35 social contact mode and 15-year episodic memory trajectories in older adults with and without hearing loss: the Elsa study

Social Contact Mode and 15-Year Episodic Memory Trajectories in Older Adults With and Without Hearing Loss: Findings from the English Longitudinal Study of Ageing

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Abstract

Objectives: Frequent social contact benefits cognition in later life although evidence is lacking on the potential relevance of the modes chosen by older adults, including those living with hearing loss, for interacting with others in their social network.

Method: 11,418 participants in the English Longitudinal Study of Ageing provided baseline information on hearing status and social contact mode and frequency of use. Multilevel growth curve models compared episodic memory (immediate and delayed recall) at baseline and longitudinally in participants who interacted frequently (offline only or offline and online combined), compared to infrequently, with others in their social network.

Results: Frequent offline (B=0.23; SE=0.09) and combined offline and online (B=0.71; SE=0.09) social interactions predicted better episodic memory after adjustment for multiple confounders. We observed positive, longitudinal associations between combined offline and online interactions and episodic memory in participants without hearing loss (B=0.50, SE=0.11) but not with strictly offline interactions (B=0.01, SE=0.11). In those with hearing loss, episodic memory was positively related to both modes of engagement (offline only: B=0.79, SE=0.20; combined online and offline: B=1.27, SE=0.20). Sensitivity analyses confirmed the robustness of these findings.

Discussion: Supplementing conventional social interactions with online communication modes may help older adults, especially those living with hearing loss, sustain, and benefit cognitively from, personal relationships.

Keywords: Social Interactions, Online Social Networking, Cognition, Hearing Loss, English Longitudinal Study of Ageing

Introduction

Growing older may motivate adults to selectively adjust their social networks in ways that affect their size and composition; specifically, older adults tend to prioritise close, emotionally-gratifying, personal contacts. Age-related motivational shifts towards emotional goals also extend to cognitive processes as meaningful, especially positive, past episodes may be disproportionately recollected (Carstensen et al., 2003). In the older adult population, social network size (Kelly et al., 2017) and contact frequency (Sharifian et al., 2019) have been positively associated with memory, which in turn, may affect adults' social engagement levels (Mousavi-Nasab et al., 2014). However, there is currently limited evidence on the extent to which different communication methods used by older adults to sustain personal relationships may influence memory long-term.

Although interpersonal contact in older age is traditionally offline (i.e., in-person and over-the-phone interactions that rely on real-time, audio-visual, or auditory-only exchanges, respectively), a growing number of older adults supplement these with online (i.e., technology-mediated) communication modes (Hunsaker & Hargittai, 2018; Lieberman & Schroeder, 2020). For example, e-mailing, which is an asynchronous, text-based, visual experience, is an online social contact method favoured by many older adults. Indeed, important well-being benefits of online social support have been reported (White & Dorman, 2001). Moreover, learning to use, and engage with, online social technology may offer direct cognitive stimulation (Myhre et al., 2017). Despite such potential, older adults often face unique barriers, including cognitive impairment and sensory loss, to adopting and benefiting from online technology (Gonsalves & Pichora-Fuller, 2008).

Sensory impairment (visual, auditory, or both) is common in older age. For many, hearing impairment presents as decreased capability to understand speech in a noisy

environment (Cavazzana et al., 2018). Listening becomes an effort, increasing the demand on cognitive resources for processing auditory signals (Heyl & Wahl, 2011). Although sometimes considered part of normal ageing, and hence not reported, hearing loss presents challenges to verbal communication; consequently, relationships may be become strained and less effective in sustaining psychosocial and cognitive functioning (Andrade et al., 2018; Wallhagen et al., 2004). The question remains, however, whether visually-intact older adults with hearing loss benefit cognitively from also regularly engaging online (Gonsalves & Pichora-Fuller, 2008; Wettstein et al., 2018). Specifically, might they be able to compensate for reduced cognitive benefits associated with ineffective verbal contact if they augmented their interpersonal communication with stimulating and supportive online interactions?

Our aim was to determine whether different modes of social contact were longitudinally related to different levels of episodic memory among older adults. To achieve this, we fitted a series of multilevel growth curve models to data from a large nationally representative panel study of adults aged 50 and older. First, we sought to determine whether frequent offline social interactions, as compared to infrequent contact, were independently and longitudinally associated with episodic memory; second, we sought to establish whether the combined use of frequent offline and online modes of contact, thus reflecting the ongoing societal trends in the use of online technology described above, offered additional episodic memory benefits (i.e., beyond traditional, or offline, only interactions); and lastly, we further explored these associations in study participants with and without self-identified hearing loss to determine whether hearing loss moderated any associations between social contact mode and episodic memory.

Methods

Study design and participants

This study draws on the nationally representative English Longitudinal Study of Ageing (ELSA) (Steptoe et al., 2013). The first wave of ELSA data was collected in 2002, and so far, there are eight waves of ELSA. The sample in the first wave was drawn from participants of the Health Survey for England in 1998, 1999, and 2001, and refreshment samples were recruited in waves 3, 4, 6 and 7. Our study was restricted to 11,418 core sample members aged from 50 to 90 years with complete information on hearing and social network contact at baseline. All respondents provided written informed consent, and ethical approval was obtained from the National Research Ethics Service.

Measures

Social network engagement

Social network engagement was based on self-reported information collected at wave 1 on the frequency and mode of interaction by study participants with their children, family, and friends. A typical question asked: *How often, on average, do you do each of the following [meet up/speak on the phone/write or email] with any of your [children/family/friends], not counting any who live with you?* Answers to each question were recorded on a six-item ordinal Likert scale, with response options ranging from less than once a year or never to three or more times a week. We then classified participants into those who: *engaged infrequently* (either offline or online); *frequently offline only*; and *frequently offline and online*. Respondents engaged infrequently with their network if they contacted their children, families, or friends less than once per month irrespective of contact mode. Participants who engaged frequently offline only were those who contacted their children, families, or friends

at least once per month by meeting up or phoning. Lastly, respondents who engaged frequently offline and online interacted with their children, families, or friends at least once per month by writing or emailing, meeting up or phoning.

Cognitive function

Information on episodic memory was collected uniformly at each wave using a measure known to have good construct validity and consistency (Tampubolon, 2015). Participants had a list of 10 words read out to them which they then had to recall immediately (immediate recall) and again at the end of the cognitive assessment (delayed recall). We summed the immediate and delayed recall scores to generate a total episodic memory score ranging from 0 – 20.

Hearing loss

Information on hearing status was collected by asking participants: 'Is your hearing [using a hearing aid as usual] excellent (1), very good (2), good (3), fair (4) or poor (5)?'. We defined hearing loss as having either fair or poor hearing (Maharani et al., 2018).

Covariates

Age was defined as the age of the respondent in the year of the survey and was treated as a continuous covariate. Sex was defined as the sex of the respondent as observed by the researchers (male as reference). Education was defined as the highest qualification attained by the respondent (UNESCO Institute for Statistics, 2012). As an indicator of socioeconomic position, income was measured by the aggregate of private pension and state pension. Marital status was classified as single, married, or cohabiting (reference), divorced or widowed.

We further categorised participants as non-smokers, past smokers, and current smokers. Drinking regularly was defined as drinking alcohol 5-7 days/week. Physical activity was defined as engaging in activities that require moderate (e.g., gardening) or vigorous (e.g., sports) levels of energy at least once a week. The presence of comorbid conditions was

treated as a dummy variable denoting whether a respondent reported ever having been diagnosed by a physician with any of the following: diabetes, hypertension, heart disease, or stroke.

Statistical analyses

Descriptive analyses of baseline variables generated means and standard deviations (SD) for numerical variables, and percentages for categorical variables. Bivariate analyses compared these characteristics in participants with and without hearing loss using Kruskal-Wallis one-way analysis of variance for numerical variables, and ordinal chi-square tests for categorical variables.

A series of multilevel growth curve models were generated for predicting episodic memory scores at Wave 1 and subsequently across further waves. The models look at individual differences in episodic memory scores (see *Supplementary File 2. Technical Background* for model details). The associations between episodic memory and social contact mode were determined in three distinct models (see Table 2). Specifically, model 1 included only social contact mode. Model 2 additionally included demographic and socioeconomic variables. Lastly, model 3 further adjusted for behavioural factors, hearing loss, and comorbidity. For model 3, we repeated the analysis separately for participants with and without hearing loss (we also ran these models for the total sample using interaction terms between hearing loss and social contact mode as shown in the right-hand pane in Table 3). *Supplementary Table 4* provide the multilevel growth curve analysis with the interaction terms between hearing loss and each of the independent variables. Finally, for more meaningful interpretation and comparison of the effects of social contact variables and other covariates on episodic memory scores (see *Supplementary Table 5*), we provided the Cohen's d values for each variable. All statistical analyses were performed using Stata 16.0.

Sensitivity analyses

We performed three sets of sensitivity analyses. We first reclassified participants' social network engagement based on the number of modes they used to contact their children, family, or friends more than once a month. Secondly, we added social network size (based on the sum of children, family, and friends who the participants have a close relationship with) to the model. We categorised participants' network size into either large (more than 10 persons) or small size (10 persons or less). Thirdly, we included information on visual loss to create a new variable on dual sensory loss (see further below). Subjective visual function, which is available in all waves of ELSA, was determined by the question: 'Is your visual [using eyeglasses as usual] excellent (1), very good (2), good (3), fair (4) or poor (5)?'. We identified participants who reported having fair or poor visual function as having visual loss. Dual sensory loss is defined as having both hearing and visual loss.

Results

At baseline, the average age of participants was 64.85 years (SD=10.05), 54% were female, 40% had completed college or higher, and 67% were married (Table 1). Age, smoking status, and comorbidities were significantly associated with hearing loss. Being female, relatively well-educated, socially active, wealthier, and physically active, were associated with less hearing loss.

Over 70% of participants reported frequently meeting or phoning their children, family, or friends (Table 1). Just over one percent interacted infrequently with close others in their social network. The proportion of participants who only relied on traditional modes for frequent social contact decreased steadily over time (*Supplementary Figure 1*). In the most recent ELSA wave, just over half of participants only engaged by meeting or phoning their friends and relatives. The percentage of participants who supplemented traditional modes of social contact with online methods increased from 24% to 45% across waves 1 to 8.

Table 2 displays the baseline and cohort linear growth curve model results for episodic memory and its relationship with social contact mode. Model 1 shows comparatively better memory scores in participants whose social interactions involved both frequent offline (B=0.36; SE=0.09) and combined offline and online (B=0.98; SE=0.09) modes. These associations remained significant albeit attenuated after controlling for demographic and socioeconomic characteristics. Additional adjustment for behavioural factors, hearing loss, and comorbidity weakened these associations further, yet both remained statistically significant in the final model (offline only: B=0.23; SE=0.09; online and offline combined: B=0.71; SE=0.09).

The two sets of results from the growth curve analysis evaluating the moderating role of hearing loss on the above associations are presented in Table 3. First, in the total sample,

hearing loss had significant moderating effects on each of the associations between mode of social engagement and episodic memory. Furthermore, in the stratified sample, only frequent engagements through combined online and offline modes were positively associated with episodic memory (B=0.50, SE=0.11) in participants without hearing loss. Among participants with hearing loss, however, frequent social interactions through offline only (B=0.79, SE=0.20), and combined online and offline (B=1.27, SE=0.20), modes were positively and significantly associated with future episodic memory. The trajectories of non-predicted and predicted episodic memory by social contact mode, stratified by hearing status, are displayed in *Supplementary Figure 2.*

The findings from our sensitivity analyses are presented in *Supplementary Tables 1-3*. Specifically, *Supplementary Table 1* displays how the number of social contact modes used by participants was associated with episodic memory. *Supplementary Table 2* demonstrates that social network size and episodic memory were not significantly associated. *Supplementary Table 3* shows that respondents with dual and single sensory loss were able to memorise fewer words than those without sensory loss. These results underscore the robustness of our analyses.

Discussion

This study adds new evidence to the body of research on social networks and cognition in later life. Our finding that frequent traditional (offline) interactions were associated with better memory suggests that older adults may benefit cognitively from interactions that involve recollecting personal experiences in terms of their content, location, and temporal occurrence. There is broad consistency with recent evidence on the benefits of social contact frequency on global cognition (Sommerlad et al., 2019) and verbal memory (Sharifian et al., 2019). It is possible that frequent, meaningful (e.g., sharing memories), offline interactions directly enhance memory through greater cognitive effort (Zuelsdorff et al., 2019). Alternatively, supportive offline interactions may counteract adverse neurophysiological responses to stress (Cohen & Wills, 1985).

The observed memory benefits associated with supplementing traditional communication with online methods supports the idea that online exchanges may provide older adults with valuable opportunities for recollecting and sharing past experiences. These findings broadly corroborate earlier reports showing an inverse association between internet use and cognitive impairment (d'Orsi et al., 2018) but further indicate that online methods may facilitate social support exchanges between older adults and personal connections they might otherwise not be able to sustain (Myhre et al., 2017). Engaging with technology may also directly stimulate neuronal networks since different cognitive functions, including memory, are required at each step of the process of effectively communicating online (Hultsch et al., 1999).

The larger associations between social contact mode and memory observed in those living with hearing loss is both a novel and seemingly counterintuitive finding, especially considering the impact hearing loss may have on communicative efficiency, cognition, and

social relationships (Kamil et al., 2015; Mick et al., 2014). However, it is possible that close others successfully adapt their communicative behaviour (e.g., concentrate on positive, rather than negative, past events) to meet the emotional demands of the person affected by hearing loss (Dickinson & Hill, 2007). If true, this might also account for the lack of effect on memory of offline only interactions in participants without hearing loss; it is possible that such interactions (compared to when hearing loss is present) include to a greater degree emotionally negative, as well as positive, exchanges, cancelling out any long-term benefits on memory (Rook, 2001). Additionally, those living with reduced hearing ability may also engage differently online, although the extent, or cognitive impact, of this is unclear. Alternatively, hearing loss might help some older adults concentrate more on the task at hand (e.g., composing an e-mail) if their impairment effectively reduces background noise.

Our study has some potential caveats. For example, we did not include information on other cognitive functions that also support independent living and are subject to considerable age-related decline (Deary et al., 2009). Details on hearing aid use were also not available to us, and thus could not be taken into account in the data analysis. This is important given that the extent of use of social technology, including e-mail, may be less for older adults with uncorrected hearing loss than those with intact hearing (Gonsalves & Pichora-Fuller, 2008). Importantly, information on hearing loss was self-reported and based on a single question. Lastly, the information available on online interactions was derived from a single question that combined e-mail and letter writing. Considering the steady decline in letter writing as a mode of communication, our online exposure category is likely to reflect more e-mail interactions than letter exchanges although the degree of this is unclear.

Our findings have implications for policy aiming at promoting social connections of older adults (Department for Digital, Culture, Media and Sport, 2018). Adopting online methods may benefit those living with hearing loss, whose regular social engagement may be

restricted (Holman et al., 2019; Mick et al., 2014). Our results also support individual-based strategies that address communication challenges faced by older adults and members in their social network.

In conclusion, we observed better episodic memory in older adults who combined offline and online modes for communicating with others in their social network. The associations between social contact mode and memory were modified by hearing status i.e., those living with hearing loss experienced greater cognitive benefits. These novel findings support policies and strategies aiming at promoting cognitive function through improved offline and online social interactions in later life.

Author contributions

Conception and design – SBR, AM, GT; Data analysis – AM; Interpretation of results – SBR, AM, GT; Manuscript writing and critical revision – SBR, AM, GT. All authors have reviewed the final version approved for publication.

Conflicts of interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Supplementary data

Supplementary data mentioned in the text are available online (see *Supplementary File 1. Tables and Figures & Supplementary File 2. Technical Background*).

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Table 1 Baseline attributes of the total sample and by hearing status. Source: ELSA wave 1.

Table 2 Growth curve models predicting episodic memory scores. Source: ELSA waves 1-8.

Table 3 Growth curve models predicting episodic memory scores in participants with and without hearing loss. Source: ELSA waves 1-8.

Table 1 Baseline attributes of the total sample and by hearing status. *Source:* ELSA wave 1.

	Total sample N=11,418	**No hearing loss N=8,968**	**Hearing loss N=2,450**	**p value**
Episodic memory, mean (SD)	9.41 (3.56)	9.73 (3.49)	8.23 (3.58)	< .001
Social engagement mode, %				
Infrequent	1.30	1.18	1.74	< .001
Frequent offline only	74.51	72.82	81.00	
Frequent offline and online	24.19	26.00	17.26	
Sociodemographic factors				
Age, mean (SD)	64.85 (10.05)	63.92 (9.73)	68.24 (10.45)	< .001
Female, *%*	54.48	57.88	42.04	< .001
Marital status, %				< .001
Single	5.45	5.58	4.98	
Married	67.02	67.43	65.54	
Divorced	10.63	10.97	9.35	
Widowed	16.91	16.03	21.13	
Education				< .001
Less than high school	43.40	40.43	54.24	
High school	15.77	16.71	12.33	
Some college	40.83	42.85	33.43	
Income				< .001
1st quintile (lowest)	19.83	19.27	21.86	
2nd	19.72	18.75	23.26	
3rd	20.12	19.59	22.06	
4th	20.09	20.95	16.95	
5th quintile (highest)	20.24	21.44	15.88	
Work				
Employees	30.71	33.24	21.43	< .001
Volunteers	4.83	4.65	5.47	
Neither	64.47	62.11	73.10	
Lifestyle factors				
Smoking status				< .001
Non-smoker, n (%)	33.53	34.68	29.31	
Current smoker, n (%)	48.76	48.20	50.78	
Past smoker, n (%)	17.72	17.12	19.92	
Drink 5-7 days/week, n (%)	28.20	28.71	26.30	.021
Moderate exercise, n (%)	56.91	58.92	49.41	< .001
Vigorous exercise, n (%)	17.94	18.99	14.00	< .001
Comorbidity				
Diabetes, n (%)	7.42	6.61	10.37	< .001
Heart disease, n (%)	16.85	14.84	24.20	< .001
Hypertension, n (%)	37.82	36.53	42.53	< .001
Stroke, n (%)	4.35	3.69	6.78	< .001

Table 2 Growth curve models predicting episodic memory scores. Source: ELSA waves 1-8.

	Model 1 [a]	**Model 2** [a]	**Model 3** [a]
Social engagement mode, reference: Infrequent			
Frequent offline only	0.36 (0.09)***	0.26 (0.09)**	0.23 (0.09)*
Frequent offline and online	0.98 (0.09)***	0.76 (0.09)***	0.71 (0.09)***
Hearing loss			-0.24 (0.03)***
Sociodemographic factors			
Age		-0.10 (0.00)***	-0.09 (0.00)***
Female		0.76 (0.04)***	0.75 (0.04)***
Marital status, reference: married			
Single		-0.10 (0.07)	-0.08 (0.07)
Separated/divorced		-0.01 (0.05)	0.02 (0.05)
Widowed		-0.19 (0.04)***	-0.18 (0.04)***
Education, reference: less than high school			
High school		1.39 (0.05)***	1.34 (0.05)***
College or higher		1.77 (0.04)***	1.69 (0.04)***
Income, reference: 1st quintile (lowest)			
2nd		0.17 (0.03)***	0.13 (0.03)***
3rd		0.41 (0.04)***	0.34 (0.04)***
4th		0.58 (0.04)***	0.49 (0.04)***
5th quintile (highest)		0.70 (0.04)***	0.58 (0.04)***
Work, reference: employees			
Volunteers		0.35 (0.04)***	0.33 (0.04)***
None of them		0.00 (0.03)	0.00 (0.03)
Lifestyle factors			
Smoking, reference: non-smoker			
Past smoker			-0.05 (0.03)
Current smoker			-0.21 (0.05)***
Drink regularly			0.09 (0.03)**
Moderate physical activity			0.30 (0.02)***
Vigorous physical activity			0.16 (0.03)***
Comorbidity			
Hypertension			0.02 (0.03)
Heart disease			-0.03 (0.03)
Diabetes mellitus			0.02 (0.05)
Stroke			-0.78 (0.07)***
Intercept	9.59 (0.09)***	9.48 (0.10)***	9.43 (0.11)**

Note: [a] Presented are coefficients and standard errors. * p < .05; ** p < .01; *** p < .001.

Table 3 Growth curve models predicting episodic memory scores in participants with and without hearing loss. Source: ELSA waves 1-8.

	No hearing loss [a]	**Hearing loss** [a]	**All respondents**
Hearing loss			-0.97 (0.20)**
Social engagement mode, reference: Infrequent			
Frequent offline only	0.01 (0.11)	0.79 (0.20)***	0.03 (0.11)
Frequent offline and online	0.50 (0.11)***	1.27 (0.20)***	0.52 (0.11)***
Frequent offline only*hearing loss			0.76 (0.20)***
Frequent offline and online*hearing loss			0.69 (0.21)***
Sociodemographic factor			
Age	-0.09 (0.00)***	-0.11 (0.00)***	-0.09 (0.00)***
Female	0.75 (0.04)***	0.68 (0.07)***	0.75 (0.04)***
Marital status, reference: married			
Single	-0.14 (0.08)	0.02 (0.15)	-0.09 (0.07)
Separated/divorced	0.04 (0.05)	0.06 (0.11)	0.02 (0.05)
Widowed	-0.20 (0.05)***	-0.04 (0.09)	-0.18 (0.04)***
Education, reference: less than high school			
High school	1.32 (0.06)***	1.19 (0.10)***	1.34 (0.05)***
College or higher	1.67 (0.04)***	1.55 (0.08)***	1.69 (0.04)***
Income, reference: 1st quintile (lowest)			
2nd	0.18 (0.04)***	0.00 (0.08)	0.13 (0.03)***
3rd	0.40 (0.04)***	0.23 (0.08)**	0.34 (0.04)***
4th	0.53 (0.04)***	0.41 (0.09)***	0.49 (0.04)***
5th quintile (highest)	0.62 (0.05)***	0.66 (0.10)***	0.58 (0.04)***
Work, reference: employees			
Volunteers	0.32 (0.04)***	0.31 (0.10)**	0.33 (0.04)***
None of them	-0.02 (0.03)	-0.03 (0.08)	0.00 (0.03)
Lifestyle factors			
Smoking, reference: non-smoker			
Past smoker	-0.05 (0.04)	0.04 (0.07)	-0.05 (0.03)
Current smoker	-0.23 (0.05)***	-0.13 (0.10)	-0.21 (0.05)***
Drink regularly	0.10 (0.03)**	0.12 (0.07)	0.09 (0.03)**
Moderate physical activity	0.29 (0.02)***	0.38 (0.05)***	0.30 (0.02)***
Vigorous physical activity	0.15 (0.03)***	0.27 (0.07)***	0.16 (0.03)***
Comorbidity			
Hypertension	0.03 (0.03)	-0.01 (0.06)	0.02 (0.03)
Heart disease	-0.02 (0.04)	-0.05 (0.07)	-0.03 (0.03)
Diabetes mellitus	-0.12 (0.05)*	-0.05 (0.09)	-0.07 (0.05)
Stroke	-0.74 (0.08)***	-0.72 (0.13)***	-0.78 (0.07)***
Intercept	9.64 (0.13)***	8.91 (0.23)***	9.62 (0.12)***

Note: [a] Presented are coefficients and standard errors. * p < .05; ** p < .01; *** p < .001