

## Brief Report

# English Longitudinal Study of Aging: Can Internet/E-mail Use Reduce Cognitive Decline?

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**Background.** Cognitive decline is a major risk factor for disability, dementia, and death. The use of Internet/E-mail, also known as digital literacy, might decrease dementia incidence among the older population. The aim was to investigate whether digital literacy might be associated with decreased cognitive decline in older adulthood.

**Methods.** Data from the English Longitudinal Study of Aging cohort with 6,442 participants aged 50–89 years, followed for 8 years, with baseline cognitive testing and four additional time points. The main outcome variable was the relative percentage change in delayed recall from a 10-word-list learning task across five separate measurement points. In addition to digital literacy, socioeconomic variables, including wealth and education, comorbidities, and baseline cognitive function were included in predictive models. The analysis used Generalized Estimating Equations.

**Results.** Higher education, no functional impairment, fewer depressive symptoms, no diabetes, and Internet/E-mail use predicted better performance in delayed recall.

**Conclusions.** Digital literacy may help reduce cognitive decline among persons aged between 50 and 89 years.

**Key Words:** Cognitive decline—Prevention—Digital literacy—Cohort study—Ageing.

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**C**OGNITIVE decline (CD) often begins in individuals aged between 45 and 60 years (1). Studies have reported several risk factors for the incidence of CD, including social and demographic factors, diseases like hypertension, arteriosclerosis, and diabetes, genes, functional capacity, and nutrition. Social and cognitive activity can be protective factors (2–5).

Over the last 10 years, there has been a marked increase in computer and Internet use in older adulthood, such that 56% of those aged between 65 and 74 years, have Internet access (6). This widespread achievement, often known as digital literacy (DL), represents the ability to engage, plan, execute, and evaluate digital actions such as web browsing and exchanging E-mails as aids for dealing with daily life tasks (7). Digital literacy may also reduce the incidence of dementia (8). In the United Kingdom, recent estimates suggest that dementia prevalence may be lower than previously thought, and this decrease is possibly related to reductions in modifiable risk factors (9). This enables the hypothesis that changes in Internet/E-mail use status over time might be related to changes in memory status. However in 2014 6.4 million in

the United Kingdom have never used the Internet, with 74% of those over 65 years and half from socially disadvantaged backgrounds (10), which are at higher risk of developing dementia and would benefit more from DL inclusion policies. This study aims to investigate whether Internet/E-mail use might be associated with decreased CD in older adulthood.

## METHODS

### *Design, Setting, and Participants*

Data from English Longitudinal Study of Aging (ELSA), a biennial prospective observational study, nationally representative of England, of people aged 50 years or older (11). Data from 8 years of follow-up (5 waves: 2002–2011) were utilized. At Wave 1, 11,391 participants were interviewed (age  $64.99 \pm 9.97$  years, 54.26% women). Our sample consisted of 6,442 participants with data from at least three time intervals, 114 participants aged 90 years or older were excluded due to lack of data on the use of Internet/E-mail.

The study was approved by the National Research Ethics Service.

### Measurements

The outcome was the delayed 10 word-list learning recall calculated as its relative percentage change over each interval between surveys  $t_0$  and  $t_1$ ,  $t_1$  and  $t_2$ ,  $t_2$  and  $t_3$ ,  $t_3$  and  $t_4$ ; considering the ceiling (10 words) and the floor (zero words), presenting a variation from  $-100\%$  to  $+100\%$ . This measure accounts for the ceiling and the floor effects (12) reflecting individual change accurately (13). Our main predictor for DL was “I use Internet or E-mail: yes/no” calculated for each time interval and categorized into three groups: current user of Internet/E-mail (answered yes at both interval time points), intermittent user (answered no at one time point and yes at the other), and nonuser (answered no at both time points). Socioeconomic variables were education measured as the highest qualification achieved (degree or equivalent, intermediate, and no qualification), and total net (non-pension) household wealth categorized in quartiles, both measured at  $t_0$  (11). Age at  $t_0$  was classified using 10-year age groups (50–59 years, 60–69 years, 70–79 years, and 80–89 years). Based on the risk of dementia, low cognitive function at  $t_0$  was defined as “yes” (0–3 words recalled), or “no” (4–10 words recalled), and used for stratification and adjustment purposes (14).

Functional impairment, diabetes, cardiovascular diseases, and depressive symptoms were assessed at the beginning of each time interval ( $t_0$ ,  $t_1$ ,  $t_2$ , and  $t_3$ ). Functional impairment (self-reported) included six activities of daily living and seven instrumental activities of daily living. It was categorized as difficulty in at least one of the 13 activities or no difficulty. Information on diabetes and cardiovascular diseases were self-reported doctor-diagnoses. The eight-item scale from the Centre of Epidemiological Studies—Depression was used with a score of  $\geq 4$  points to define cases of depression (15).

### Statistical Analysis

Unadjusted and adjusted beta regression coefficients and 95% confidence intervals were calculated through Generalized Estimating Equations (GEE), unstructured within-group correlation, and robust variance estimator (12, 16). The bivariate analyses consisted of calculating mean relative percentage changes of the outcome for subgroups of gender, age, education, wealth quartiles, DL, functional impairment, diabetes, depressive symptoms, and cardiovascular diseases, stratified for low cognitive function at baseline (yes/no). For multiple analyses, we used the modeling of changes between two consecutive measurements of both the outcome variable and the main predictor (not absolute values at each time-point). Therefore, a person could change from the status of “current user” of Internet/E-mail

to “intermittent” and then “nonuser” between time intervals. According to Twisk (16), this model can handle the predictor longitudinal effect over time (within subjects effect) and not the cross-sectional effect (between subjects). Because there were five time points, four consecutive intervals were used ( $t_0-t_1$ ,  $t_1-t_2$ ,  $t_2-t_3$ ,  $t_3-t_4$ ). A temporal relation between the predictor and the outcome was also established, through 2-year lagged models, in which DL in the preceding interval was related to the relative percentage delayed recall change in the subsequent interval. All models were adjusted for age, gender, time, and low cognitive function at  $t_0$ . Adjusted analyses were performed in three steps. The first model included wealth and education. The second model included DL (changes in use of Internet/E-mail) because, as a recent phenomenon in society, we wanted to see its effect on socioeconomic status (SES) and aging. Functional impairment, diabetes, cardiovascular diseases, depressive symptoms, and risk factors for CD were included in the third model. Statistical significance was determined at  $p < .05$ . Interactions between the DL, gender, age, and wealth were also tested in the multiple analyses. All analyses were performed using Stata 11.0. To evaluate homogeneity in Generalized Estimating Equations models, other covariance structures were tested. Nonlagged models comparing the entire sample with our analytic sample were tested in order to address attrition.

### RESULTS

The mean baseline age was  $63.5 \pm 9.1$  years, 55.3% were female, 13.8% had a degree, 29.7% had low cognitive function at baseline, 23.2% had functional impairment, 6.1% had diabetes, and 35.1% used Internet/E-mail at  $t_0$  (Table 1). In total, 78.3% had complete follow up, from  $t_0$  to  $t_4$  with dropouts more likely to be older, male, less educated, poorer, with lower baseline cognition, and non/infrequent users of Internet/E-mail.

There was a significant decline in delayed recall over time of  $-3.6\%$  (95% CI:  $-4.03$  to  $-3.31$ ) which was higher in the oldest and lower cognitive function groups at baseline (Table 2). Higher baseline wealth and education predicted lower decline, and people with a degree improved in delayed recall. People with functional impairment, diabetes, cardiovascular diseases, or depressive symptoms had a significant decline in recall. People who reported being nonusers of Internet/E-mail and intermittent users showed decline, whereas current users increased their delayed recall capability, and the difference was almost 8.63% over the follow up with a strong effect size of 0.996. The same profile was observed in the stratified analysis. As expected, the group with lower cognitive function at baseline presented higher CD, but even for this group there was a significant variation in percentage change of the word recall, with better performance for those who used Internet/E-mail.

Multiple analyses (Table 3) confirmed the bivariate one. Model 1 shows the social gradient of wealth on delayed

Table 1. Sample Characteristics at Baseline by Covariates Among Older Adults From English Longitudinal Study of Aging, England, 2002–2003

		N	%	95% CI
Gender	Female	3562	55.3	54.1–56.5
Age	50–59 years	2615	40.6	39.4–41.7
	60–69 years	2105	32.7	31.5–33.8
	70–79 years	1329	20.6	19.6–21.6
	≥80 years	393	6.1	5.5–6.7
Education	Degree	886	13.7	12.9–14.6
	Intermediate	3301	51.2	50.0–52.5
	No education	2255	35.0	33.8–36.2
Low cognitive function	Yes (0–3 words recalled)	1899	29.7	28.5–30.7
	No (4–10 words recalled)	4500	70.3	69.2–71.5
Functional impairment	Difficulties performing ADLs/IADLs	1492	23.2	22.1–24.2
Diabetes	Self-reported diabetes	398	6.2	55.9–67.7
Cardiovascular diseases	Self-reported cardiovascular diseases	3093	48.0	46.8–49.2
Depressive symptoms	4 or more points on CES-D scale	851	13.3	12.5–14.2
Digital literacy	Use of Internet/E-mail	2207	35.1	33.9–36.3

Notes: ADLs = activities of daily living; CES-D scale = Centre of Epidemiological Studies Depression scale; IADLs = instrumental activities of daily living.

Table 2. Mean Relative Percentage Changes in Delayed Recall Between Time Intervals and 95% Confidence Intervals According to Age, Gender, Wealth Quartile, Education, Physical Disability, Diabetes, Cardiovascular Diseases, Depressive Symptoms, and Digital Literacy, English Longitudinal Study of Aging, England, 2002–2010

		Low Cognitive Function at Baseline*					
		Total		Yes		No	
		Mean <sup>†</sup>	95% CI	Mean <sup>†</sup>	95% CI	Mean <sup>†</sup>	95% CI
Total		–3.67	–4.03 to –3.31	–7.41	–8.18 to –6.63	–2.05	–2.44 to –1.65
Men <sup>‡</sup> (n = 2,859)	50–64	–0.74	–1.29 to –0.19	–2.06	–3.45 to –0.67	–0.32	–0.91 to 0.27
	65–89	–9.87	–10.75 to –8.99	–11.77	–13.23 to –10.32	–8.06	–9.11 to –7.01
Women <sup>‡</sup> (n = 3,540)	50–64	1.44	0.87 to 2.01	0.55	–1.01 to 2.13	1.84	1.23 to 2.45
	65–89	–9.16	–9.97 to –8.35	–11.52	–12.91 to –10.13	–7.56	–8.54 to –6.59
Wealth quartile <sup>‡</sup> (n = 6,397)	1st (poorest)	–7.58	–8.41 to –6.74	–10.99	–12.44 to –9.55	–5.33	–6.33 to –4.33
	2nd	–4.98	–5.74 to –4.23	–8.82	–10.43 to –7.21	–3.20	–4.01 to –2.38
	3rd	–2.69	–3.44 to –1.95	–5.36	–7.05 to –3.66	–1.72	–2.53 to –0.90
	4th (wealthiest)	0.16	–0.54 to 0.86	–1.64	–3.39 to 0.12	0.74	–0.00 to 1.49
Education <sup>‡</sup> (n = 6,399)	Degree	2.01	1.09 to 2.92	–0.02	–2.76 to 2.71	2.72	1.77 to 3.67
	Intermediate	–2.13	–2.60 to –1.67	–5.01	–6.15 to –3.88	–1.15	–1.65 to –0.65
	No qualification	–8.39	–9.02 to –7.74	–10.36	–11.47 to –9.25	–6.64	–7.50 to –5.99
Functional impairment <sup>§</sup> (ADLs/IADLs) (n = 6,399)	No	–2.10	–2.50 to –1.70	–5.04	–6.00 to –4.09	–0.96	–1.39 to –0.53
	Yes	–7.94	–8.79 to –7.08	–11.63	–13.10 to –10.16	–5.52	–6.53 to –4.51
Diabetes <sup>§</sup> (n = 5,516)	No	–3.34	–3.72 to –2.96	–7.01	–7.85 to –6.18	–1.83	–2.24 to –1.42
	Yes	–7.23	–8.49 to –5.96	–10.35	–12.56 to –8.13	–4.88	–6.37 to –3.40
Cardiovascular diseases <sup>§</sup> (n = 6,442)	No	–1.65	–2.17 to –1.12	–5.03	–6.33 to –3.74	–0.41	–0.96 to 0.13
	Yes	–5.21	–5.71 to –4.72	–8.79	–9.76 to –7.81	–3.41	–3.97 to –2.84
Depressive symptoms <sup>§</sup> (n = 6,360)	No	–2.74	–3.14 to –2.34	–6.66	–7.52 to –5.80	–1.67	–2.09 to –1.25
	Yes	–6.68	–7.81 to –5.55	–10.41	–12.57 to –8.26	–4.78	–6.12 to –3.43
Digital literacy (use of Internet/E-mail) <sup>§</sup> (n = 6,259)	No user	–7.12	–7.69 to –6.65	–8.66	–9.70 to –7.63	–6.01	–6.67 to –5.34
	Intermittent	–1.83	–3.09 to –0.57	–3.50	–6.24 to –0.75	–1.24	–2.54 to 0.16
	Current user	1.58	1.06 to 2.10	0.27	–1.13 to 1.68	1.95	1.39 to 2.51

Notes: ADLs = activities of daily living; IADLs = instrumental activities of daily living.

\*Low cognitive function at baseline: 0 to 3 words recalled (yes); 4 to 10 words recalled (no).

<sup>†</sup>Mean estimated through Generalized Estimating Equations.

<sup>‡</sup>Measured at baseline ( $t_0$ ).

<sup>§</sup>Measured at baseline and at each of the four follow-up interviews (from  $t_0$  to  $t_4$ ).

recall, adjusted for age, gender, education, time, and cognitive function at  $t_0$ . In Model 2, when the changes in use of Internet/E-mail were added to the model, the effect of wealth was reduced. Model 3 shows that when physical disability,

depression, and diabetes were added, the effect of wealth was no longer significant. Cardiovascular diseases were excluded from the model because their effect was nonsignificant. Increased use of Internet/E-mail was associated with

Table 3. Adjusted Relative Percentage Change in Delayed Recall Over Covariates Among Older Adults From English Longitudinal Study of Aging, England, 2002–2010

	Model 1*			Model 2†			Model 3‡		
	Coeff <sup>§</sup>	95% CI	<i>p</i> <sup>  </sup>	Coeff <sup>§</sup>	95% CI	<i>p</i> <sup>  </sup>	Coeff <sup>§</sup>	95% CI	<i>p</i> <sup>  </sup>
Wealth quartile									
1st (poorer)	Ref		<.001	Ref		.007	Ref		.089
2nd	0.34	−0.96 to 1.64		0.18	−1.19 to 1.55		−0.23	−1.61 to 1.12	
3rd	1.62	0.33 to 2.91		1.05	−0.32 to 2.43		0.56	−0.83 to 1.94	
4th (wealthiest)	2.42	1.15 to 3.69		1.69	0.32 to 3.07		0.89	−0.51 to 2.30	
Education			<.001			<.001			<.001
Degree	Ref			Ref			Ref		
Intermediate	−2.74	−3.95 to 1.53		−1.81	−3.13 to −0.51		−1.88	−3.19 to −0.57	
None	−5.38	−6.79 to 3.98		−3.77	−5.34 to −2.19		−3.85	−5.43 to −2.29	
Digital literacy (use of Internet/E-mail)						<.001			<.001
No user				Ref			Ref		
Intermittent user				2.83	1.22 to 4.45		2.54	0.93 to 4.15	
Current user				3.30	2.22 to 4.39		3.07	1.97 to 4.17	
Functional impairment (difficulty performing ADLs/IADLs)									.001
No							Ref		
Yes							−1.91	−3.14 to −0.68	
Depressive symptoms									.008
No							Ref		
Yes							−2.20	−3.84 to −0.56	
Diabetes									.050
No							Ref		
Yes							−1.74	−3.44 to −0.05	

Notes: ADLs = activities of daily living; IADLs = instrumental activities of daily living. Significant *p* values in bold numbers.

\*Model 1 is adjusted for age, gender, time, baseline cognitive function, wealth, and education.

†Model 2 is adjusted for all covariates from Model 1 along with digital literacy.

‡Model 3 is the fully adjusted model (adjusted for all covariates from Model 2 along with digital literacy, physical disability, depressive symptoms, and diabetes).

§The estimates are beta regression coefficients with 95% confidence intervals (95% CI) calculated through 2-year lagged Generalized Estimating Equations models.

||*p* values from Wald test.

significant improvement in delayed recall over time intervals. People who were current users of Internet/E-mail presented an improvement of 3.07% in delayed recall when compared with those who were nonusers of Internet/E-mail. This effect remained after full adjustment. The interactions tested between DL, age, gender, and wealth were nonsignificant. The other covariance structures and the comparison between the whole sample and the analytic sample yielded similar results, showing that the dropouts did not affect the results.

## DISCUSSION

This is the first major study to show that being digitally literate can improve memory, and benefits of looking at within-individual variation (trajectory) using repeated measurement of memory over several years, repeated assessment of Internet/E-mail use over time and measure of relevant SES and health covariates, in a large prospective cohort.

The effect of DL was independent of age and SES and may suggest that DL increases brain and cognitive reserve (17,18) or leads to the employment of more efficient cognitive networks to delay CD (19). This effect was found even in more at risk groups (ie, lower cognitive function at baseline) whose cognitive trajectories were also well

captured by the percentage change measure. Known risk factors like increasing age, depressive symptoms, diabetes, and functional impairment were also linked to CD (20). In line with other studies, we found that lower CD was linked with higher education (21). Study limitations include the absence of information about frequency of E-mail/Internet use. To minimize practice effects, the ELSA questionnaire used four different and validated 10 word lists to access delayed recall in each wave. The significant increase in memory found even in the low cognitive group makes practice effect an improbable possibility because this is not easy to occur in this type of population (22). However, the possibility of practice effect particularly among higher cognitive groups, rather than a true gain in effect, especially from Internet/E-mail use cannot be completely ruled out.

Potential selection bias due to participant losses was addressed through sensitivity analysis and was less likely to occur because the comparison between the whole sample and the analytic sample yielded similar results.

In line with our results, another study within the same population showed DL can also decrease the incidence of instrumental activities of daily living impairment, which often coincides with CD, as it is part of the dementia process itself (23).

The ELSA cohort has also showed DL can improve healthy behaviors such as physical activity, higher consumption of fruits and vegetables, less smoking, and more adhesion to cancer screening (24) leading to a better health and, consequently, better outcomes. The national representativeness of ELSA adds to the robustness of the results which indicate that DL is an independent protective factor against CD. Countries where policy interventions regarding improvement in DL are implemented may expect lower incidence rates for dementia over the coming decades.

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