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

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Supplementary File 2. Technical Background

1. Data sources

We used data from the population-based English Longitudinal Study of Ageing (ELSA). ELSA is a biannual, nationally representative, longitudinal study of men and women aged 50 and older living in communities in England providing information on demographics, social, economics, behavioural, and health. The first wave of the study was conducted in 2002 with 11,391 respondents who had previously participated in the Health Survey for England and their partners. To date, there have been eight waves of ELSA. Ethical approval for ELSA was obtained from the National Health Service Research Ethics Committees under the National Research and Ethics Service. All respondents gave written informed consent. All methods were performed in accordance with approved guidelines and regulations.

2. Study population

Definition

The study population was individuals aged 50 years and older in England included in ELSA.

Inclusion/exclusion criteria

This study included only respondents aged between 50 and 90 years old. Respondents will be excluded if 1) they are younger than 50 years old or older than 90 years old; or 2) the data on hearing and social network contact at baseline are not available.

3. Study measures

This subsection provides the definitions, categorisations and types for each variable used in this study. The dependent variable in this study was episodic memory. The main independent variables were social engagement mode and hearing loss. This study included an extensive set of confounders, including

demographic, socioeconomic, health behaviours and comorbidities. Table 1 summarises the names, categorisations and types of the variables.

Table 1. Names and codes of the variables

Variables	**Codes**	**Type**
Episodic memory	Number of words	Ratio
Social engagement mode	1=infrequent (reference) 2=frequent offline only 3=frequent offline and online	Nominal
Hearing loss	0=No (reference) 1=Yes	Nominal/binary
Sensory loss	1=no sensory loss (reference) 2=have single sensory loss 3=have dual sensory loss	Ordinal
Demographic characteristics		
Age	Years (centred at 50)	Ratio
Gender	0=male (reference) 1=female	Nominal/binary
Marital status	1=married/cohabiting (reference) 2=single 3=separated/widowed 4=widowed	Nominal
Education	1=less than high school (reference) 2=high school 3=college or higher	Ordinal
Income	1= 1st quintile or lowest income (reference) 2= 2nd quintile 3= 3rd quintile 4= 4th quintile	Ordinal

	5= 5th quintile or highest income	
Work	1=employees (reference) 2=volunteers 3=none of them	Nominal
Health and lifestyle		
Smoking status	1=non-smoker (reference) 2=past smoker 3=current smoker	Nominal
Drinking behaviour	0=not drink regularly (reference) 1=drink regularly	Nominal/binary
Moderate physical activity	0=do moderate physical activity fewer than 5 days/week 1=do moderate physical activity at least 5 days/week	Nominal/binary
Vigorous physical activity	0=do vigorous physical activity fewer than once a week 1=do vigorous physical activity at least once a week	Nominal/binary
The presence of chronic diseases		
Diabetes mellitus	0=do not have diabetes mellitus (reference) 1=have diabetes mellitus	Nominal/binary
Heart disease	0=do not have not had heart disease (reference) 1=have had heart disease	Nominal/binary
Hypertension	0=do not have hypertension (reference) 1=have hypertension	Nominal/binary

Stroke	0=have not had stroke (reference) 1=have had stroke	Nominal/binary

i. *Episodic memory*

The cognitive performance measure in this study is the cognitive test available in all waves in ELSA, namely episodic memory. Episodic memory is defined through a total score combining the number of words that the respondents recall immediately after a list of 10 words is read out (immediate recall) and at the end of the cognitive module (delayed recall). The maximum score for episodic memory is 20.

ii. *Social engagement mode*

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

iii. *Hearing loss and dual sensory loss*

Sensory loss is measured using self-reported hearing and vision quality. The information on hearing function available in the all waves of ELSA included only self-reported hearing quality, which was determined using the question: 'Is your hearing [using a hearing aid as usual] excellent (1), very good (2), good (3), fair (4) or poor (5)?'. We identified participants who reported having fair or poor hearing in the first wave as having a hearing loss.

In the sensitivity analysis, we included variable visual loss to create variable dual sensory loss. Subjective visual function is available in the all waves of ELSA, which was determined using 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 a visual loss. Dual sensory loss is defined as having both hearing and visual loss.

iv. *Covariates/potential confounding factors*

a) Age

   Age was defined as the age of the respondent in the year of the survey. It is treated as a continuous covariate. We centred the age at 50 years old.

b) Gender

   Gender was defined as the sex of the respondent as observed by the researchers. It compares females (=1) to males (=0).

c) Marital status

   The marital status of the respondent was categorised into married/cohabiting (as reference), single, divorced/separated and widowed.

d) Education was defined as the highest qualification attained by the respondent, based on the International Standard Classification of Education ISCED-97 codes (UNESCO, 2012). The education completed by respondents was categorised as: less than high school, high school and college or higher. The ISCED-97

classified education into: Level 0, Pre-primary education; Level 1, Primary education of first stage of basic education; Level 2, Lower secondary or second stage of basic education; Level 3, (Upper) secondary education; Level 4, Post-secondary non-tertiary education; Level 5, First stage of tertiary education; and Level 6, Second stage of tertiary education. The respondent's educational level was categorised into less than high school if the highest education attainment is Level 0 to Level 2 (reference), high school if the respondent finished Level 3 or 4, and college or higher if the respondent completed Level 5 or higher.

e) Income

We used the aggregate of private pension and state pension to measure income. Income was treated as quintiles with lowest income as the reference.

f) Work

The employment status of the respondent was categorised into employees (as reference), volunteers and other than those two categories.

g) Smoking status

Respondents were categorised as current smokers, past smokers, or non-smokers (reference). Respondents were categorised as past smoker if they ever smoked in the past, but not at the time of survey. A current smoker was defined as one who was smoking either every day or on some days at the time of survey.

h) Drink regularly

Drinking regularly was defined as drinking alcohol 5-7 days/week.

i) Physical exercise

Physical exercise was defined as engaging in activities that require moderate (e.g. gardening, cleaning the car or taking a walk) or vigorous (e.g. sports, heavy housework, or a job that involves physical labour) levels of energy at least once a week.

j) Having chronic diseases

The presence of chronic illness was treated as a dummy variable denoting whether a respondent reported ever having been

diagnosed by a physician with any of these conditions: diabetes mellitus, heart disease (including myocardial infarction, coronary thrombosis and any other heart problem including congestive heart failure), hypertension and stroke.

4. Data Analysis

Descriptive analysis

Descriptive analysis consisted of the number and percentage of responses in each category for categorical variables, as well as the mean, median, standard deviation (SD), minimum, and maximum for continuous variables. All mean, median, and standard deviation values were formatted to two more decimal places than the measured value. All percentages were rounded to two decimal places.

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.

Multilevel growth curve models

Longitudinal data is defined as a type of data collected by tracking the same type of information on the same respondents at multiple points in time. Multilevel growth curve models were used to assess the relationship between social engagement mode, hearing impairment and other predictor variables on episodic memory scores as a ratio criterion variable for longitudinal data. One of the advantages of using multilevel growth curve models are that they allow unbalanced design as individuals may vary in their number of measurements due to attrition. Furthermore, they allow for between-individual variation in the timing of measurement *t*. In these multilevel growth curve models, random effects were used to model inter-individual heterogeneity in both baseline level and annual rates of changes in memory.

Denote by Z_{ti} the timing of occasion *t* for individual *i*. Suppose Y_{ti} is a linear function of Z_{ti} and covariates X_{ti}.

$Y_{ti} = \alpha_{0i} + \alpha_{1i} Z_{ti} + \beta X_{ti} + e_{ti}$

$\alpha_{0i} = \alpha_0 + u_{0i}$ (individual variation in level of Y)

$\alpha_{1i} = \alpha_1 + u_{1i}$ (individual variation in growth rate)

where Y_{ti} = episodic memory at time *t* for individual *i*, u_{0i} and are u_{1i} individual-level residuals and e_{ti} are normally distributed occasion-level residuals. Residuals at level individual and occasion assumed uncorrelated with X_{ti}.

The longitudinal associations between social contact mode and episodic memory scores were determined in three distinct models. The first model 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. In a final step, we repeated model 3 separately for participants with and without hearing loss. We further 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.

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 the measures of visual impairment in the analysis and create the sensory loss variable.

Statistical software

The analyses were performed using STATA Version 16. We used *xtset* and *xtreg* command for the multilevel growth curve analysis and *twoway lfit* command in STATA to produce the graphs.