) cohort (Liao & Scholes, 2017). Using REWB models, we explored the sex-specific associations between social support/strain and cognitive decline separately by relationship type.

Herein, we update this work by extending the follow-up to 16-years. Whilst cognition is a multifaceted construct, verbal memory was chosen as the outcome due to being available in all waves and its sensitivity to both age-related cognitive decline (Nilsson, 2003) and perceived stress (Wolf, 2009; Vondras et al., 2005). Cognitive decline evolves slowly: hence, non-significant associations in our earlier study may be more detectable herein as adding more waves yields a larger and long-term observed decline in verbal memory as the cohort ages, as well as higher inter-individual variability in the rate of decline.

Research questions

Separately by sex, after adjustment for sociodemographics and physical- and mental-health, we estimated answers to the following research questions:

Q1. *Between-person associations*. Do higher mean levels of social support associate with higher baseline memory and with slower decline? Do higher mean levels of social strain associate with lower baseline memory and with faster decline?

Q2. *Within-person associations*. Do higher-than-usual levels of social support associate with higher baseline memory and with slower decline? Do higher-than-usual levels of social strain associate with lower baseline memory and with faster decline?

These questions were examined separately for global and relationship-specific social support/strain. We hypothesized that relationship-specific associations would be most

prominent for social ties that are less easily pruned over time (spouse and children versus friends and extended family members). We further hypothesized that spousal associations would be most prominent for men, due to greater dependence on their spouses for emotional support.

Materials and methods

Study design and participants

ELSA is an ongoing study of community-dwelling adults in England; a detailed description of ELSA is available elsewhere (Steptoe et al., 2013). Data collection occurs biennially via face-to-face interviews in participants' homes, and, after a computer-assisted personal interview, self-completion questionnaires are filled in. Overall, 11,391 adults (born before 1 March 1952) participated in wave 1 (2002-03: 67% response rate). To minimise potential for reverse causality, we excluded participants at wave 1 with doctor-diagnosed Alzheimer's or Parkinson's disease, dementia, or serious memory impairment ($n = 126$); proxies ($n = 130$); and those aged 90+ ($n = 99$). Inclusion criteria for the present study were (1) valid memory data and (2) positive response to the self-completion questionnaire. Among the eligible participants at wave 1 ($n = 11,037$), 98% had valid memory data ($n = 10,837$), of whom, 93% returned the self-completion questionnaire ($n = 10,109$). These participants contributed 49,286 observations over the 9 waves (Figure S1). On average, participants contributed 4.9 (standard deviation [SD] 3.0) waves of data. Participants provided signed consent for study participation and linkage to mortality data; ethical approval was granted by the London Multicentre Research Ethics Committee (MREC/01/2/91).

Assessment of verbal memory

Verbal memory tests were administered at each wave using immediate and delayed word recall tasks. Participants were presented with a list of 10 words that were read out by a computer at the rate of 1 word for every 2 s. The word list was randomly assigned from four potential word lists. Participants were asked to recall as many words as they could (immediate recall); the words could be recalled in any order. Participants were asked to recall the list of words after a five-minute interval during which they completed other cognitive tests (delayed recall). Scores for immediate recall and delayed recall could each range from 0 to 10, with higher scores indicating better task performance. Both scores were summed to measure the words correctly recalled (range, 0–20); these were normally distributed, suggesting the absence of floor- or ceiling-effects. Word-recall tests have shown good construct validity and consistency (Baars et al., 2009).

Social support and social strain

Questions on social support/strain were asked for each individual relationship (spouse/partner; children; extended family members; friends) at each wave via self-completion. Three items examined participants' perception of social support (positive evaluations of relationship quality): (1) '*How much do they really understand the way you feel about things?*'; (2) '*How much can you rely on them if you have a serious problem?*'; and (3) '*How much can you open up to them if you need to talk about your worries?*'. Responses on each item ranged from 'not-at-all' (scored 0) to 'a lot' (scored 3). For each individual relationship, a social support score was calculated using the average of the non-missing items (range, 0–3). Participants without the relevant social ties (e.g. those not living with a spouse or partner) scored zero. A global score for social support was calculated by averaging the scores across the four relationships.

Three items examined negative evaluations of relationship quality (i.e. social strain): (1) '*How much do they criticize you?*'; (2) '*How much do they let you down when you are counting on them?*'; and (3) '*How much do they get on your nerves?*'. For each individual relationship, a social strain score was calculated using the average of the non-missing items (range, 0–3; higher scores indicated higher strain). Participants without relevant social ties were scored zero. A global score for social strain was calculated by averaging the scores across the four relationships.

Confounders

Based on previous research (Zaninotto et al., 2018; Yin et al., 2019), we identified three time-independent confounders (assessed at wave 1): age (50–89 y) and socioeconomic position (SEP: wealth and education). Time-dependent confounders were healthy lifestyle behaviors (smoking, alcohol consumption, physical activity); social participation (organisational membership); physical functioning; and depressive symptoms. Total wealth represented the sum of financial, physical and housing wealth, minus debts, and was grouped into quintiles (lowest to highest). Educational status was categorised as low (compulsory schooling); medium (up to high school) and high (university degree or higher). Smoking status was classified as current cigarette smoker or not; alcohol consumption was classified as whether had an alcoholic drink during the last 12 months. Participants were asked how often they engaged in moderate and in vigorous sports/activities: we classified participants as physically active or inactive. A social participation score was created based on involvement in 8 activities related to civic participation, leisure activities and cultural engagement. For physical functioning, a mobility limitation score was based on the number of reported difficulties in performing 6 basic activities of daily living tasks (ADL); a score for the number of depressive symptoms was based on the 8-item Center for Epidemiologic Studies Depression Scale (Radloff, 1977). Further details on these confounders are provided as Supplementary Material (Table S1).

Statistical analyses

Data were analysed using Stata v16.1. Statistical significance was based on two-sided probability ($p < .05$). Analyses were weighted using the wave 1 weight to ensure the sample was broadly representative of the community-dwelling English population aged 50+ years at baseline. Means and SD (continuous variables) and percentages (categorical variables) were calculated to present sample characteristics by study wave. Sex-specific linear random/mixed effects models with study-wave-since-baseline as timescale (range, 0–8) estimated baseline levels and change (slope, per 2-year increase in follow-up time) in memory. We conducted three model-based analyses.

Unadjusted model: verbal memory decline by age-at-baseline

First, nonlinearity in the rate of memory decline was assessed by including linear and quadratic terms (time^2); baseline age (centred at 65 years) and age^2; and their statistical interaction

(time × age) as predictors in the fixed (population-average) part of the model.

REWB models with global measures of social support/strain

Second, the global measures of social support/strain were added as predictors in REWB models. A single time-varying independent variable is included twice by (1) assigning the respective variable the same value over all waves (each participant's *mean* score across all waves), and (2) allowing each participant's score to vary over time (by use of a deviation score: the difference between the wave-specific and mean value) (Twisk & de Vente, 2019). The former estimates between-person effects; the latter estimates within-person effects. As social support and strain may independently influence memory, the models contained four terms of primary interest: the main effects and their interaction with time (linear change only). For the main effects, the between-person effect ($\beta_{\text{between-effect}}$) represents the difference in baseline memory per unit difference between participants in their mean level of social support/strain; the within-person effect ($\beta_{\text{within-effect}}$) represents the (population-averaged) difference in baseline memory for a given participant whose level of social support/strain at baseline was 1 unit higher than their usual level (Hoffman & Stawski, 2009). Terms for the interaction with time (e.g. $\beta_{\text{between-effect}\times\text{time}}$) represent the absolute difference in the linear slope per unit increase in social support/strain; positive and negative coefficients indicate that a unit increase in social support/strain slowed and increased the rate of memory decline, respectively.

Fully-adjusted models contained time, time^2, age, age^2, social support, social strain, and the confounders. Interaction terms for each were included to represent differences in the linear slope. The number of prior memory tests on a measurement occasion (range, 0–8) was included to correct for practice effects (Vivot et al., 2016); this term also proxies characteristics that influence attrition, which in turn, strongly associate with cognitive task performance (Karlamangla et al., 2009).

To compensate for item non-response, multiple imputation using chained equations (MICE) was used to fill-in missing values for social support/strain and the confounding variables (Enders, 2011). Regression coefficients were averaged across 10 imputed datasets using Rubin's rules. Further details on our approach for handling item non-response are provided as Supplementary Material (Table S2).

REWB models with relationship-specific measures of social support/strain

Separate analyses with global and relationship-specific measures were performed to explore whether any significant associations observed using global measures were consistent across relationships or unique to a specific source of social support/strain. Hence, in our third analysis, we fit REWB models using the relationship-specific measures of social support/strain (separate models for spouse/partner; children; family; friends).

Sensitivity analysis

Joint modelling of the longitudinal outcome alongside a survival model for time to death (Sabia et al., 2012) was used to assess the impact of biases associated with study drop-out on our main findings. Joint models assume that the association between the survival and longitudinal processes is underlined by shared random effects (Raitanen et al., 2020). Joint modelling enables adjustment for informative drop-out due to death (e.g. if participants with lower memory scores have lower survival over follow-up than those with higher scores, resulting in nonignorable drop-out) (Raitanen et al., 2020). Among the analytical sample (n = 10,109 participants), 1,947 were known to have died during follow-up (mortality data are currently available only up to wave 6 (2010–11); thereafter we could not identify those lost to the study through death). The REWB and Weibull proportional hazards models were specified for the longitudinal and survival submodels, respectively.

Results

Table 1 shows the characteristics of key variables for those remaining in the study over time. Mean age at baseline was 64 y, 47% were male, and 41% had completed no more than compulsory schooling. At baseline, participants correctly recalled on average 9.5 (SD 3.5) words (immediate plus delayed recall). Global and relationship-specific scores for social support and social strain showed similar levels over time.

Memory trajectories by age-at-baseline

In unadjusted models, memory scores initially remained fairly stable but then declined more rapidly per 2-year time interval (β_{time^2}: p<.001; Figure 1 and Table S3); reaching the maximum at 2.2 and 3.0 years-since-baseline for men and women aged 65, respectively.

REWB models with global levels of social support/strain

Separately for social support/strain, the fully-adjusted coefficients for the between- and within-person effects, and their interaction with time, are shown in Table 2.

Q1. Between-person associations

Higher mean levels of global social strain were associated with lower baseline memory among men ($\beta_{\text{between-effect}}$ = −0.441; 95% CI [−0.703, −0.179]; p=.001) and among women ($\beta_{\text{between-effect}}$ = −0.479; 95% CI [−0.732, −0.225]; p<.001). Higher mean global social support was marginally associated with slower memory decline among men ($\beta_{\text{between-effect}\times\text{time}}$ = 0.030; 95% CI [−0.002, 0.061]; p=.067).

Q2. Within-person associations

Higher-than-usual levels of global social support and social strain were not significantly associated with baseline memory or its rate of change.

REWB models with relationship-specific measures of social support/strain

Results from the relationship-specific models are shown in Table 3.

Spouse/partner

Q1. Between-person associations

Faster decline in memory was observed among men with higher mean levels of spousal strain ($\beta_{\text{between-effect}\times\text{time}}$ = −0.043;

Table 1. Analytical sample characteristics by study wave.

	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 6	Wave 7	Wave 8	Wave 9
	2002–03	2004–05	2006–07	2008–09	2010–11	2012–13	2014–15	2016–17	2018–19
Characteristics	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Participants (*n*)	10,109	7395	6184	5271	5197	4638	3996	3463	3033
Time-dependent:									
Age, years	64 (10.1)	66 (9.7)	67 (9.4)	69 (9.0)	70 (8.0)	71 (7.5)	72 (7.0)	73 (6.5)	75 (6.6)
Verbal memory (0–20)	9.5 (3.5)	10.1 (3.4)	10.2 (3.6)	10.3 (3.5)	10.3 (3.6)	10.4 (3.6)	10.2 (3.6)	10.2 (3.7)	10.1 (3.7)
Social support:									
Spouse/partner (0–3)	1.9 (1.3)	1.9 (1.3)	1.9 (1.3)	1.8 (1.3)	1.8 (1.3)	1.8 (1.3)	1.8 (1.3)	1.7 (1.3)	1.7 (1.3)
Children (0–3)	2.1 (1.0)	2.1 (1.0)	2.1 (1.0)	2.1 (1.0)	2.1 (1.0)	2.1 (1.0)	2.2 (1.0)	2.1 (1.0)	2.1 (1.0)
Extended family (0–3)	1.7 (1.0)	1.7 (1.0)	1.7 (1.0)	1.7 (1.0)	1.6 (1.0)	1.6 (1.0)	1.7 (1.0)	1.6 (1.0)	1.6 (1.0)
Friends (0–3)	2.0 (0.9)	2.0 (0.8)	2.1 (0.8)	2.1 (0.8)	2.0 (0.9)	2.0 (0.9)	2.1 (0.9)	2.0 (0.9)	2.0 (0.9)
Global (0–3)[a]	1.9 (0.6)	1.9 (0.6)	2.0 (0.6)	1.9 (0.6)	1.9 (0.6)	1.9 (0.6)	1.9 (0.6)	1.9 (0.6)	1.9 (0.6)
Social strain:									
Spouse/partner (0–3)	0.6 (0.6)	0.6 (0.6)	0.6 (0.6)	0.6 (0.6)	0.6 (0.6)	0.6 (0.6)	0.6 (0.6)	0.6 (0.6)	0.6 (0.6)
Children (0–3)	0.6 (0.6)	0.6 (0.6)	0.6 (0.6)	0.6 (0.6)	0.6 (0.6)	0.5 (0.6)	0.6 (0.6)	0.6 (0.6)	0.5 (0.6)
Extended family (0–3)	0.6 (0.7)	0.6 (0.7)	0.6 (0.6)	0.6 (0.6)	0.5 (0.6)	0.5 (0.6)	0.5 (0.6)	0.5 (0.6)	0.5 (0.6)
Friends (0–3)	0.5 (0.5)	0.5 (0.5)	0.5 (0.5)	0.5 (0.5)	0.5 (0.5)	0.4 (0.5)	0.5 (0.5)	0.4 (0.5)	0.4 (0.5)
Global (0–3)[a]	0.6 (0.4)	0.6 (0.4)	0.6 (0.4)	0.5 (0.4)	0.5 (0.4)	0.5 (0.4)	0.5 (0.4)	0.5 (0.4)	0.5 (0.4)
Social participation (0–8)	1.5 (1.5)	1.6 (1.5)	1.5 (1.4)	1.5 (1.4)	1.5 (1.4)	1.6 (1.4)	1.6 (1.5)	1.6 (1.4)	1.6 (1.4)
Depressive symptoms (CESD: 0–8)	1.5 (1.9)	1.5 (1.9)	1.4 (1.9)	1.3 (1.8)	1.4 (1.9)	1.2 (1.7)	1.3 (1.7)	1.2 (1.7)	1.3 (1.7)
Mobility limitations (ADL: 0–6)	0.4 (0.9)	0.4 (0.9)	0.4 (0.9)	0.3 (0.8)	0.3 (0.9)	0.3 (0.9)	0.3 (0.9)	0.4 (0.9)	0.4 (0.9)
Current smoker (%)	18	14	13	12	11	9	9	7	6
Ever drunk alcohol (%)	89	89	89	88	87	85	85	85	84
Physically inactive (%)	17	15	15	16	18	18	18	21	22
Time-independent:									
Men (%)	47	46	46	46	45	45	45	46	45
Compulsory schooling (%)	41	37	35	33	32	30	29	27	25
Lowest wealth (%)	19	17	16	15	15	15	15	14	14

ADL: activities of daily living; CESD: Center for Epidemiologic Studies Depression Scale; SD: standard deviation.
The number of participants (*n*) is shown for those with non-missing memory scores and who completed self-completion questionnaires: estimates are based on participants with non-missing data on these variables.
[a]Scores averaged across 4 sources: spouse; children; extended family; friends.

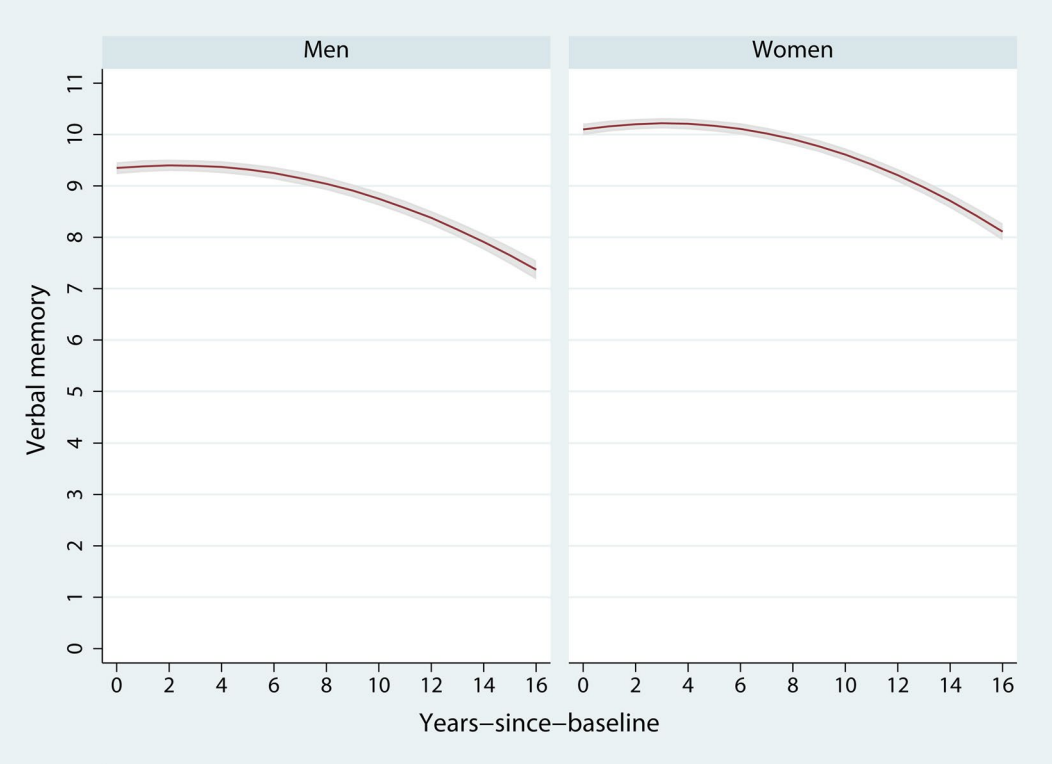

Figure 1. Verbal memory trajectories by sex.

95% CI [−0.084, −0.002]; *p*=.039). Women with higher mean levels of spousal strain had marginally lower baseline memory ($\beta_{\text{between-effect}}$ = −0.168; 95% CI [−0.343, 0.007]; *p*=.059).

Q2. Within-person associations

Among men, a higher-than-usual level of spousal strain at baseline was marginally associated with lower baseline memory ($\beta_{\text{within-effect}}$ = −0.142; 95% CI [−0.295, 0.010]; *p*=.068).

Children

Q1. Between-person associations

A slower decline in memory was observed among men with higher mean levels of support from children ($\beta_{\text{between-effect×time}}$ = 0.020; 95% CI [0.002, 0.039]; *p*=.033). Women with higher mean levels of strain from children had lower baseline memory ($\beta_{\text{between-effect}}$ = −0.276; 95% CI [−0.447, −0.104]; *p*=.002).

Table 2. Results from REWB models of the between-persons and within-person associations between social support/strain and verbal memory (all sources).

	Social support			Social strain		
Type of association by sex	B	95% CI	*p*-value	β	95% CI	*p*-value
Men (n = 4595)						
Between-effect	0.070	−0.082, 0.221	0.367	**−0.441**	**−0.703, −0.179**	**0.001**
Between-effect × time	0.030	−0.002, 0.061	0.067	−0.029	−0.083, 0.026	0.302
Within-effect	−0.005	−0.184, 0.174	0.954	−0.069	−0.296, 0.159	0.554
Within-effect × time	−0.027	−0.074, 0.021	0.269	0.004	−0.058, 0.065	0.909
Women (n = 5514)						
Between-effect	0.007	−0.143, 0.158	0.925	**−0.479**	**−0.732, −0.225**	**<0.001**
Between-effect × time	0.021	−0.010, 0.052	0.187	0.025	−0.025, 0.075	0.331
Within-effect	0.056	−0.123, 0.236	0.534	0.179	−0.011, 0.369	0.065
Within-effect × time	−0.025	−0.069, 0.019	0.265	−0.043	−0.093, 0.006	0.084

β: beta coefficient; CI: confidence interval; REWB: random effects within-between model.
Model adjusted for time-since-baseline; time^2; age (centered at 65); age^2; time × age; time × age^2; number of prior memory assessments; education; wealth; healthy lifestyle behaviors; social participation; depression; and mobility limitations. Results in bold indicate $p < .05$. Full model is shown in supplementary data (Table S3).

Table 3. Results from REWB models of the between-persons and within-person associations between social support/strain and verbal memory by relationship type.

Type of	Spouse			Children			Extended family members			Friends		
association by sex	β	95% CI	*p*-value	β	95% CI	*p*-value	β	95% CI	*p*-value	β	95% CI	*p*-value
Men (n = 4595)												
Social support:												
Between-effect	0.065	−0.029, 0.160	0.177	0.078	−0.013, 0.169	0.092	−0.096	−0.209, 0.017	0.094	**0.173**	**0.048, 0.299**	**0.007**
Between-effect × time	0.016	−0.003, 0.035	0.096	**0.020**	**0.002, 0.039**	**0.033**	0.006	−0.015, 0.028	0.559	0.006	−0.020, 0.033	0.627
Within-effect	−0.019	−0.146, 0.108	0.765	0.009	−0.131, 0.150	0.895	−0.009	−0.103, 0.086	0.854	−0.008	−0.111, 0.095	0.879
Within-effect × time	−0.013	−0.043, 0.018	0.416	0.003	−0.032, 0.039	0.862	−0.010	−0.033, 0.012	0.369	−0.008	−0.033, 0.017	0.543
Social strain:												
Between-effect	−0.152	−0.351, 0.047	0.134	−0.131	−0.355, 0.094	0.249	**−0.358**	**−0.553, −0.163**	**<0.001**	**−0.382**	**−0.627, −0.137**	**0.002**
Between-effect × time	**−0.043**	**−0.084, −0.002**	**0.039**	0.001	−0.038, 0.039	0.976	−0.013	−0.053, 0.027	0.518	−0.047	−0.095, 0.000	0.051
Within-effect	−0.142	−0.295, 0.010	0.068	0.033	−0.130, 0.196	0.688	−0.031	−0.146, 0.085	0.605	−0.052	−0.195, 0.091	0.472
Within-effect × time	0.012	−0.027, 0.052	0.542	−0.008	−0.047, 0.031	0.682	0.006	−0.025, 0.038	0.696	0.007	−0.031, 0.044	0.733
Women (n = 5514)												
Social support:												
Between-effect	−0.043	−0.128, 0.041	0.315	0.052	−0.028, 0.133	0.201	−0.025	−0.124, 0.075	0.627	**0.291**	**0.168, 0.414**	**<0.001**
Between-effect × time	0.003	−0.014, 0.020	0.752	0.000	−0.017, 0.018	0.957	0.012	−0.009, 0.033	0.255	0.003	−0.025, 0.030	0.854
Within-effect	0.015	−0.082, 0.111	0.767	0.079	−0.056, 0.214	0.251	−0.025	−0.102, 0.052	0.522	−0.009	−0.103, 0.085	0.855
Within-effect × time	−0.019	−0.043, 0.006	0.131	−0.015	−0.050, 0.020	0.398	−0.007	−0.026, 0.012	0.483	0.013	−0.011, 0.037	0.278
Social strain:												
Between-effect	−0.168	−0.343, 0.007	0.059	**−0.276**	**−0.447, −0.104**	**0.002**	−0.179	−0.377, 0.019	0.077	−0.206	−0.451, 0.039	0.099
Between-effect × time	0.017	−0.018, 0.051	0.340	0.013	−0.024, 0.050	0.488	0.001	−0.035, 0.038	0.952	0.010	−0.035, 0.056	0.659
Within-effect	0.020	−0.116, 0.157	0.770	0.077	−0.059, 0.213	0.266	0.048	−0.062, 0.158	0.391	0.078	−0.056, 0.211	0.253
Within-effect × time	−0.008	−0.043, 0.027	0.660	−0.022	−0.055, 0.012	0.210	−0.011	−0.040, 0.018	0.455	−0.011	−0.045, 0.022	0.505

β: beta coefficient; CI: confidence interval; REWB: random effects within-between model.
Model adjusted for time-since-baseline; time^2; age (centered at 65); age^2; time × age; time × age^2; number of prior memory assessments; education; wealth; healthy lifestyle behaviours; social participation; depression; and mobility limitations. Results in bold indicate $p < .05$.

Q2. Within-person associations

Higher-than-usual levels of social support and social strain from children were not significantly associated with baseline memory or its rate of change.

Extended family members

Q1. Between-person associations

Men with higher mean levels of strain from extended family members had lower baseline memory ($\beta_{between\text{-}effect}$ = −0.358; 95% CI [−0.553, −0.163]; p<.001); a similar but weaker association was observed among women ($\beta_{between\text{-}effect}$ = −0.179; 95% CI [−0.377, 0.019]; p=.077).

Q2. Within-person associations

Higher-than-usual levels of social support and social strain from extended family members were not significantly associated with baseline memory or its rate of change.

Friends

Q1. Between-person associations

Men with higher levels of strain from friends had lower baseline memory ($\beta_{between\text{-}effect}$ = −0.382; 95% CI [−0.627, −0.137]; p=.002) and showed faster decline ($\beta_{between\text{-}effect\times time}$ = −0.047; 95% CI [−0.095, 0.000]; p=.051). Greater support from friends was associated with higher baseline memory among men

($\beta_{between\text{-}effect}$ = 0.173; 95% CI [0.048, 0.299]; p=.007) and among women ($\beta_{between\text{-}effect}$ = 0.291; 95% CI [0.168, 0.414]; p<.001).

Q2. Within-person associations

Higher-than-usual levels of social support and social strain from friends were not significantly associated with baseline memory or its rate of change.

Sensitivity analysis

In agreement with our main analysis, men with higher spousal strain showed faster decline in memory ($\beta_{between\text{-}effect\times time}$ = −0.025; 95% CI [−0.043, −0.007]; p=.006). A similar but non-significant finding was found for men with higher levels of strain from friends ($\beta_{between\text{-}effect\times time}$ = −0.017; 95% CI [−0.038, 0.003]; p=.098), whilst men with greater support from children showed slower decline ($\beta_{between\text{-}effect\times time}$ = 0.009; 95% CI [0.000, 0.018]; p=.051). Slower memory decline was also observed among men with higher spousal support ($\beta_{between\text{-}effect\times time}$ = 0.012; 95% CI [0.004, 0.021]; p=.003) (Tables S5–S6).

Discussion

Drawing on the convoy model of social relations (Kahn & Antonucci, 1980) as a theoretical framework, our study enhances understanding of which aspects of social relations associate with cognitive functioning in older age. Among English community-dwelling older adults, we observed that associations between social support/strain and verbal memory (assessed by immediate and delayed word-recall tasks) were dependent on the personal and situational characteristics that shape convoys over the life-course. Longitudinal associations showed between- rather than within-person effects, were most prominent in men, and varied by relationship: higher levels of strain from spouse and from friends were associated with faster memory decline; greater support from children was associated with a slower decline.

Our study suggests a number of ways to move this field of inquiry forward, both in terms of scientific knowledge and practical implications. First, extending follow-up from 8-years previously (Liao & Scholes, 2017) to 16-years in the present study increased statistical power and ensured more precision. Compared with our earlier null findings (Liao & Scholes, 2017), herein we showed higher mean levels of spousal strain and support from children to be associated with faster and slower memory decline in men, respectively. As the length of follow-up for aging cohorts such as HRS increases, and as cognitive decline evolves slowly, researchers should consider replicating earlier studies whose findings were based on relatively short follow-up.

Secondly, previous studies have assessed social support/strain only at baseline (Seeman et al., 2001, Zahodne et al., 2019) or cumulatively (Liao et al., 2014; Seeman et al., 2011), and so have not investigated whether change over time in levels of social support/strain within-persons influence cognitive decline independently of differences between-persons. Confirming the utility of REWB models (Hülür, 2021), our study showed that the cross-sectional and longitudinal associations mainly reflected differences between-persons in mean levels of social support/strain, highlighting the need to prioritise interventions at the between- rather than within-person level.

Thirdly, previous studies that adjusted for sex in multivariable models (Zahodne et al., 2019) may have masked sex-dependent effects. Our findings suggest that unique social relationships may exert differential stress effects, especially in men. We highlight the importance of targeting interventions among those older men with more strained relationships with their spouse/partner and with friends. The significant association between spousal strain and faster memory decline (observed in both the main and sensitivity analysis) perhaps reflects the greater fragility of men's support network due to greater dependence on their spouses for emotional support (Antonucci & Akiyama, 1987; Liu et al., 2021). High levels of strain in close relations can act as a chronic stressor (Kuiper et al., 2016; Zahodne et al., 2019), which in turn, negatively affects memory (Conrad & Bimonte-Nelson, 2010).

Different aspects of social relations do not exist in isolation nor are easily separable (Sharifian et al., 2020). Interventions at different levels (individual, dyadic, network, community) targeting deficiencies in structural aspects by increasing social contact/engagement (so reducing social isolation, linked to 4% of dementia cases (Livingston et al., 2020)) may benefit relationship quality by increasing opportunities for forming new supportive relationships and improving existing ones. Alongside individual-level programs that address behavioral (e.g. friendship formation skills) and cognitive (e.g. greater understanding of others' mental states) processes, community practitioners could focus on problem-solving, to enable older adults, especially men, to sustain friendships that are rewarding and increase cognitive reserve (Sharifian et al., 2020), but which entail disagreements and annoyances (Blieszner et al., 2019). To support intervention efforts, more research is needed to identify the factors/processes that interfere with friendship enactment and satisfaction (Blieszner et al., 2019) and make some older adults more vulnerable than others to the harm of negative social exchanges (Rook, 2014).

Strengths and limitations

Strengths of our study include the benefits of analysing the ELSA cohort, which includes its relatively large sample size (enabling sex-stratified analyses), assessment of social support/strain across relationships, and validated tests of verbal memory. Our analyses were strengthened by a longer follow-up period relative to other studies, enabling a longer-term assessment of social support/strain and memory decline.

Our findings however should be interpreted cautiously. First, assessments of social support/strain were based on self-reports. Our estimates could be subject to differential response bias if those with higher memory were more likely to positively bias their perceptions of social support/strain, thereby potentially upwardly biasing effect sizes (Seeman et al., 2011). Secondly, adjustment for a wide range of variables may have produced an underestimation of effect sizes since some of the impact of social support/strain on memory may have been mediated through factors such as health behaviors and depressive symptomology. Thirdly, the large number of tests by fitting sex- and relationship-specific models increased the risk of type 1 error. We also acknowledge that the magnitude of associations for a specific relationship may be moderated by the levels of support/strain from other sources; future research should investigate, for example, whether differences in the rate of memory decline by levels of spousal strain are modified by levels of support from children, friends or extended family. Fourthly, study dropout is a limitation inherent to cognitive aging studies. Whilst random

effects models are robust under the assumption that data is missing at random, and we adjusted for practice effects, our findings should still be interpreted in the context of an aging cohort that was increasingly selective over time, with those most healthy and affluent being most likely to remain. Fifthly, the role of reverse causality cannot be eliminated, although we minimised its influence by excluding potentially cognitively unhealthy participants at baseline. Furthermore, previous studies have suggested that reverse causality is not an explanation through, for example, initial cognitive performance not being predictive of subsequent changes in relationship quality (Liao et al., 2014; Luo et al., 2021). Finally, as in all observation studies, our findings could have been influenced by additional confounders such as personality characteristics that were not available.

Conclusion

In conclusion, although modest in magnitude, our findings provide robust evidence for the notion that higher and lower levels of social support and social strain, respectively, can reduce the rate of memory decline in middle- and older-age, especially in men. These findings can inform future research studies and intervention strategies designed to maximise the potential role of high-quality social relations in achieving healthy cognitive aging.

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