SUPPLEMENT 1

Further education improves cognitive reserve and triggers improvement in selective cognitive functions in older adults: the Tasmanian Healthy Brain Project

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Detailed description of statistical analyses

Calculating Prior CR

A composite proxy measure of prior CR was calculated for each participant in accordance with previously published methodology [1]. Test scores included in the prior CR proxy measure included: the Wechsler Test of Adult Reading [WTAR; 2] to estimate baseline intellectual capacity; five sub-scores from the Life Experience Questionnaire [LEQ; 3] (Young Adulthood Specific and Non-specific; and the Midlife Specific, Non-specific and Continuing Education Bonus) to quantify previous lifetime experience in education, occupation and leisure activities; and the Medical Health Questionnaire [4] to obtain each individuals total years of prior education. Prior CR was calculated for each participant using factor analysis defined regression coefficients as previously developed [1]. The equation to calculate prior CR = .370 (WTAR estimated full scale IQ) + .408 (Prior education in years) + .567 (LEQ Young Adulthood Specific) + .565 (Young Adulthood Non-specific) + .630 (LEQ Midlife Non-specific) + .875 (LEQ Midlife Continuing Education Bonus) + 1.004 (LEQ Midlife Specific).

Principal Components Analyses

Composite scores were created for each cognitive domain by Principal Components Analysis consistent with an approach utilised in previous work by this group [5; see also Supplement 1]. Briefly, episodic memory comprised Logical Memory test [LMI, LMII; 6], Rey Auditory Verbal Learning Test [RAVLT; 7] and Paired Associates Learning [PAL; 8]. Working memory comprised Digit Span [9], Letter Number Sequencing [9], Spatial Span [SSP; 8], and Spatial Working Memory [SWM; 8]. Executive function comprised Trail Making Test Trail B [TMT B; 10], 24-item Victoria version Stroop Colour-Word Test [Stroop C; 10] and Rapid Visual Processing [RVP A'; 8]. Finally, language processing comprised Vocabulary [9], Comprehension [9] and Boston Naming Test [11]. For each respective test, individual raw scores were standardised to z-scores against the sample mean and standard deviation at baseline assessment. To create the domain composite scores, the z-scores from relevant tests were multiplied by the factor coefficients produced from the principal components analyses (PCA). Thus, cognitive domain composite scores represent decline or improvement over time relative to the sample mean at baseline.

Initially, four separate PCAs were conducted to compute composite scores for each cognitive domain at baseline using SPSS, version 19. Previous studies of the THBP have used similarly constructed composite scores [5].The factorability of items in each cognitive domain was assessed with reference to a number of recognised criteria. Firstly, it was observed that all tests specific to each domain correlated .3 or greater with at least one other test. Secondly, the Kaiser-Meyer-Olkin measure of sampling adequacy was above the recommended value of .60 [12] and in each case Bartlett's test of sphericity was significant. The diagonals of the anti-image correlation matrices (measures of sampling adequacy) were all above the .5 recommended minimum [13]. Based on these indicators, factor analysis was considered to be suitable with all 14 neuropsychological tests.

It was specified in the analysis that one component be extracted for each domain of cognitive function. Given the large sample size, item factor loadings of ≥ .3 could be considered statistically significant [12]. However, only factor loadings of ≥ .4 were considered to have practical interpretability in the present study. The results of the PCA are presented in Supplementary Table 1.

Table S1. *Principal component analysis results for composite cognitive domain scores*

Cognitive domain	Eigenvalue (variance explained)	Test Name	Mean	SD	Loading
Episodic memory	2.51 (62.65%)	LM I immediate recall total	48.31	8.30	.89
N = 497		LM II delayed recall total	30.15	6.41	.87
		RAVLT 1-5 recall total	53.14	8.86	.76
		PAL first trial memory score	18.35	3.35	.61
Working memory	2.01 (50.23%)	Letter number sequencing	11.67	2.39	.80
N = 496		Digit span	18.77	3.91	.76
		SSP span length	5.76	1.20	.65
		SWM between errors	25.63	18.58	-.61
Executive function	1.71 (57.03%)	RVP A’	.91	.05	-.79
N = 495		Stroop C time	25.94	7.53	.75
		TMT B time	59.02	19.67	.73
Language processing	1.81 (60.35%)	Vocabulary	56.90	5.78	.86
N = 498		Comprehension	26.15	3.41	.80
		Boston Naming Test	57.68	2.90	.65

Factor coefficients for each of the test scores were combined into a single factor score using a regression method, yielding a z-score. The equation that resulted in episodic memory score = .356 (LM I) + .346 (LM II) + .305 (RAVLT) + .245 (PAL). The equation that resulted in working memory score = .397 (Letter Number Sequencing) + .376 (Digit Span) +

.325 (SSP) - .306 (SWM). The equation that resulted in executive function score = .439 (Stroop C) + .424 (TMT B) - .460 (RVP A'). Finally, the equation that resulted in language processing score = .360 (Boston Naming Test) + .442 (Comprehension) + .477 (Vocabulary). To calculate domain composite scores for the subsequent time points (T1, T2, T3), baseline (T0) referenced z-scores for the relevant tests were imputed into these formula.

Multiple Group Latent Growth Curve Modelling

Multiple group latent growth curve modelling (LGCM) was conducted using Mplus 7.4 [14] maximum likelihood estimation. Initially, the control group and the intervention group were examined separately to check that both groups had the same basic trajectories (i.e. linear or quadratic). Prior CR was included as a covariate in all models. Subsequently, the approach outlined by Acock [15] was followed. The model was estimated simultaneously for the control and the intervention groups with no constraints on any parameters. This allowed the estimated parameters of the model to be different in terms of: the intercept, the slope term and variances. To then test whether the intercept and slopes were significantly different between the control and intervention groups, two constrained models were estimated. One with the intercept term held equal across groups to test whether the groups had a different intercept. The second model held the linear term equal across groups to test whether the groups had a different slope. A series of chi-square difference tests then revealed if the model which allowed intercept and slope parameters to vary between groups was a significantly better fit compared to the constrained models.

In all models, time was paramatised with time scores that represented years since study entry and the intercept loadings of the four time points were fixed at one. Initially, Mplus default parameters were used which were as follows: the means, variances and covariances of the growth factors were estimated. Incremental model changes such as fixing

growth factor variance to zero were also investigated to find the best fitting model. In each model, the intercept term represented the mean of each respective cognitive domain score, the linear growth term represented the annual rate of change in score, and the quadratic growth term indicated the change in the rate of change (accelerating or decelerating change).

Descriptive data results

Means and standard deviations for cognitive domain scores at each time point as a function of group are presented in Supplementary Table 2. Due to the well documented relationship between education [16] and other aspects of life experience and cognitive function [17] prior CR was included in all models as a covariate.

Table S2. *Sample neuropsychological performance as a function of group*

		Control			Intervention		
		N	M	*(SD)*	*N*	M	*(SD)*
Episodic Memory	T0 -Baseline	100	-.15	1.01	343	.04	1.00
	T1	91	-.07	.95	272	.13	.99
	T2	66	.16	.89	199	.42	.97
	T3	46	.39	.96	102	.79	.90
Working Memory	T0 -Baseline	100	-.13	1.03	342	.03	1.00
	T1	91	-.08	1.01	271	.03	.99
	T2	67	.02	.98	200	.094	.98
	T3	46	-.02	1.15	102	.21	1.05
Executive Function	T0 -Baseline	100	-.03	.61	342	.02	.62
	T1	91	.03	.64	270	-.03	.65
	T2	67	-.12	.62	198	-.10	1.10

	T3	45	-.14	.59	101	.02	.65
Language Processing	T0 -Baseline	100	-.12	1.03	344	.07	.96
	T1	92	-.04	1.02	272	.19	.95
	T2	68	-.08	1.24	201	.35	.83
	T3	46	.02	.90	102	.29	.87

Multiple Group Latent Growth Curve Modelling (LCGM) results

Group specific means for each cognitive domain derived by LCGM are presented in Supplement Table 3.

Table S3. *Estimates (SE) of group specific means for latent variables.*

	Control Model estimates (*SE)* (*N* =100)	Intervention Model estimates (*SE)* (*N* = 344)
Episodic memory		
Intercept	-.191 *(.096)**	-.002 *(.053)*
Linear growth rate	.170 *(.028)***	.217 *(.017)***
Covariates		
Prior CR		
Intercept	.072 *(.039)*	.040 *(.022)*
Linear term	.001 *(.014)*	.013 *(.009)*
Age		
Intercept	-.055 *(.014)***	-.046 *(.008)***
Linear term	-.003 *(.005)*	.000 *(.003)*
Working memory		
Intercept	-.127 *(.099)*	.027 *(.053)*
Linear growth rate	.037 *(.026)*	.045 *(.016)***
Covariates		

Prior CR		
Intercept	.069 *(.042)*	.082 *(.022)***
Linear term	.024 *(.011)**	.000 *(.008)*
Age		
Intercept	-.034 *(.015)**	.048 *(.007)***
Linear term	-.006 *(.004)*	-.002 *(.002)*
Executive function		
Intercept	.000 *(.056)*	.010 *(.032)*
Linear growth rate	-.022 *(.026)*	-.009 *(.018)*
Covariates		
Prior CR		
Intercept	.006 *(.024)*	.040 *(.014)*
Linear term	-.001 *(.012)*	.001 *(.061)*
Age		
Intercept	-.031 *(.009)***	-.026 *(.005)***
Linear term	-.001 *(.005)*	.002 *(.003)*
Language processing		
Intercept	-.087 *(.102)*	.081 *(.049)*
Linear growth rate	-.006 *(.027)*	.077 *(.019 **)*
Covariates		
Prior CR		
Intercept	.176 *(.041)***	.157 *(.021)***
Linear term	-.016 *(.012)*	-.008 *(.009)*
Age		
Intercept	-.018 *(.015)*	.000 *(.007)*
Linear term	-.003 *(.004)*	-.004 *(.003)*

Note: * $p. < .05$, ** $p. < .01$.

Analysis of the influence of Social Networks

Linear models were an excellent fit of the data for both groups (Table S4.1). In both groups, variance was fixed at zero with the linear model then simultaneously fitted to both groups. Examination of the model estimates for both groups (Table S4.2 and Figure S4.1) indicate that for both groups the intercept at bassline was significantly different to 0 and that both groups displayed a non-significant positive linear growth term, with the control group displaying a larger growth term than the intervention group. These results indicate that both groups display a non-significant increase in social networks over the first 4 years of the trial, but this increase is not significant.

Table S4. *LCGM model fit for Lubben Social Network Scale*

	Group		N	Chi square test			RMSEA	SRMR	CFI
				$\chi2$	df	p			
LSNS Scaled	Control	Linear	100	16.603	14	.278	.029	.072	.996
Score	Intervention	Linear	344						

Table S5. *Estimates of group specific means (SE) for Lubben Social Network Scale*

	Control Model estimates (*SE)* (*N* =100)	Intervention Model estimates (*SE)* (*N* = 344)
LSNS Scaled Score		
Intercept	53.21 *(1.27)***	52.73 *(.723)* **
Linear growth rate	.526 *(.377)*	.149 *(.263)*

Note: * *p.* < .05, ** *p.* < .01.

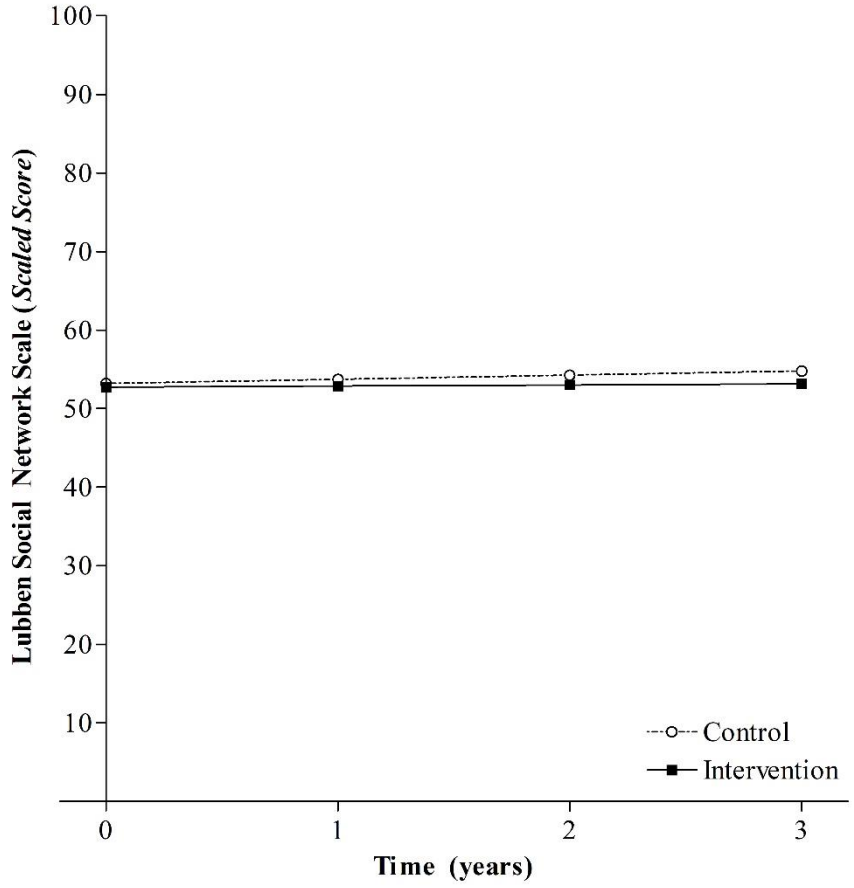

Figure S1. *Model-predicted LSNS trajectories over 4 years for individuals in the control group and the intervention group.*

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