

Supplementary material

Jindra et al.: Depression and memory function - evidence from cross-lagged panel models with unit fixed effects in ELSA and HRS

TABLE S1
Descriptive statistics of main variables by cohort

		ELSA								
		Age			Cognition			CES-D		
		Mean	Std	N	Mean	Std	N	Mean	Std	N
<i>Cross-Sectional</i>										
	Wave 1	65.02	10.24	11453	9.40	3.57	11104	1.60	1.99	11103
	Wave 2	66.68	9.80	8852	9.86	3.61	8708	1.59	1.96	8693
	Wave 3	68.06	9.59	7592	9.99	3.73	7402	1.51	1.96	7382
	Wave 4	69.55	9.12	6680	9.98	3.70	6430	1.41	1.90	6415
	Wave 5	70.85	8.69	6300	9.96	3.81	5993	1.53	1.96	5962
	Wave 6	72.15	8.29	5710	10.13	3.81	5426	1.32	1.84	5390
	Wave 7	73.39	7.78	4942	9.87	3.85	4680	1.39	1.83	4654
<i>Longitudinal</i>					Mean	Std	N	Mean	Std	N
	Overall				9.83	3.71	49743	1.50	1.94	49599
	Between					3.34	11264		1.70	11253
	Within					2.09			1.19	
		HRS								
		Age			Cognition			CES-D		
		Mean	Std	N	Mean	Std	N	Mean	Std	N
<i>Cross-Sectional</i>										
	Wave 3	67.05	10.59	17429	9.86	3.91	15820	1.35	1.89	15808
	Wave 4	68.34	10.36	15241	10.02	3.98	13700	1.68	1.97	13687
	Wave 5	69.57	9.94	13684	9.69	3.81	12188	1.59	1.93	12175
	Wave 6	70.87	9.48	12325	9.73	3.68	10922	1.52	1.94	10907
	Wave 7	72.01	8.97	11205	9.29	3.52	10091	1.47	1.95	10060
	Wave 8	73.25	8.46	10095	9.16	3.62	9315	1.47	1.95	9296
	Wave 9	74.48	7.91	9135	9.16	3.55	8427	1.40	1.91	8417
	Wave 10	75.94	7.22	7967	8.92	3.46	7197	1.34	1.87	7178
	Wave 11	77.05	6.78	7135	8.76	3.43	6540	1.38	1.89	6521
	Wave 12	78.26	6.28	6200	8.65	3.50	5687	1.40	1.92	5667
<i>Longitudinal</i>					Mean	Std	N	Mean	Std	N
	Overall				9.46	3.73	99887	1.47	1.93	99716
	Between					3.27	16375		1.62	16364
	Within					2.39			1.24	

Notes: All statistics are based on the maximum information available.

TABLE S2
Unadjusted OLS results - pooled and by wave

	y = cognition					y = CES-D				
	β	se	p-value	R^2	Obs.	β	se	p-value	R^2	Obs.
ELSA:										
Wave 1	-0.300	0.017	0.0000	0.028	11059	-0.094	0.005	0.0000	0.028	11059
Wave 2	-0.277	0.020	0.0000	0.023	8677	-0.082	0.006	0.0000	0.023	8677
Wave 3	-0.303	0.023	0.0000	0.026	7371	-0.085	0.006	0.0000	0.026	7371
Wave 4	-0.336	0.024	0.0000	0.030	6406	-0.089	0.006	0.0000	0.030	6406
Wave 5	-0.349	0.026	0.0000	0.033	5962	-0.094	0.007	0.0000	0.033	5962
Wave 6	-0.331	0.029	0.0000	0.026	5389	-0.079	0.007	0.0000	0.026	5389
Wave 7	-0.402	0.032	0.0000	0.037	4650	-0.092	0.007	0.0000	0.037	4650
Pooled	-0.322	0.013	0.0000	0.029	49514	-0.322	0.013	0.0000	0.029	49514
HRS:										
Wave 3	-0.385	0.016	0.0000	0.035	15808	-0.090	0.004	0.0000	0.035	15808
Wave 4	-0.366	0.017	0.0000	0.033	13687	-0.090	0.004	0.0000	0.033	13687
Wave 5	-0.352	0.017	0.0000	0.032	12175	-0.091	0.004	0.0000	0.032	12175
Wave 6	-0.347	0.018	0.0000	0.034	10907	-0.097	0.005	0.0000	0.034	10907
Wave 7	-0.341	0.019	0.0000	0.036	10060	-0.105	0.006	0.0000	0.036	10060
Wave 7	-0.343	0.019	0.0000	0.034	9296	-0.099	0.006	0.0000	0.034	9296
Wave 7	-0.327	0.021	0.0000	0.031	8417	-0.096	0.006	0.0000	0.031	8417
Wave 10	-0.322	0.022	0.0000	0.030	7178	-0.095	0.006	0.0000	0.030	7178
Wave 11	-0.329	0.022	0.0000	0.033	6521	-0.099	0.007	0.0000	0.033	6521
Wave 12	-0.303	0.024	0.0000	0.028	5667	-0.091	0.007	0.0000	0.028	5667
Pooled	-0.340	0.010	0.0000	0.031	99716	-0.091	0.003	0.0000	0.031	99716

Notes: Each row contains one separate model. Standard errors for the pooled model are corrected for clustering at the individual level and p-values are for two-sided tests.

TABLE S3
Goodness of fit measures for cross-lagged panel models with unit fixed effects

	ELSA			HRS		
	RMSEA	TLI	CFI	RMSEA	TLI	CFI
Y = cognition:						
Specification 1	0.029	0.967	0.976	0.027	0.955	0.966
Specification 2	0.034	0.956	0.970	0.028	0.950	0.962
Specification 3	0.029	0.967	0.979	0.029	0.945	0.959
Specification 4	0.022	0.982	0.990	0.020	0.971	0.979
Specification 5	0.025	0.982	0.996	0.020	0.971	0.979
Y = CES-D:						
Specification 6	0.019	0.979	0.985	0.016	0.978	0.983
Specification 7	0.029	0.953	0.968	0.027	0.940	0.955
Specification 8	0.025	0.964	0.977	0.026	0.944	0.959
Specification 9	0.022	0.971	0.984	0.024	0.954	0.966
Specification 10	0.011	0.994	0.999	0.021	0.962	0.973

Notes: Fit measures for models in Table 2. Fit measures are based on models without robust standard errors. Due to the large sample size, we do not report χ^2 statistics.

TABLE S4
Likelihood ratio tests of random effects assumption

	ELSA			HRS		
	χ^2	df	p-value	χ^2	df	p-value
Specification 1	2896.1	13	0.000	5473.1	19	0.000
Specification 2	4059.2	13	0.000	6154.6	19	0.000
Specification 3	3738.1	13	0.000	6651.3	19	0.000
Specification 4	2026.4	12	0.000	5032.9	19	0.000
Specification 5	1155.9	8	0.000	5741.8	19	0.000
Specification 6	2973.6	13	0.000	4790.4	19	0.000
Specification 7	3758.1	13	0.000	6425.8	19	0.000
Specification 8	3272.4	13	0.000	6825.9	19	0.000
Specification 9	2142.2	12	0.000	6392.2	19	0.000
Specification 10	837.5	8	0.000	5693.5	19	0.000

Notes: The likelihood ratio tests are based on models without robust standard errors.

TABLE S5
Goodness of fit measures for cross-lagged panel models with random effects

	ELSA			HRS		
	RMSEA	TLI	CFI	RMSEA	TLI	CFI
Y = cognition:						
Specification 1	0.063	0.843	0.867	0.050	0.843	0.868
Specification 2	0.081	0.749	0.786	0.055	0.804	0.832
Specification 3	0.085	0.722	0.761	0.060	0.757	0.789
Specification 4	0.075	0.783	0.817	0.054	0.794	0.818
Specification 5	0.093	0.739	0.816	0.063	0.721	0.750
Y = CES-D:						
Specification 6	0.060	0.788	0.820	0.043	0.848	0.871
Specification 7	0.076	0.669	0.717	0.056	0.748	0.784
Specification 8	0.079	0.643	0.692	0.060	0.709	0.747
Specification 9	0.078	0.649	0.703	0.061	0.691	0.727
Specification 10	0.078	0.688	0.780	0.063	0.670	0.705

Notes: Fit measures are based on models without robust standard errors. Due to the large sample size, we do not report χ^2 statistics.

TABLE S6
Cross-lagged panel models with fixed effects - $y = \text{cognition}_t$

	ELSA					HRS				
	Specification 1 β (s.e.)	Specification 2 β (s.e.)	Specification 3 β (s.e.)	Specification 4 β (s.e.)	Specification 5 β (s.e.)	Specification 1 β (s.e.)	Specification 2 β (s.e.)	Specification 3 β (s.e.)	Specification 4 β (s.e.)	Specification 5 β (s.e.)
$CES - D_t$	-0.074 0.016	-0.068 0.019	-0.083 0.025	-0.077 0.045	-0.148 0.087	-0.046 0.010	-0.060 0.011	-0.073 0.012	-0.096 0.016	-0.099 0.020
$CES - D_{t-1}$	0.017 0.015	0.254 0.015	0.441 0.019	0.005 0.033	-0.062 0.062	-0.029 0.009	-0.029 0.009	-0.032 0.010	-0.048 0.012	-0.050 0.015
$CES - D_{t-2}$		-0.021 0.017	0.208 0.017	-0.027 0.027	-0.094 0.052			0.002 0.009	-0.040 0.011	-0.038 0.014
$CES - D_{t-3}$				-0.027 0.021	-0.047 0.042				-0.048 0.011	-0.054 0.013
$CES - D_{t-4}$				0.021	0.426 0.033				0.011	0.268 0.012
Cog_{t-1}	0.131 0.009					0.124 0.006				
Cog_{t-2}		0.019 0.008					0.088 0.005			
Cog_{t-3}			-0.015 0.008	0.057				-0.002 0.005	0.680	
Cog_{t-4}				0.069 0.011	0.000				0.040 0.006	0.000
Cog_{t-5}					-0.016 0.015					-0.008 0.006
N	11313	11313	11311	11309	11304	17009	17009	17009	17008	17008

Notes: All models are estimated using full information maximum likelihood. Robust standard errors are reported and p-values are for two-tailed tests. All models are adjusted for wave and age.

TABLE S7
Cross-lagged panel models with fixed effects - $y = CES - D_t$

	ELSA					HRS				
	Specification 6 β (s.e.)	Specification 7 β (s.e.)	Specification 8 β (s.e.)	Specification 9 β (s.e.)	Specification 10 β (s.e.)	Specification 6 β (s.e.)	Specification 7 β (s.e.)	Specification 8 β (s.e.)	Specification 9 β (s.e.)	Specification 10 β (s.e.)
Cog_t	-0.032 0.006	-0.034 0.006	-0.041 0.008	-0.048 0.017	-0.108 0.041	-0.026 0.003	-0.026 0.003	-0.028 0.004	-0.030 0.004	-0.031 0.005
Cog_{t-1}	-0.007 0.005	0.129 0.005	0.116 0.006	-0.010 0.012	-0.055 0.028	-0.005 0.003	-0.005 0.003	-0.004 0.003	-0.005 0.004	-0.008 0.005
Cog_{t-2}		-0.005 0.005	0.374 0.005	-0.006 0.009	-0.042 0.021			-0.005 0.003		
Cog_{t-3}				0.760 0.008	0.704 0.016			-0.008 0.003		
Cog_{t-4}				-0.006 0.011	0.552					
$CES - D_{t-1}$	0.141 0.010					0.174 0.007				
$CES - D_{t-2}$		0.021 0.009					0.052 0.006			
$CES - D_{t-3}$			-0.009 0.010	0.401				-0.006 0.006		
$CES - D_{t-4}$				-0.021 0.013					-0.013 0.007	
$CES - D_{t-5}$					0.005 0.016					-0.017 0.008
N	11308	11308	11306	11304	11299	17008	17008	17008	17007	17007

Notes: All models are estimated using full information maximum likelihood. Robust standard errors are reported and p-values are for two-tailed tests. All models are adjusted for wave and age.

TABLE S8
Cross-lagged panel models with unit fixed effects and additional time-varying variables

	$y = \text{cognition}_t$							
	ELSA				HRS			
	β	se	p-value	N	β	se	p-value	N
Specifications 1:								
<i>Cog</i> _{<i>t</i>-1}	0.141	0.009	0.0000	11150	0.128	0.006	0.0000	16638
<i>CES</i> - <i>D</i> _{<i>t</i>}	-0.075	0.016	0.0000		-0.046	0.010	0.0000	
<i>Hypertension</i> _{<i>t</i>}	-0.383	0.152	0.0116		-0.037	0.071	0.5962	
<i>Diabetes</i> _{<i>t</i>}	-0.632	0.214	0.0031		0.634	0.119	0.0000	
<i>Heart problems</i> _{<i>t</i>}	-0.878	0.159	0.0000		-0.349	0.102	0.0006	
<i>Stroke</i> _{<i>t</i>}	-2.863	0.284	0.0000		-1.809	0.146	0.0000	
<i>Smokes</i> _{<i>t</i>}	0.186	0.156	0.2341		0.132	0.087	0.1325	
<i>Married</i> _{<i>t</i>}	0.606	0.163	0.0002		0.144	0.086	0.0925	
Specifications 2:								
<i>Cog</i> _{<i>t</i>-2}	0.017	0.008	0.0287	11151	0.089	0.005	0.0000	16659
<i>CES</i> - <i>D</i> _{<i>t</i>}	-0.067	0.019	0.0005		-0.061	0.011	0.0000	
<i>CES</i> - <i>D</i> _{<i>t</i>-1}	0.023	0.015	0.1267		-0.027	0.009	0.0043	
<i>Hypertension</i> _{<i>t</i>-1}	0.036	0.101	0.7208		-0.070	0.052	0.1798	
<i>Diabetes</i> _{<i>t</i>-1}	0.208	0.143	0.1451		0.102	0.068	0.1332	
<i>Heart problems</i> _{<i>t</i>-1}	-0.202	0.115	0.0791		-0.074	0.058	0.2046	
<i>Stroke</i> _{<i>t</i>-1}	-0.306	0.206	0.1373		-0.285	0.090	0.0014	
<i>Smokes</i> _{<i>t</i>-1}	0.046	0.127	0.7161		-0.030	0.074	0.6887	
<i>Married</i> _{<i>t</i>-1}	0.557	0.114	0.0000		0.105	0.056	0.0603	
Specifications 3:								
<i>Cog</i> _{<i>t</i>-3}	-0.016	0.008	0.0548	11151	-0.002	0.005	0.6508	16678
<i>CES</i> - <i>D</i> _{<i>t</i>}	-0.099	0.021	0.0000		-0.057	0.011	0.0000	
<i>CES</i> - <i>D</i> _{<i>t</i>-2}	-0.023	0.016	0.1308		-0.015	0.009	0.0942	
<i>Hypertension</i> _{<i>t</i>-2}	0.148	0.113	0.1904		0.014	0.052	0.7830	
<i>Diabetes</i> _{<i>t</i>-2}	0.264	0.174	0.1290		-0.021	0.066	0.7537	
<i>Heart problems</i> _{<i>t</i>-2}	-0.084	0.145	0.5637		-0.099	0.059	0.0962	
<i>Stroke</i> _{<i>t</i>-2}	-0.372	0.248	0.1341		-0.237	0.100	0.0181	
<i>Smokes</i> _{<i>t</i>-2}	-0.219	0.143	0.1247		-0.124	0.076	0.1063	
<i>Married</i> _{<i>t</i>-2}	0.495	0.134	0.0002		0.255	0.059	0.0000	
Specifications 4:								
<i>Cog</i> _{<i>t</i>-4}	0.069	0.011	0.0000	11245	0.042	0.006	0.0000	16702
<i>CES</i> - <i>D</i> _{<i>t</i>}	-0.072	0.029	0.0133		-0.048	0.013	0.0002	
<i>CES</i> - <i>D</i> _{<i>t</i>-3}	-0.017	0.018	0.3669		-0.027	0.010	0.0083	
<i>Hypertension</i> _{<i>t</i>-3}	0.237	0.143	0.0989		0.056	0.055	0.3080	
<i>Diabetes</i> _{<i>t</i>-3}	0.156	0.239	0.5127		0.084	0.077	0.2767	
<i>Heart problems</i> _{<i>t</i>-3}	-0.220	0.207	0.2863		-0.032	0.070	0.6446	
<i>Stroke</i> _{<i>t</i>-3}	-0.108	0.302	0.7196		-0.122	0.126	0.3311	
<i>Smokes</i> _{<i>t</i>-3}	-0.381	0.196	0.0515		-0.014	0.081	0.8581	
<i>Married</i> _{<i>t</i>-3}	0.195	0.177	0.2696		0.256	0.069	0.0002	
Specifications 5:								
<i>Cog</i> _{<i>t</i>-5}	-0.014	0.015	0.3270	11290	-0.007	0.006	0.2522	16728
<i>CES</i> - <i>D</i> _{<i>t</i>}	-0.049	0.052	0.3488		-0.036	0.015	0.0195	
<i>CES</i> - <i>D</i> _{<i>t</i>-4}	-0.007	0.027	0.7872		0.005	0.012	0.6784	
<i>Hypertension</i> _{<i>t</i>-4}	-0.157	0.235	0.5042		0.079	0.068	0.2458	
<i>Diabetes</i> _{<i>t</i>-4}	-0.756	0.321	0.0185		0.032	0.090	0.7258	
<i>Heart problems</i> _{<i>t</i>-4}	0.178	0.339	0.5994		0.107	0.089	0.2309	
<i>Stroke</i> _{<i>t</i>-4}	-0.826	0.686	0.2283		-0.167	0.144	0.2485	
<i>Smokes</i> _{<i>t</i>-4}	0.046	0.266	0.8636		0.047	0.099	0.6314	
<i>Married</i> _{<i>t</i>-4}	-0.210	0.327	0.5198		0.223	0.082	0.0064	

Notes: All models are estimated using full information maximum likelihood and with unit fixed effects. Robust standard errors are reported and p-values are for two-tailed tests. All models are adjusted for wave and age. Reference categories: hypertension, diabetes, heart problems, stroke, smoking and married = 0/no. Hypertension, diabetes, heart problems, and stroke are doctor diagnosed conditions reported by the individual.

TABLE S9
Cross-lagged panel models with unit fixed effects and additional time-varying variables

	y = CES-D _t							
	ELSA				HRS			
	β	se	p-value	N	β	se	p-value	N
Specifications 6:								
<i>CES - D_{t-1}</i>	0.141	0.011	0.0000	11145	0.171	0.007	0.0000	16637
<i>Cog_t</i>	-0.022	0.006	0.0000		-0.024	0.003	0.0000	
<i>Hypertension_t</i>	0.082	0.108	0.4476		0.037	0.037	0.3059	
<i>Diabetes_t</i>	-0.293	0.181	0.1063		-0.047	0.054	0.3812	
<i>Heart problems_t</i>	0.441	0.139	0.0015		0.193	0.050	0.0001	
<i>Stroke_t</i>	0.385	0.230	0.0939		0.412	0.069	0.0000	
<i>Smokes_t</i>	-0.128	0.106	0.2254		-0.031	0.053	0.5565	
<i>Married_t</i>	-1.502	0.126	0.0000		-0.788	0.046	0.0000	
Specifications 7:								
<i>CES - D_{t-2}</i>	0.025	0.009	0.0052	11146	0.056	0.006	0.0000	16658
<i>Cog_t</i>	-0.033	0.006	0.0000		-0.027	0.003	0.0000	
<i>Cog_{t-1}</i>	-0.007	0.005	0.1614		-0.005	0.003	0.0586	
<i>Hypertension_{t-1}</i>	-0.054	0.057	0.3415		-0.041	0.028	0.1425	
<i>Diabetes_{t-1}</i>	0.048	0.082	0.5551		0.031	0.038	0.4159	
<i>Heart problems_{t-1}</i>	-0.054	0.073	0.4598		0.048	0.034	0.1646	
<i>Stroke_{t-1}</i>	0.209	0.116	0.0710		0.093	0.052	0.0757	
<i>Smokes_{t-1}</i>	0.103	0.076	0.1766		0.019	0.044	0.6656	
<i>Married_{t-1}</i>	0.461	0.080	0.0000		0.412	0.036	0.0000	
Specifications 8:								
<i>CES - D_{t-3}</i>	-0.006	0.010	0.5428	11146	-0.001	0.006	0.8431	16677
<i>Cog_t</i>	-0.033	0.007	0.0000		-0.027	0.003	0.0000	
<i>Cog_{t-2}</i>	-0.002	0.005	0.7551		-0.004	0.003	0.1459	
<i>Hypertension_{t-2}</i>	0.012	0.064	0.8517		-0.055	0.030	0.0674	
<i>Diabetes_{t-2}</i>	-0.006	0.103	0.9506		-0.026	0.040	0.5067	
<i>Heart problems_{t-2}</i>	-0.046	0.088	0.6025		-0.037	0.037	0.3258	
<i>Stroke_{t-2}</i>	0.057	0.155	0.7156		0.074	0.065	0.2536	
<i>Smokes_{t-2}</i>	0.098	0.095	0.2992		-0.006	0.049	0.8965	
<i>Married_{t-2}</i>	0.387	0.080	0.0000		0.378	0.036	0.0000	
Specifications 9:								
<i>CES - D_{t-4}</i>	-0.021	0.013	0.1055	11240	-0.010	0.007	0.1755	16701
<i>Cog_t</i>	-0.036	0.009	0.0001		-0.026	0.004	0.0000	
<i>Cog_{t-3}</i>	0.005	0.006	0.3843		-0.006	0.003	0.0684	
<i>Hypertension_{t-3}</i>	0.035	0.085	0.6796		-0.046	0.035	0.1859	
<i>Diabetes_{t-3}</i>	0.060	0.144	0.6764		0.052	0.047	0.2737	
<i>Heart problems_{t-3}</i>	-0.157	0.127	0.2192		-0.049	0.046	0.2792	
<i>Stroke_{t-3}</i>	0.151	0.207	0.4666		0.105	0.077	0.1717	
<i>Smokes_{t-3}</i>	-0.209	0.102	0.0411		-0.069	0.054	0.1993	
<i>Married_{t-3}</i>	-0.021	0.119	0.8612		0.253	0.041	0.0000	
Specifications 10:								
<i>CES - D_{t-5}</i>	0.006	0.016	0.7356	11285	-0.014	0.008	0.0931	16727
<i>Cog_t</i>	-0.041	0.017	0.0148		-0.025	0.005	0.0000	
<i>Cog_{t-4}</i>	-0.005	0.008	0.5094		-0.005	0.003	0.1428	
<i>Hypertension_{t-4}</i>	-0.001	0.136	0.9967		-0.024	0.041	0.5595	
<i>Diabetes_{t-4}</i>	-0.082	0.236	0.7298		0.078	0.059	0.1810	
<i>Heart problems_{t-4}</i>	-0.391	0.242	0.1068		0.028	0.055	0.6071	
<i>Stroke_{t-4}</i>	0.251	0.529	0.6350		0.118	0.099	0.2307	
<i>Smokes_{t-4}</i>	0.084	0.160	0.5984		0.023	0.063	0.7158	
<i>Married_{t-4}</i>	0.145	0.176	0.4116		0.132	0.046	0.0045	

Notes: All models are estimated using full information maximum likelihood and with unit fixed effects. Robust standard errors are reported and p-values are for two-tailed tests. All models are adjusted for wave and age. Reference categories: hypertension, diabetes, heart problems, stroke, smoking and married = 0/no. Hypertension, diabetes, heart problems, and stroke are doctor diagnosed conditions reported by the individual.