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# The Relationship of Bilingualism Compared to Monolingualism to the Risk of Cognitive Decline or Dementia: A Systematic Review and Meta-Analysis

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**Abstract**.
**Background:** Bilingualism may contribute to cognitive reserve, protect against cognitive decline, and delay the onset of dementia.
**Objective:** We systematically reviewed evidence about the effect of bilingualism on subsequent cognitive decline or dementia.
**Methods:** We searched electronic databases and references for longitudinal studies comparing cognitive decline in people who were bilingual with those who were monolingual and evaluated study quality. We conducted meta-analyses using random effects models to calculate pooled odds ratio of incident dementia.
**Results:** We included 13/1,156 eligible articles. Meta-analysis of prospective studies of the effects of bilingualism on future dementia gave a combined Odds Ratio of dementia of 0.96 (95% CI 0.74–1.23) in bilingual participants ($n = 5,527$) compared to monolinguals. Most retrospective studies found that bilingual people were reported to develop symptoms of cognitive decline at a later age than monolingual participants.
**Conclusion:** We did not find that bilingualism protects from cognitive decline or dementia from prospective studies. Retrospective studies are more prone to confounding by education, or cultural differences in presentation to dementia services and are therefore not suited to establishing causative links between risk factors and outcomes.

Keywords: Bilingualism, cognitive decline, dementia, prospective cohort studies



## INTRODUCTION

As the number of people with dementia continues to rise worldwide, with the accompanying social and healthcare burden [1], there is growing interest in factors that may delay or prevent the onset of cognitive decline and dementia [2]. It is recommended that people should learn multiple languages to delay the onset of dementia [3].

Cognitive reserve, defined as resilience to neuropathological damage [4], has been shown to delay dementia onset, possibly by enhancing neural networks [5] or improving specific cognitive strategies [6]. Being fluent in two or more languages may contribute to cognitive reserve [7], and this may be a specific effect, rather than the general effect of more education, because switching languages possibly leads to an enhanced executive function rather than enhancing medial temporal memory circuitry [8]. Bilingualism, however, is complex and heterogeneous and is linked to factors, such as education, that can also affect risk of dementia [9].

Retrospective studies have found that bilingualism delays the onset of dementia by around four years [7, 10, 11]. Some prospective studies have similarly found a protective effect of learning additional

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languages [12–14], while others have not [15–17]. We therefore systematically reviewed the literature in this field to clarify the link between bilingualism and cognitive decline or dementia.

## METHODS

### *Search strategy*

We searched PubMed (from 1946) and Web of Knowledge (from 1900) until 23 November 2016, using search terms "bilingual*" OR "language" AND "dementia", "AD", "Alzheimer*" OR "cognit*". We placed no limits on language or date of publication. We combined the search results and removed duplicates. We searched the references of included papers for further papers of interest.

### *Inclusion criteria*

We included primary research published in peer-reviewed publications in any language which fulfilled the following three criteria:

- included people who spoke more than one language and a comparison group who did not.
- reported on cognitive function in participants not diagnosed with pre-existing neurological disorders.
- reported either a quantitative cognitive outcome measure on a validated cognitive test or incident dementia or incident mild cognitive impairment.

### *Exclusion criteria*

- Meeting abstracts and letters.
- Comparisons between multilinguals and bilinguals with no monolingual group.

### *Searches and inclusion of papers*

One of the authors (NM) conducted the searches and read all titles and abstracts. She read papers of studies with abstracts or titles that met inclusion criteria in full to decide whether they met inclusion criteria and discussed those which there were any questions about with the other authors.

### *Quality assessment*

Two of the authors (NM and AS) independently read included papers and assessed their quality using an eight-point checklist from the Newcastle-Ottawa scale for non-randomized studies [18] (see Supplementary Table 1). The questions were: Was the cohort representative of a defined population? Was the exposure (language status) accurately defined and measured? Was outcome clearly defined and measured? Have the authors adjusted for all important confounding factors? Was follow-up complete (>70%) (including death as follow-up)? Was follow-up long enough (>5 years)?

We pre-specified that we would categorize as higher quality studies those with a definition of or assessment of bilingualism, with reliable and valid cognitive outcome measures and adjusted for important confounders known to be associated with cognitive outcomes such as age, sex, education, vascular risk factors, and other potential confounders such as immigration and socio-economic status. This was to ensure that higher quality studies had valid measures of the exposure and outcome and the findings could not be accounted for by known confounders. We contacted authors for further information regarding their studies if this was not clear, in order to be able to assess quality accurately.

### *Analysis*

If studies had multiple waves of data collection, we examined data from after the five-year follow-up. We planned to combine data from three or more studies where possible using a meta-analysis. We extracted raw data of numbers of people diagnosed with dementia in the respective bilingual and non-bilingual groups and combined unadjusted odds ratios from included studies, to calculate an overall unadjusted risk of developing dementia in bilinguals versus non-bilinguals using random effects models meta-analyses [19] with RevMan version 5.3 software. This approach is suitable for combining studies from heterogeneous populations and when different binary outcome measures are reported as it accounts for between-study variance [20].

## RESULTS

The PRISMA diagram in Fig. 1 shows our search strategy results. We included 13 of 1,154 articles, reporting 13 separate studies fulfilling our criteria. Four studies were excluded after the full paper was retrieved—one because there was no record of whether or not participants spoke more than one

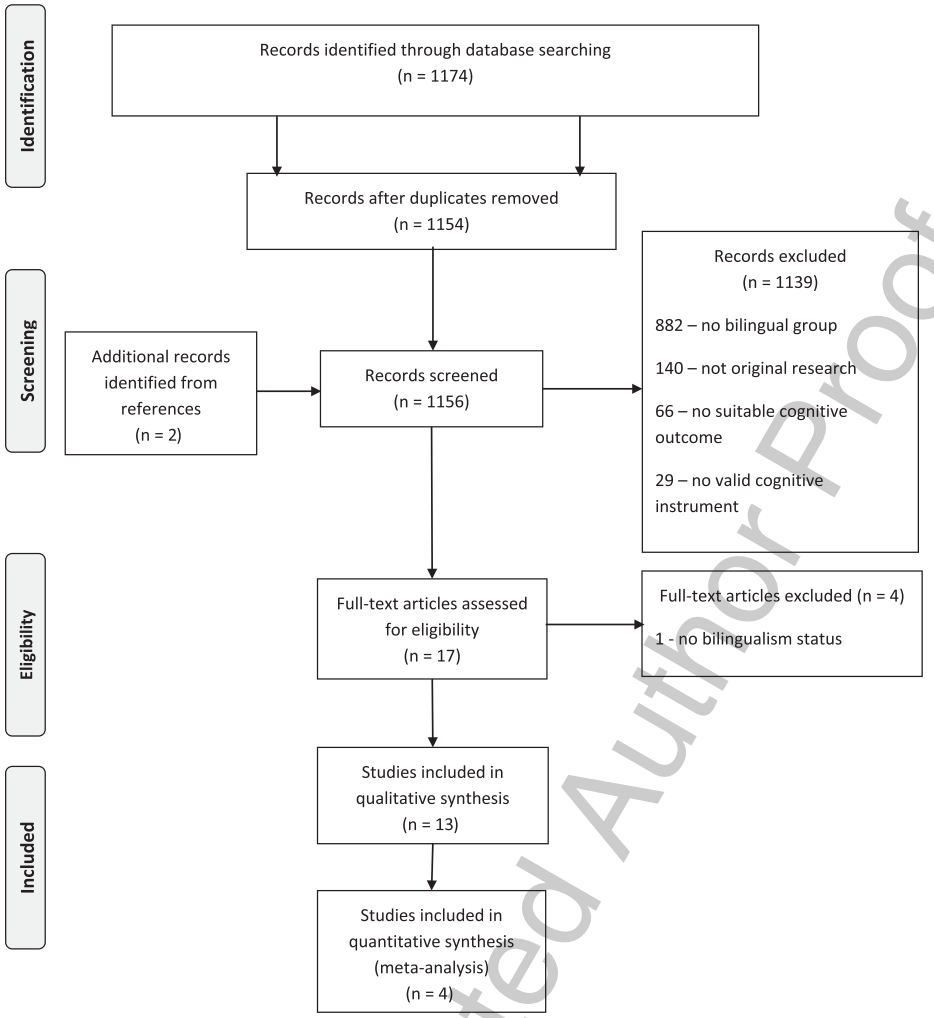


Fig. 1. PRISMA diagram showing search results and included studies.

language, [14], another because it did not include a monolingual comparator group [21]. and two because they compared bilingual participants with multilingual rather than monolingual participants [12, 13]. Of the included studies, five were prospective and reported in Table 1 and eight were retrospective or cross-sectional and are reported in Table 2. We contacted and obtained additional information on follow-up rates and outcomes from authors of two included papers. Quality scores for each item in all studies are given in Supplementary Table 2.

*Prospective studies (see Table 1)*

The prospective studies all recruited a random sample of community-dwelling participants without baseline cognitive impairment [15–17, 22, 23]. Bilingualism was defined as the self-reported ability to communicate in two languages. One study validated reports of bilingualism with a reading test [17] but used self-defined proficiency in primary analyses. The outcome, measured at least five years later, was either cognitive testing or formal diagnostic assessments. One study interviewed people in English and defined them as native English speakers or non-native English speakers with the latter group being asked if they spoke another language and how often they spoke it [23]. This study may therefore have included some bilingual native English speakers in the 'monolingual' group.

Four higher quality studies used dementia diagnosis as the outcome [15–17, 23]. All of these studies made the diagnosis by using cognitive screening tests then further cognitive assessment if scores

Table 1
Prospective studies

| Study | Quality score | Participants and Setting; Country | N | Number of years follow-up | Follow-up rate (%) | Definition of bilingualism; comparator groups | Procedure | Baseline differences | What controlled for | Outcome |
|---|---|---|---|---|---|---|---|---|---|---|
| Bak et al. [22] | 5 | Healthy general population of people aged 11 years in 1947 – from Scottish Mental Survey; Scotland | 853 | 50 | 78.1 | Bilingualism self-defined as learning another language well enough to communicate in it; monolingual | Childhood intelligence at age 11 then cognitive tests 50 years later | Not stated | Childhood intelligence, age, sex, participant and father's social class | Passive/active bilingualism ↑ scores on g-factor (estimate 0.23/0.29, $p = 0.01/0.03$) |
| Lawton et al. [15] | 5 | Community dwelling Hispanic people identified from census; USA | 1789 | 10 | 99.3 | Bilingualism self-defined as speaking more than one language at least "very often"; monolingual | Cognitive screen. If scores low further neuropsychology testing and specialist adjudication | Bilingual participants had significantly more years of education | Immigrant status | Mean age of dementia diagnosis of bilingual participants (79.31 years) not significantly different from monolingual participants (81.10), $F(1, 77) = 1.27$, $p = 0.26$ |
| Sanders et al. [23] | 7 | Community based longitudinal study of aging. Medicare recipients or registered voters sampled; USA | 1779 | 7 | 91.6 | Non-native English speakers (NNES) (bilingual); native monolingual English speakers (NES) | Neuro-psychological assessment at baseline; then annually. Dementia diagnosis by specialist consensus | NNES older, more likely to be white, married and immigrant, less educated, less hypertension than NES | Sex, race, years of education, immigration marital status, self-reported hypertension, diabetes, myocardial infarction, and stroke | No association between NNES status and incident dementia (HR 1.26, 95% CI 0.76–2.09; $p = 0.36$) |
| Yeung et al. [16] | 5 | Longitudinal study of Community dwelling elders, randomly selected from health care register; Canada | 1468 | 5 | 67.4 | Self-described: Monolinguals (56%) versus English as second language (38%) versus English bilinguals (5%) | Cognitive screening. Specialist examination & diagnosis if scored below cut off | No significant differences in age or education across all groups. | Age, sex, education, subjective memory loss at baseline | No association between language status and dementia: Adjusted OR 0.99 (95% CI 0.61, 1.59) in bilinguals versus monolinguals |
| Zahodne et al. [17] | 7 | Longitudinal aging study, from Medicare registry. No baseline cognitive impairment; USA | 1067 | 23 | 80.8 | All Spanish speakers. Bilinguals reported speaking English 'well' or 'very well'. Subgroup validated with reading test | Cognitive tests administered at each visit. Diagnosis by specialist consensus | Bilinguals younger, more education, more females, younger age of immigration | Age, sex, education, proportion of life spent in the U.S., country of origin, and recruitment wave | No difference in adjusted rate of dementia conversion in Cox regression: HR = 1.18 (95% CI: 0.96 – 1.46) |

Table 2
Retrospective studies. MMSE, Mini-Mental State Examination; MCI, mild cognitive impairment

| Study | Quality score | Setting and participants; Country | N | Definition of bilingualism; comparator group | Procedure | Baseline differences | What controlled for | Outcome |
|---|---|---|---|---|---|---|---|---|
| Alladi et al. [10] | 3 | People in memory clinic diagnosed with dementia; India | 648 | Self-defined ability to communicate in more than one language; monolinguals | Family members of people with dementia asked when first symptoms noticed | Bilinguals more likely to be male, have received more education, be urban dwellers | Literacy, years of education, sex, family history, vascular risk | Bilinguals onset of symptoms 4.5 years later than monolinguals unadjusted $p < 0.0001$ Adjusted analyses $F_{1458} = 4.89$, $p = 0.027$ |
| Bialystok et al. [11] | 2 | People in memory clinic diagnosed with dementia; Canada | 184 | Most of adult life using two languages, judged by specialists based on notes; monolinguals | People with dementia and their family members asked when first symptoms noticed | Bilinguals older, less educated, lower MMSE, lower occupation, more likely to be immigrants | Age, education and occupation | Bilinguals onset of symptoms 4 years later than monolinguals, $p < 0.003$, No difference in rate of cognitive decline. |
| Bialystok et al. [27] | 3 | People in memory clinic diagnosed with dementia or MCI & no other neurological condition; Canada | 149 | Majority of adult life using two languages, judged by specialists; monolinguals | Patients and family members of people asked when first symptoms noticed | Bilinguals significantly less educated, more likely to be migrants, less likely to smoke and drink alcohol | Education and immigration | Bilinguals onset of MCI symptoms 4.7 years than monolinguals and 7.2 years later Alzheimer's dementia $F_{1,145} = 10.75$, $p = 0.001$ |
| Chertkow et al. [29] | 4 | Memory clinic patients diagnosed with dementia; Canada | 632 | Most of adult life using two or more languages; monolinguals | Clinician consensus about age at dementia diagnosis. | No between group differences in age, years of education or initial MMSE | Sex, education, and immigrant status | No significant difference between bilingual and monolinguals' age of diagnosis or MMSE scores |
| Clare et al. [26] | 3 | Memory clinic patients or on register diagnosed with dementia and MMSE score >18/30; Wales | 86 | Self-defined, speaking >1 language for most of life. Also objective measure of proficiency; monolinguals | Age at time of diagnosis from clinical records. | Bilinguals less highly qualified though years education not significantly different | Education | No significant difference in age of diagnosis $F(1,79) = 2.97$, $p = 0.089$) or executive function scores |

(*Continued*)

Table 2
(*Continued*)

| Study | Quality score | Setting and participants; Country | N | Definition of bilingualism; comparator group | Procedure | Baseline differences | What controlled for | Outcome |
|---|---|---|---|---|---|---|---|---|
| Craik et al. [7] | 2 | People in memory clinic diagnosed with dementia; Canada | 211 | Majority of adult life using two languages, judged by specialists based on notes; monolinguals | Patients and family members of people asked when first symptoms noticed | Bilinguals older, less educated, more immigrants, lower employment status | Sex | Bilinguals onset of symptoms 5.1 years than monolinguals. Two way ANOVA ($F(1205) = 16.25$, $p < 0.0001$) with bilingualism and sex |
| Ossher et al. [25] | 2 | People referred by physician or advert responders with subjective memory complaints and at least MCI on testing; Canada | 111 | Majority of adult life using two languages, judged by specialists based on info in notes; monolinguals | Screened by memory tests. Those with objective memory impairment had more f cognitive tests for MCI subtype | No significant differences in education or gender. No information on employment status | Nil | Bilinguals onset of amnestic MCI 4.5 years later than monolinguals ($t(66) = 2.46$, $p < 0.02$). No difference in multiple domain MCI or in duration of symptoms based on informant report |
| Woumans et al. [28] | 2 | Memory clinic patients with dementia diagnosis; Belgium | 134 | Self-defined at least "good" on second language and speaking it $\geq$ once a week; monolinguals | Family members of people diagnosed with dementia asked when first symptoms noticed | No statistics given but bilinguals more educated | Sex, occupation and education | Age of onset of symptoms 4.6 years later in bilinguals ($F(1109) = 7.05$, $p = 0.009$) |

were low. One of these studies calculated an odds ratio for developing dementia, adjusted for age, sex, education, and subjective memory loss [16]. The others compared mean age of dementia diagnosis [15], hazard ratio for incident dementia [23], and Cox regression on rate of dementia conversion [17], respectively. None of these studies found significant differences between bilingual and monolingual participants.

These outcomes were too heterogeneous to be combined in a meta-analysis but all the papers contained raw data of numbers of people diagnosed with dementia in the respective bilingual and non-bilingual groups. We extracted this data and conducted a meta-analysis of 5,527 participants. The meta-analysis combined unadjusted odds ratios from included studies to calculate an overall unadjusted odds ratio of developing dementia in bilinguals versus non-bilinguals of 0.96 (95% CI 0.74–1.23) (see Fig. 2), which indicates no advantage of bilingualism in protecting against dementia compared to monolingualism. In the studies included in the meta-analysis, two reported bilinguals to have received more education, one found no significant difference between education of bilinguals and monolinguals, and one reported that they received less education although reading level and therefore English proficiency, was similar in both groups.

Another, lower quality, study did not control for any confounding factors (e.g., sex, education) [22]. This study used scores on validated tests of different cognitive functions such as verbal fluency and memory. It found that those who were bilingual had higher scores on the tests of premorbid cognitive functioning, National Adult Reading Test [24] and General Fluid-Type Intelligence (G-factor), than monolinguals.

*Retrospective studies (see Table 2)*

The included retrospective studies were generally set in memory clinics or other specialist centers where people with memory complaints came for assessment. Trained specialists made diagnoses of dementia or mild cognitive impairment (MCI) according to validated diagnostic criteria. Most of the participants in these studies had come seeking help for cognitive complaints. One study recruited participants by advertising to the public and specifically requesting physician referrals of people with memory complaints [25] and participation required subjective memory complaints. Bilingualism was defined either by self-report of the ability to speak two languages, or as speaking two languages for most of one's adult life. One study in this group also included an objective measure of language proficiency [26].

Five studies asked informants when they had first noticed participants' symptoms of cognitive impairment [7, 10, 11, 27, 28]. All of these studies found that bilingual participants' informants noticed symptom onset four to five years later than their monolingual counterparts. In all of these studies, bilingual participants were either more likely to be immigrants or to have had more years of education than monolingual participants.

Three studies used age of diagnosis at the clinic visit at which they were diagnosed with either all-cause dementia or MCI as the outcome [25, 26, 29]. Of these, two found no significant difference in age of diagnosis between monolinguals and bilinguals and no significant differences in years of education between the two groups [26, 29]. The third study found that age of diagnosis of amnestic MCI, was on average 4.5 years later in bilinguals than monolinguals but there was no difference in age of diagnosis for multiple domain MCI (mean difference –2.6 years, $t(41) = 1{\cdot}11$; $p = 0.27$) [25]. The monolingual and bilingual participants did not differ in years of education but there was no information on their employment or immigrant status.

## DISCUSSION

Our systematic review is the first to bring together all published evidence comparing cognitive decline or dementia in people who are bilingual compared to those who are monolingual. We found that, in individual prospective studies, there was no difference between bilingual and monolingual participants in the rate of development of dementia when baseline differences were taken into account. Combining these studies in this new meta-analysis has strengthened this conclusion as we found no reduction in the odds ratio of dementia in those who were bilingual compared to those who were not. By contrast, bilingual participants present around 4.5 years later in retrospective studies, where individuals' participation in the study depended on self-presentation, and time of initial symptoms are self-reported rather than standardized.

Studying the effect of an exposure, in this case bilingualism, on outcome is ideally carried out prospectively in order to reduce recall bias and clarify

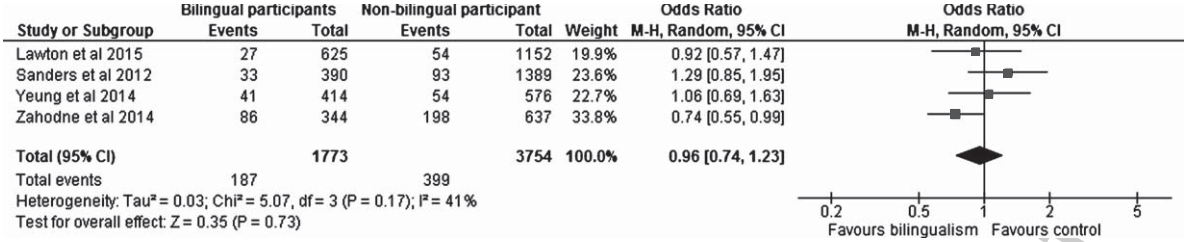


Fig. 2. Forest plot showing odds ratio of developing dementia in those defined as bilingual versus those who were not.

the temporal relationship. None of the prospective studies of the development of dementia as an outcome found any protective effect of bilingualism, either individually, when adjusted for confounders, or on meta-analysis. These studies were large, examined all participants for dementia using standard methods, with good follow-up rates, controlled for confounders, had a duration of 5–10 years and measured incidence of dementia, a clinically relevant outcome. As large high-quality prospective studies have not shown an association between bilingualism and dementia, this indicates that bilingualism is not an independent protective factor.

A prospective but lower quality study (which did not control for sex or education) was not included in the meta-analysis as it measured cognitive function rather than incident dementia. It found bilingualism had a protective effect on cognition. In this study, bilingual people scored more highly on the National Adult Reading Test, which is a measure of premorbid attainment, suggesting higher cognition and education at entry; although there was no information on baseline differences in participants [22]. Thus, differences in the groups' outcomes may be due to educational or social differences rather than to bilingualism itself.

Retrospective studies in this review usually used either informant report about the date of onset of symptoms or the date of presentation to memory clinic as date of onset. This is potentially influenced by many personal and cultural factors. People from minority ethnic backgrounds tend to seek help later for dementia [30] and may define the onset of symptoms differently, potentially explaining findings of later reported symptom onset from retrospective studies that included more immigrants in the bilingual group. Although some of these studies adjusted statistically for baseline differences in education, they cannot account for cultural differences in help-seeking.

Retrospective studies that did not include a greater number of people from immigrant backgrounds in the bilingual groups, usually included bilingual participants with higher levels of education. Education is protective against cognitive decline [31]. Although these studies have adjusted for education in their analyses, where group assignation is non-random, there is no way of determining whether associations between group membership (bilingual versus non-bilingual) and the dependent variable are due to random error or a true group difference [32]. In addition, years of education completed is not always an indicator of quality of education and the latter could be influenced by other variables such as socioeconomic status.

Two studies which did not qualify for inclusion, compared multilingual participants with bilingual participants. Both of these studies were conducted in countries where speaking multiple languages is common and participants were likely to switch between different languages many times a day. One study had a 14% follow-up rate and did not compare those who dropped out and those who did not [12]. The other was cross-sectional and found being multilingual rather than bilingual was protective, giving an odds ratio of 0.3 for cognitive impairment (95% Confidence Interval 0.10–0.92) after adjustment for education and age [13]. Both studies found that knowing and using more than two languages seems to confer a cognitive advantage and multi-lingualism may differ from bilingualism but there is not enough evidence as yet to draw definitive conclusions.

*Strengths and limitations of this review*

Our review was systematic and we searched using broad search terms and refined our search strategy to include as many potentially relevant papers as possible. We also hand searched references of relevant papers to identify further papers. We are therefore unlikely to have missed papers matching our inclusion criteria. We also emailed authors for missing information or clarification and this improved the accuracy of our information. Quality rating was completed using a scale which is widely used and

independently derived. The quality was rated by two authors independently. However, only one author screened titles and abstracts for inclusion. We have not carried out a funnel plot to screen for publication bias but as most of the prospective studies found negative results, publication bias is unlikely to positively skew the results. We could only carry out a meta-analysis on unadjusted odds ratios so our estimate is likely to over-estimate the effect of bilingualism.

*Conclusion*

We did not find evidence that bilingualism, when appropriately adjusted for education, protects from cognitive decline or dementia. Public health policy should therefore remove recommendations regarding bilingualism [3] as a strategy to delay dementia and instead concentrate on more generally reducing cognitive inactivity [33].

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## SUPPLEMENTARY MATERIAL

The supplementary material is available in the electronic version of this article: http://dx.doi.org/10.3233/JAD-170131.

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