The Relationship of Bilingualism to Cognitive Decline: the Australian Longitudinal Study of Ageing

Short Title: Bilingualism and cognitive decline

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Abstract

Objectives: We wished to clarify the link between bilingualism and cognitive decline, and examine whether improved executive function due to bilingualism may be a factor in preventing cognitive decline.

Methods: We used the Australian Longitudinal Study of Ageing which collected data on 2087 participants aged over 65 over 20 years. We compared baseline demographics, health and social characteristics between bilingual and non-bilingual participants. We used Linear Mixed Models analysis to explore the effect of bilingualism on MMSE score over time and linear regression to explore the effect of bilingualism on baseline MMSE scores, controlling for pre-specified potential confounders.

Results: Bilingual participants had lower baseline MMSE scores than the non-bilingual population (Mean difference = -2.3 points; 95% confidence intervals = 1.56-2.90). This was fully explained by education and National Adult Reading Test scores (17.4; Standard Deviation (SD) =7.7 versus 28.1; SD= 8.2) which also partly explained baseline executive function test scores differences. Bilingual and non-bilingual participants did not differ in MMSE decline over time (-0.33 points, p=0.31) nor on baseline tests of executive function (-0.26, p=0.051).

Conclusions: In this cohort, education rather than bilingualism was a predictor of MMSE score and being bilingual did not protect from cognitive decline. We conclude that bilingualism is complex and when it is not the result of greater educational attainment it does not always protect from cognitive decline. Neuroprotective effects of bilingualism over time may be attributable to the precise patterns of language use but not to bilingualism per se.

Key points

Previous retrospective studies have found that bilingualism delays the onset of dementia symptoms.

A recent meta-analysis of prospective studies based in Northern America found no difference in dementia risk between monolingual and bilingual participants.

We aimed to further clarify the link between bilingualism and cognitive decline by examining a cohort conducted in a different cultural context and including tests of language and executive function. We did not find any evidence that bilingualism protects against cognitive decline nor that it enhances executive function.

INTRODUCTION:

Dementia is a growing health and socio-economic concern worldwide because the ageing population means there are increased numbers of people living with the illness (Prince et al. 2015). There is evidence that it may be possible to delay or prevent some dementias through lifestyle factors. In particular, a high level of education contributes to cognitive reserve, and is thought to confer a degree of resilience such that, despite brain pathology, clinical dementia's onset can be delayed by up to seven years (Valenzuela and Sachdev 2006). While education in general contributes to increasing cognitive reserve it has been hypothesised that learning and using two languages, that is bilingualism, may be a specific mechanism to increase cognitive reserve, so that those who are bilingual had more temporal lobe atrophy for the same level of functional decline and so were compensating better for their neuro-pathological damage (Craik et al. 2010;Gold 2015;Schweizer et al. 2012). Comparison of people who are bilingual and those who are monolingual using brain imaging has found that bilingualism maintains brain white matter integrity which usually declines with age (Luk et al. 2010). It is theorised that these advantages are because people who are bilingual manage competing languages in everyday life and switch between them, enhancing their executive function and protecting against loss of executive function (Bialystok et al. 2004).

Most retrospective studies have found in bilingual people diagnosed with dementia, symptoms of cognitive decline are recorded an average of four years later compared to those who are monolingual (Alladi et al. 2013;Bialystok et al. 2007;Bialystok et al. 2014;Craik et al. 2010). This is consistent with a neuroprotective effect of bilingualism but might also reflect an association with education rather than with bilingualism, or cultural factors leading to later presentation of dementia from minority ethnic populations (Mukadam et al. 2011).

Prospective longitudinal studies can circumvent the effect of cultural differences in reporting cognitive concerns. Some have shown people who are bilingual scoring higher on cognitive tests and being diagnosed with dementia at a later age (Sanders et al. 2012) but others have not (Zahodne et al. 2014). A recent systematic review and meta-analysis found no difference in the risk of developing dementia in prospective studies comparing bilinguals versus monolinguals (Mukadam et al. 2017) All studies included in the meta-analysis were conducted in northern America. Cohort differences may arise because people can be bilingual for a variety of reasons and use their languages in differing ways. For example, some may have learned their first language in their country of origin and then moved so they speak one language at home and another at work. Others may live in societies where most people have at least two languages because of diversity in the population and use both languages in their daily affairs.

Some studies have considered whether other factors, known to be risk factors for dementia, such as age, sex, education and immigration status (Kave et al. 2008;Sanders et al. 2012;Wilson et al. 2015;Zahodne et al. 2014), could account for the differences in rate of cognitive decline, but only a minority have been able to take into account the possible effect of other risk factors, such as vascular pathology (Sanders et al. 2012;Zahodne et al. 2014) and none have had information about other risk factors for dementia , such as a history of depression or reduced social contact and activities (Valenzuela & Sachdev 2006).

AIMS

We aimed to further clarify the link between bilingualism and cognitive decline by examining a cohort conducted in a different cultural context compared to the recent meta-analysis and including tests of language and executive function. The bilingual participants in the cohort were literate, non-native speakers of English who used their native language at home. The monolingual participants used only English at home. We aimed to take into account the possible other causes of cognitive decline which may differ between those who are monolingual and bilingual (demographic characteristics including education; vascular risk factors; depression and social activities); and to consider whether there is a difference in executive function in those who are bilingual and those who are not.

HYPOTHESES

1. Cognitive decline in people who are bilingual will be slower than in those who are not, taking into account possible confounders listed above.

2. Those who are bilingual will perform better on tests of executive function compared to those who are not.

METHODS

Setting: The Australian Longitudinal Study of Ageing (ALSA) is Australia's multi-dimensional population-based study of human ageing (Andrews et al. 1989). ALSA commenced in 1992, recruiting 2087 participants aged 65 years or more who lived in and around Adelaide, South Australia and there have been a further 13 waves of data collection, with the latest in 2014. Our analysis focused on 12 of the 14 waves of data collection as these were the ones available when we began the study.

Measures: The baseline questionnaire (http://www.flinders.edu.au/sabs/fcas/alsa/) collected information about demographic characteristics, language use, physical health, depressive symptomatology and included comprehensive cognitive testing using the Mini-Mental State Examination (MMSE) (Folstein et al. 1975). Participants also completed the National Adult Reading Test (NART) at baseline as a measure of pre-morbid educational achievement (Nelson H. and Willison J. 1991).There were three language and executive function tests used in this cohort: the Boston naming test (Kaplan et al. 2001), describing similarities and differences between items, and tests of verbal fluency (Bryan and Luszcz 1997). Further cognitive testing was also carried out in Waves 3, 6, 7, 9, 11 and 12 at 2, 7, 10, 15, 17 and 20 years post-baseline respectively

Language: Participants were asked if they spoke another language at home other than English, whether they needed an interpreter and whether they felt comfortable conversing in English. Information about when a language was acquired was not obtained. Subjective reports correlate with objective measures of language proficiency and are a valid measure (Gollan et al. 2011). Most of the questionnaire was self-administered in English without an interpreter, so those completing the questionnaire needed a good command of English. We classed those who said they spoke another language at home other than English as bilingual with the reasonable assurance in the present cohort that their other language was their native tongue. Those who answered no to this question were defined as non-bilingual for this study.

Other questions asked included:

Demographics: Age, sex, years of education, birth place and occupational history.

Social networks: Whether people lived alone or not, marital status, regular social activities and networks.

Physical health: Questions on a wide range of physical illnesses, smoking status, alcohol consumption and whether participants exercised regularly.

Mental health: Previous history of mental illness or "nervous breakdown" and scores on the Centre for Epidemiologic Studies Depression Scale (CES-D).

Analysis: We used SPSS version 20.0 (IBM Corporation, released 2011) for all analyses. We summarised descriptive statistics for demographic characteristics, depressive symptoms, vascular health, bilingual or monolingual status, social activity and cognitive state. We contrasted scores for those defined as bilingual and those who were not using t-tests to compare numerical variables and chi-squared tests for categorical variables.

As the data involved repeated measures at different time points, we used mixed models analysis with MMSE score as our primary outcome measure. The primary model included time and bilingualism as fixed factors with baseline MMSE as a covariate and a random effect for participant. The residuals from the mixed model were not normally distributed, but given the large sample size, we can draw valid inference regarding the effect estimates (Jacqmin-Gadda et al. 2007). We have assumed that the treatment effect is constant across waves.

As there were three tests of language and executive function (verbal fluency, describing similarities and the Boston naming test) we calculated z-scores for each of these tests and combined them to obtain a composite z-score for language and executive function.

To further clarify the link between bilingualism and cognitive status, we carried out a cross-sectional stepwise forward linear regression using the data from baseline (Wave 1) as this had the highest numbers of participants and the most power. The dependent variable was mean MMSE in Wave 1 and independent variables were any variables that were significantly different between the two language groups and may affect cognitive decline in the observed direction. We checked for correlation between MMSE and education-related variables to rule out collinearity which may have affected statistical analyses. Several social contact variables were highly correlated (e.g. contact with children and grandchildren), so to maintain power, we entered only one into the regression model, choosing the one with most real-world applicability.

RESULTS

Table 1 compares baseline demographic characteristics for people who were bilingual with the remainder of the population. At baseline the mean age of the whole sample was 78.2 years (standard deviation (SD) =6.7). The sample was roughly evenly split between men and women. Most people had left school before the age of 18 years, were married and living in the community with others. The bilingual population was younger (mean difference = -2.2 years, $p<0.0001$), more commonly married ($p=0.028$) and living in the community with others ($p=0.002$). They were also less educated ($p<0.0001$), less commonly had worked previously ($p=0.019$) and more frequently born outside Australia ($p<0.0001$). This latter group primarily came from Italy, Poland, Hungary, Germany and other European countries.[place Table 1 here]

Table 2 shows health and social characteristics in the bilingual and non-bilingual populations. Bilingual participants scored lower on the NART, had fewer medical conditions but more frequently had diabetes and less commonly had had a transient ischaemic attack. They smoked more often, less commonly exercise and had less social contact with their immediate families. [Place Table 2 here]

The numbers of participants in each wave were: Wave 1=2087, 2=1779, 3=1679, 4=1504, 5=1171, 6=791, 7=487, 8=349, 9=213, 11=168, 12=111. Between nine and 10 percent of participants in each wave were bilingual. This is shown in Table 3, along with numbers lost to follow-up. In the mixed models analysis, taking into account wave of data collection (time) and baseline MMSE, there was no effect of bilingualism status on MMSE decline (Mean difference -0.33, p=0.305, shown in Table 4). The estimate for time, comparing Wave 12 to baseline cognition is -1.25 (95% CI -1.87 to -0.62). [Place Tables 3 and 4 here]

We found Spearman's rho correlation between MMSE and age of leaving school was 0.161 ($p<0.0001$) and between tertiary education and MMSE was 0.131 ($p<0.0001$). In unadjusted linear regression, the mean MMSE in bilingual participants was estimated to be 2.23 points lower (95% CI 1.56-2.90) at baseline than non-bilingual participants (p-value of <0.0001). The adjusted linear regression model, including all relevant predictor variables is shown in Table 5. Addition of the NART and tertiary education to the linear regression model modified the relationship of bilingualism to MMSE, so there was no significant difference between the estimated baseline MMSE of those who were bilingual and those who were not (-0.96 points; 95% CI -1.97, 0.06; p=0.064). Only the NART and tertiary education improved the fit of the data to the model and no other variables were significantly associated with MMSE. A one point increase on the NART is estimated to increase MMSE score by 0.13 points (95% CI 0.11-0.16) and this effect is highly significant (p<0.0001). Overall the difference in cognition between bilingual and non-bilingual participants is explained by differences in baseline education and NART.[place table 5 here]

Regression analysis with language and executive function test scores for baseline (Wave 1) as the dependent variable showed that NART was the only significant predictor of scores in this model and the effect of bilingualism reduced from -0.93 (p<0.0001) to -0.26 (p=0.051) on addition of other variables. These results are presented in Table 6. [place Table 6 here]. Raw scores on language and executive functions tests are in Appendix Table 3. Appendix table 4 shows the composite z scores of the language and executive function tests in bilingual and non-bilingual participants and t-test results. Bilingual participants had lower language and executive function test scores compared to the rest of the population at most waves although numbers of bilingual participants completing this testing in later waves was very low.

Those with lower baseline MMSE scores had less data in further waves of cognitive testing. Logistic regression using missing-ness in Wave 3 (the second wave for cognitive data collection) as the dependent variable, showed that a lower MMSE was significantly associated with missing MMSE scores in Wave 3 (p<0.0001).

In a post-hoc sensitivity analysis to see if migrant status could explain the lack of protection of bilingualism, we used t-tests to analyse the effect of migrant status, on MMSE as a function of bilingual status (bilingual or non-bilingual). Bilingual migrant participants had significantly lower MMSE scores in waves 1, 3 and 6 compared to non-bilingual migrant participants as shown in Appendix Table 5 (e.g. mean difference in Wave 1 = -2.22; 95% CI -3.09, -1.35; p<0.0001). There were less than seven bilingual non-migrant participants in each wave and their test scores were the same as non-bilingual non-migrant participants in all waves. We also examined the effect of education by analysing those with tertiary education separately to those without and found no significant differences in MMSE between bilingual and non-bilingual migrant participants who had completed tertiary education. By contrast, MMSE scores in bilingual migrant participants without tertiary education were significantly lower compared to non-bilingual migrants without tertiary education.

DISCUSSION

In this cohort of those who were bilingual and spoke a language at home different to the language of the country in which they live, cognitive decline did not differ between bilingual and non-bilingual participants. Bilingualism neither protected from nor exacerbated decline. By contrast, more education in terms of time in formal education was protective and no other factor proved significant when it was taken into account, apart from the NART. The bilingual participants also had lower language and executive function scores which was explained by the NART. While the NART is strongly predicted by years of education, reading levels are also related to quality of education (Manly et al. 2002). Thus our findings show that cognitive scores are related to ethnicity and accounted for by quantity and quality of education.

This is the first time that bilingualism has been examined in a longitudinal cohort, with detailed data on physical and mental health as well as important demographic factors and executive function tests At baseline, bilingual participants had lower

MMSE scores than non-bilingual participants, possibly due to lower educational attainment but this difference was lost over time in the follow up population as those with lower MMSEs less commonly completed further cognitive testing.

The results may seem at odds with some of the published literature but research in this field is challenging because of the many potential confounding variables associated with bilingualism (Bak 2016). Prospective studies permit mitigation of some confounding variables. Three other prospective studies also report no differences in cognitive decline between bilingual and non-bilingual participants (Lawton et al. 2015;Yeung et al. 2014;Zahodne et al. 2014) and these were all in populations where bilingualism may be acquired due to immigration to a predominantly English-speaking country, like our sample.

The ALSA population of immigrants who are bilingual and who do not speak English (the language of testing) at home, contrasts with studies where people are tested in their first language and bilingualism is due to better education rather than change of country. Wilson et al. (2015) found that more years of language instruction, before the age of 18 years, reduced the risk of developing Mild Cognitive Impairment. However, those who receive more language instruction may have had more education and it is unclear whether being bilingual is a specific protection. This is also the case in another study where cognitive decline was delayed in those who spoke English better than their native Spanish, which might again be due to a higher level of educational attainment (Gollan et al. 2011). It may be that educational attainment also accounts for the positive effects of bilingualism found in an Edinburgh cohort (Bak et al. 2014) but as the authors do not comment on baseline differences in education or control for education in their analysis, it is difficult to interpret their findings.

We found no significant effect in the mixed models indicating that had bilingualism had no effect, so did not adjust for age to find if this weakened the effect. Age was not included in the regression analysis because, it could not account for observed correlations

Other studies finding cognitive advantages in speaking additional languages were conducted in multilingual societies in which all participants were at least bilingual (Kave et al. 2008;Perquin et al. 2013). Participants differ as they are immersed in a multilingual society, obtain extensive practice in speaking additional languages and switch between different languages several times a day. Language use in such circumstances may enhance executive functioning (Green and Abutalebi 2013) in a way that knowing another language and using it in just one environment (e.g., the home or work) may not. In such circumstances, speakers may not know words for certain concepts in their other language and language switching will be rare.

Strengths and limitations

The strengths of this study are the relatively long follow-up in a large sample, with detailed demographic, physical health, mental health and social activity information and cognitive testing using a standard measure of global cognition as well as language and executive function tests. It is also the first study of its type with an Australian cohort. Previous cohorts have mostly been in North America, Europe and Israel.

The limitations of our study are that there was significant attrition in the sample over time and that there was a larger loss to follow up in those with lower MMSE. However, the use of mixed models which includes all data strengthens the validity of our conclusions. In addition, the native language proficiency of our bilingual participants may have declined over time. We may also have missed participants who speak a language other than English outside of their homes though in the predominantly monoglot context of the cohort that number may be small.

The MMSE is partly a language based instrument so people with less fluent English and less education do worse without having declined cognitively. Thus our data using the NART and showing it accounts for the lower baseline is a strength, as the effect of education on NART scores is the same regardless of ethnicity or first language (Cosentino et al. 2007). We also did not find a large association between MMSE and measures of education. We acknowledge that the language and executive function tests in this cohort are weighted towards language and therefore could be affected by lack of familiarity with English. In this cohort, those who were able to answer the study's lengthy and detailed questionnaire in English, had to have a reasonable level of written English but may still have been disadvantaged by less fluent spoken English.

Another limitation is the lack of data on dementia diagnosis which would have enhanced the clinical relevance of this analysis.

We would conclude from the results of our analysis that bilingualism is complex and that simply speaking two languages does not protect from cognitive decline or enhance executive function. The precise pattern of language use in bilingual speakers may be critical and certainly such information is necessary to more fully disentangle the longer-term neuroprotective effect of bilingualism from other factors such as educational attainment.

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Authorship: Naaheed Mukadam conceptualized the study, obtained the data, drafted and revised the manuscript and carried out statistical analyses as planned by the statistician. Fatima Jichi supervised and interpreted the statistical analyses and revised the methods and results sections of the manuscript. David Green conceptualized the study and revised the manuscript. Gill Livingston conceptualized the study and revised the manuscript.

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Table 1: Baseline demographic characteristics of bilinguals and non-bilinguals (N = number of participants, *nb=numbers missing in non-bilingual group and b=numbers missing in bilingual group), § **=** t-test for linear and X^2 for categorical data

		Non-bilinguals N=1894	**Bilinguals N=193**	
Characteristic (number missing)	**Sub-group**	**N(%) or mean(s.d.)**	**N(%) or mean(s.d.)**	**Statistical significance§**
Age		78.4(6.7)	76.2(6.7)	p<0.0001
Sex	Male	948(50.1)	108(56.0)	p=0.118
	Female	946(49.9)	85(44.0)	
Marital status (nb*=1)	Married/ de facto	1219(64.6)	145(75.1)	p=0.028
	Separated/Divorced	44(2.3)	5(2.6)	
	Widowed	552(29.2)	42(21.8)	
	Never married	75(4.0)	1(0.5)	
Housing	Institution	124(6.5)	2(1.0)	p=0.002
	Community (alone)	492(26.0)	33(17.1)	
	Community (with others)	1278(67.5)	158(81.9)	
Annual income (nb=146, b=11)	<$AUD 12,000	627(35.9)	59(32.4)	p=0.104
	$12,000-50,000	1096(62.7)	123(67.6)	
	>$AUD 50,000	25(1.4)	0(0)	
Age left school (nb=26)	No schooling	21(1.1)	9(4.7)	p<0.0001
	<14	255(13.7)	51(26.4)	
	14-17	1514(81.0)	98(50.8)	
	18+	78(4.2)	35(18.1)	
Tertiary education (nb=20)	Yes	631(33.7)	69(35.8)	p=0.561
Years in Australia		40.8(19.3)	41.3(10.5)	p=0.723
Currently working (nb=18)	Yes	28(1.5)	3(1.6)	p=0.936
	No	1848(98.5)	190(98.4)	
Previously working (nb=47, b=3)	Yes	1734(93.9)	170(89.5)	p=0.019
	No	113(6.1)	20(10.5)	
Australian born	Yes	1417(74.8)	7(3.6)	p<0.0001
	No	477(25.2)	186(96.4)	

Table 2: Baseline health and social characteristics of bilinguals and non-bilinguals (*nb=numbers missing in non-bilingual group and b=numbers missing in bilingual group), § **=** t-test for linear and X^2 for categorical data

		Non-bilinguals N=1894	**Bilinguals N=193**	**Statistical significance§**
Characteristic (number missing)	**Sub-group**	**N(%) or mean(s.d.)**	**N(%) or mean(s.d.)**	
Number of medical conditions		5.4(3.0)	4.5(2.7)	p<0.0001
Diagnosed medical conditions	**Heart attack**	241(12.7)	22(11.4)	p=0.597
	Heart condition	359(19.0)	37(19.2)	p=0.942
	Hypertension	614(32.4)	52(26.9)	p=0.12
	Diabetes	156(8.3)	26(13.5)	p=0.015
	Transient Ischaemic Attack	175(9.2)	9(4.7)	p=0.033
	Stroke	67(3.5)	10(5.2)	p=0.248
	Other vascular disease	78(4.1)	4(2.1)	p=0.16
	Mental disorder	11(0.6)	0(0)	p=0.288
	Nervous breakdown	95(5.0)	7(3.6)	p=0.394
CES-D score		8.1(7.3)	9.3(8.5)	p=0.54
NART score(nb*=697, b=126)		28.1(8.2)	17.4(7.7)	p<0.0001
Smoking(nb=19)	**Yes (cigarettes)**	151(8.1)	25(13.0)	p=0.02
	Yes (pipe/cigar)	40 (2.1)	8 (4.1)	p=0.67
Alcohol (nb=20)	**Never**	696(37.1)	78(40.4)	p=0.65
	Less than monthly	340(18.1)	28(14.5)	
	2-4 times/month	153(8.2)	14(7.3)	
	2-3 times/week	191(10.2)	23(11.9)	
	Four or more times/week	494(26.4)	50(25.9)	
Exercise in past 2 weeks (nb=23)	**Vigorous exercise**	82(4.4)	3(1.6)	p=0.06
	Less vigorous exercise	364(19.5)	25(13.0)	p=0.028
	Exertion around the house	270(14.4)	20(10.4)	p=0.121
	None of the above	1155(61.7)	145(75.1)	
Contact with children*(nb=241,b=20)	**None**	46(2.8)	1.51(3.5)	p<0.0001

MMSE = Mini Mental State Examination, CES-D = Centre for Epidemiologic Studies Depression Scale, NART = National Adult Reading Test, sd=standard deviation

Table 3: Participant numbers and follow-up

*deceased since previous wave **includes participants who may not have completed previous waves

Timeline (Years post-baseline)	Participants (number of bilingual participants)	
Baseline	2087 (186)	
		Lost to follow up = 408 (210 deceased*)
Wave 2 (2 years)	1679 (84)	
		Lost to follow up = 888 (716 deceased)
Wave 6 (7 years)	791 (48)	
		Lost to follow up = 305 (292 deceased)
Wave 7 (10 years)	487 (129)	
		Lost to follow up = 274** (280 deceased)
Wave 9 (15 years)	213 (12)	
		Lost to follow up = 45 (165 deceased)
Wave 11 (17 years)	168 (13)	
		Lost to follow up = 57 (93 deceased)
Wave 12 (20 years)	111 (9)	

	Non-bilinguals		Bilinguals		Group effect (95% C.I.)	p value
Wave	Number	Mean MMSE (s.d.)	Number	Mean MMSE (s.d.)	-0.33 (-0.96, 0.30)	0.305
1	1864	26.0(4.3)	186	23.8(6.0)		
3	1076	27.0(2.6)	84	26.4(2.5)		
6	607	27.5(3.1)	48	25.0(4.2)		
7	380	26.1(3.5)	29	24.9(3.6)		
9	179	26.2(3.1)	12	25.3(2.5)		
11	139	27.0(3.1)	13	25.5(2.2)		
12	81	26.4(4.3)	9	25.4(5.5)		

Table 4: MMSE scores over time in bilinguals and non-bilinguals with overall group effect

MMSE = Mini Mental State Examination

CI= confidence intervals

sd=standard deviation

Variable	Mean difference	95% confidence interval		p-value
		Lower	Upper	
Other language	-0.957	-1.970	0.055	0.064
Tertiary education	0.790	0.342	1.238	0.001
NART score Wave 1	0.129	0.102	0.156	<0.0001
Diabetes	0.341	-0.390	1.072	0.361
Contact with children	0.046	-0.097	0.189	0.531
Were you born in Australia?	-0.280	-0.756	0.195	0.247
Smoker	-0.055	-0.894	0.784	0.898
Previously working	-0.368	-1.272	0.535	0.424
Age left school	-0.134	-0.300	0.031	0.110

Table 5: Linear regression model at baseline (Wave 1) with MMSE as outcome variable

NART – National Adult Reading Test

		95% confidence interval		
	Mean difference	**Lower**	**Upper**	**P value**
Other language	-0.26	-0.001	0.553	0.051
Age left school	0.03	-0.007	0.074	0.102
NART Correct: Wave 1	0.05	0.047	0.060	<0.0001
Smoker	-0.18	-0.034	0.393	0.100
Were you born in Australia?	0.06	-0.061	0.178	0.336
Diabetes	-0.03	-0.209	0.156	0.778
Contact with children	0.004	-0.032	0.040	0.813
Previously working	0.03	-0.261	0.198	0.786

Table 6: Regression of frontal lobe tests wave 1

NART – National Adult Reading Test