

Bilingualism as a strategy to delay the onset of Alzheimer's disease

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Abstract: The purpose of this study is to explore original studies which provide evidence about the effects of bilingualism on the delay of the onset of dementia, specifically Alzheimer's disease (AD). A literature review was conducted in the world's acknowledged databases: Web of Science, Scopus, and MEDLINE. Altogether, 14 original studies focusing on the research topic were detected. These included six prospective cohort studies and eight retrospective studies. Both types of studies suggest different conclusions. The findings from the prospective cohort studies state that there is no association between bilingualism and the delay of the onset of AD, while the retrospective studies claim the opposite. Despite the negative results of the prospective cohort studies, more research should be conducted on bilingualism and its impact on the delay of the onset of AD, since the brain studies have brought positive findings as far as the enhancement of cognitive reserve is concerned.

Keywords: older people, evidence, effectiveness, review, cognition

Introduction

Aging and dementia

According to the recent report of the United Nations¹ on the aging process of the world's population, the number of older people aged 60+ years has risen considerably. Globally, the number of these elderly people is growing faster than the number of people in any other age group. This accelerating trend in the rise of older population groups inevitably results in serious economic and social changes accompanied with a number of aging diseases such as dementia.

Dementia, specifically Alzheimer's disease (AD), together with heart diseases, cancer, and respiratory diseases, is one of the most common causes of death among older people.² Globally, dementia affects around 58 million people, and it is estimated that the number of older people with dementia would triple by 2050, since each year about 9.9 million new dementia cases are diagnosed worldwide.^{3,4}

Dementia is a syndrome of deterioration of cognitive functions that interferes with a patient's everyday life. This cognitive impairment has an enormous impact not only on the patient's health and his/her self-care but also on the costs of care, either at home or in a residential establishment.⁵⁻⁷ Therefore, there is sustainable effort to prevent cognitive decline which is the foremost sign of this neurological disorder. However, currently, there is no effective pharmacological treatment for the cognitive decline.⁸ Thus, there is an increasing interest in non-pharmacological alternative approaches which may maintain or even increase the so-called cognitive reserve and enable healthy older people to delay the deterioration of cognitive functions.

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Cognitive reserve, its enhancement, and bilingualism

Cognitive reserve can be defined as the resilience to neuro-pathological damage of the brain.⁹ It is assumed that this is the result of experience-based neural changes which are caused by a physically and mentally stimulating lifestyle.¹⁰ Research¹¹ indicates that especially the differences in cognitive reserve are affected by environmental enrichment. This means that although some people have signs of brain atrophy and neuronal loss, thanks to their cognitive reserve, they do not have visible difficulties in cognitive functioning.

A research study¹² revealed that 60% of general cognitive ability is of genetic origin, but there are some non-pharmacological activities such as performing physical and mental activities, which play an important role in its enhancement as well.¹³ Antoniou et al¹⁰ claim that some of these non-pharmacological activities which are aimed at the stimulation of the cognitive functions might delay the cognitive decline.

One of these mental activities, which may also contribute to the enhancement of cognitive reserve, is bilingualism, that is, the ability to speak more than one language. In fact, bilingualism enables constant shifting between languages, with their distinct sounds, words, concepts, and grammatical rules, and offers effective training of executive functions such as attention, switching, inhibition, and monitoring. All these contribute to a higher cognitive reserve.¹⁴ Thus, bilingualism is considered to be connected with cognitive advantage,¹⁵ since research¹⁶ has shown that language does not only reflect the mind but also modify the brain to certain degree even in older age. Bak et al,¹⁷ Goral et al,¹⁸ and Luk et al¹⁹ report that bilingual people may enhance their cognitive reserve at later age, thanks to the use of two languages, and the so-called mental flexibility. Schweitzer et al²⁰ argue that bilingualism is a clear case of an environmental factor that helps produce cognitive reserve, although it might also affect the brain and its development and organization, and contribute to brain reserve. There are several brain studies which confirm that bilingual people usually have greater gray matter volume than monolingual individuals, which has a positive impact on the functional connectivity between gray matter regions.^{21–24} Therefore, bilingualism seems to protect against the cognitive decline that occurs during aging. This has also been confirmed by the most recent study by Estanga et al,²⁵ who conclude that bilingualism influences cognitive reserve, especially improving executive and visual-spatial functions.

Bialystok et al²⁶ claim that thanks to better mental flexibility, bilingual people have the ability to adapt to constant changes and process information effectively and adaptively. Furthermore, Lee and Tzeng²⁷ indicate that effective connectivity, thanks to second language learning, improves the capacity for language processing and general executive control by reorganizing neural circuitries. This even concerns older learners whose age is considered to be far from the so-called critical period of language acquisition. These findings have also been confirmed by Schlegel et al²⁸ who have revealed that the brain maintains its plasticity in adult age. In their study on language learning with 11 English speakers studying Chinese for nine months, they have brought evidence that white matter in older individuals might still experience considerable changes which have a positive impact on foreign language learning in aging. Bialystok²⁹ points out that the age in second language acquisition is not such a significant factor, but the length of exposure to the target language is important.

The purpose of this study is to explore original studies which provide evidence about the effects of bilingualism on the delay of the onset of AD.

Methods

The methodology of this study was based on Moher et al.³⁰ A literature review was conducted in Web of Science, Scopus, and MEDLINE databases with the goal of identifying research studies on the basis of the following key words: bilingualism AND cognitive decline, bilingualism AND dementia, and bilingualism AND AD. This review identified articles published during 2007 to May 2017.

Most of the studies on the research topic were identified in the Web of Science (146), followed by MEDLINE (129) and Scopus (104). Altogether, 379 publications were detected in the databases. The titles of all studies were checked in order to confirm whether they focused on the research topic and to eliminate duplicates. Ninety-eight studies were used for further analysis, in which the authors checked the content of the abstracts. Sixty studies were selected for the full-text analysis, out of which the findings of 14 studies were then used for the detailed analysis of the research topic (Figure 1).

A study was included if it matched the corresponding period, that is, from 2007 up to May 2017. The selection period started with the year of 2007, since this is the year when the first findings on the efficacy of bilingualism on the delay of the onset of dementia appeared.²⁶ Furthermore,

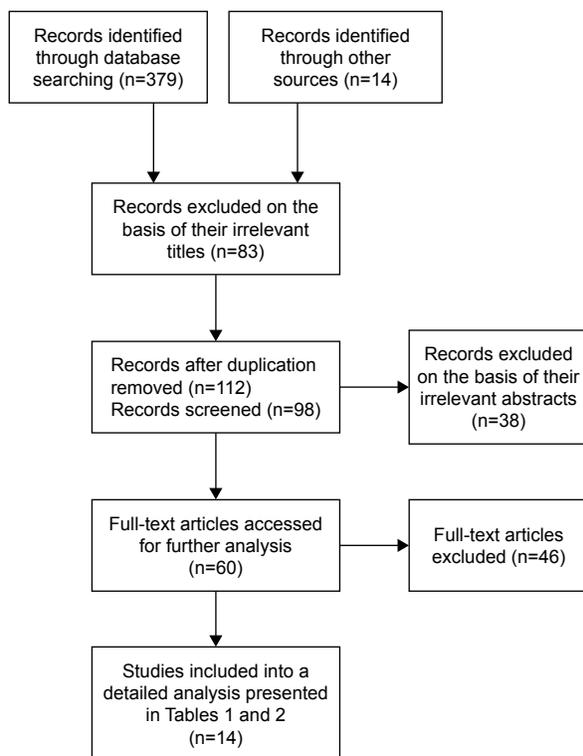


Figure 1 Results of the selection procedure.

a study was included if it involved older people and focused on the topic of bilingualism, that is, the ability to speak and write more than one language, and its effect on the onset of AD. The studies which focused only on AD were included, while the studies concentrating on other, less frequent dementias, such as frontotemporal dementia³¹ or Parkinson's diseases, were excluded.³² The studies^{18,33} that compared the performance of bilinguals to that of monolinguals on tasks such as nonverbal tasks, assumed to measure executive functioning, were excluded, as well as multilingual studies.^{34,35} The brain studies^{21–25} were also excluded. Only studies written in English were included.

Findings

Altogether, 14 original studies focusing on the research topic were detected. These included six prospective cohort studies (Table 1) and eight retrospective studies (Table 2). All studies except two^{38,45} compared both monolingual and bilingual language groups. Tables 1 and 2 provide an overview of the main findings on bilingualism and its effect on the delay of the onset of AD. The studies are presented in the alphabetical order of their first author.

The research period of the prospective studies ranges between 5 and 50 years. Overall, the number of participants

in these six studies was 8,233. All six studies in fact met the criteria for the evaluation of the quality of cohort studies set by the Newcastle–Ottawa Scale,⁴⁸ since they applied evidence-based measurement of their outcomes, such as a battery of cognitive performance tests, clinical examinations, or Cox regression. Furthermore, the followed-up period lasted 5 years at minimum, the clinical samples were derived from community samples and not referrals to specialist memory clinics, and most importantly, the age of the onset of AD was determined by standardized clinical examinations and not by subjective retrospective self-reports. In some studies, however, the self-reports were used for the assessment of language proficiency.^{36,39,40} As Zahodne et al⁴⁰ indicate, this should not have any effect on the overall results. Apart from two studies,^{17,38} the findings suggest that there is no association between bilingualism and the delay of the onset of dementia, specifically AD.

On the contrary, the results of all retrospective studies with one exception⁴³ indicate that bilingualism might delay the onset of cognitive decline, specifically AD, by approximately 4.5 years. However, the number of subjects in these studies is lower than in the prospective studies. Altogether, 1,502 patients participated in the research, ranging from 44 to 648 patients. Bakker⁴⁹ points out that in order to attain desirable levels of power, at least 139 subjects should be involved in each language group. Criterion for bilingualism in these studies is that individuals should speak two or more languages fluently, approximately 50% of the time, ideally daily, at least since their early adulthood. In addition, the findings on the age of the onset of AD are based on questionnaires and interviews with these patients, their family members, or caregivers, which might also contribute to the misinterpretation of these results. Generally, retrospective studies usually have more potential sources of bias and confounding than prospective studies.⁵⁰

Discussion

As research on bilingualism reveals, there has been an increased interest in how and whether lifelong bilingualism protects the brain from cognitive decline, specifically from the symptoms of AD.⁵¹ However, the results in favor of bilingual advantage differ as the findings from the selected research studies shown in Tables 1 and 2. Almost all retrospective studies in Table 2 demonstrate the delay of the onset of dementia by 4.5 years and manifest that bilingualism contributes to the enhancement of cognitive reserve. This has also been confirmed by recent review studies.^{51,52} Bialystok et al,⁵²

Table 1 An overview of the prospective cohort studies on bilingualism and its effect on the delay of the onset of AD

| Study | Objective | Number of subjects | Main outcome measures | Results |
|--|---|---|--|--|
| Bak et al ¹⁷ Prospective study (50 years) | To explore the effect of bilingualism on later-life cognition controlling for childhood intelligence | 853 participants | First tested at age 11 and then at the age of 70; a series of cognitive tests for participants including intelligence test, and comparing the results with their own test scores at the age of 11 | The results show that bilinguals, as well as those who acquired a second language at the later age, performed significantly better than predicted from their baseline cognitive abilities, with strongest effects on general intelligence and reading; the findings also suggest a positive effect of bilingualism on later-life cognition, including in those who acquired their second language in adulthood |
| Lawton et al ³⁶ Prospective cohort study (10 years) | To explore if clinically diagnosed AD and vascular dementia occurred later for bilingual than monolingual, immigrant, and US-born, Hispanic Americans | 1,789 community-dwelling Hispanic Americans, aged ≥ 60 years | Cognitive testing, clinical examination, and self-report using a three-point Likert-type scale for the evaluation of language proficiency | The findings show that mean age of dementia diagnosis was not significantly different for bi/monolingual, US-born or immigrant, Hispanic Americans |
| Sanders et al ³⁷ Prospective cohort study (17 years) | To verify whether n-NESs have lower risk of incident dementia/AD and that educational level might modify this relationship | 1,944 healthy older individuals ≥ 70 years | Battery of cognitive performance tests at baseline and each successive annual evaluation, and nested Cox proportional hazards models were used | n-NES status does not appear to have an independent protective effect against incident dementia/AD, and that n-NES status may contribute to risk of dementia in an education-dependent manner |
| Wilson et al ³⁸ Prospective cohort study (5.8 years) | To test the hypothesis that foreign language and music instruction in early life are associated with lower incidence of MCI and slower rate of cognitive decline in old age | 964 healthy older individuals | Cognitive testing and clinical classification of MCI | The results indicate that higher levels of foreign language and music instruction during childhood and adolescence are associated in old age with lower risk of developing MCI but not with the rate of cognitive decline |
| Yeung et al ³⁹ Prospective cohort study (5 years) | To determine whether bilingualism is associated with dementia in cross-sectional or prospective analyses of older adults | 1,616 community-living healthy older adults | Self-reports, cognitive testing, and clinical examination | The results reveal that there is no association between speaking more than one language and dementia |
| Zahodne et al ⁴⁰ Prospective cohort study (23 years) | To test the hypothesis that dementia is diagnosed at older ages in bilinguals compared to monolinguals | 1,067 healthy older Hispanic immigrants in New York | Self-report using a four-point Likert-type scale for the evaluation of language proficiency, Selective Reminding Test, Boston Naming Test, tests of verbal and nonverbal abstraction and letter fluency, Color Trails Test, and Cox regression | The findings do not support a protective effect of bilingualism on age-related cognitive decline or the development of dementia |

Abbreviations: AD, Alzheimer's disease; n-NESs, non-native English speakers; MCI, mild cognitive impairment.

by comparing monolingual and bilingual older individuals on measures of cognitive function and brain structure, emphasize that bilingualism is a protective factor against the symptoms of dementia. Nevertheless, their review leaves out some of the important prospective studies on this topic.^{36,37,39} The same is true for the study by Alvarez and Rodriguez.⁵³

On the contrary, the findings from the prospective studies exert nonsignificant results as far as the bilingual advantage

is concerned. The latest meta-analytic review study provides conclusive results about this.⁵⁴ Mukadam et al⁵⁴ on the basis of effect sizes (odds ratio of dementia of 0.96 [95% CI 0.74–1.23] in bilingual participants [n=5,527] compared to monolinguals) from the analyzed studies have concluded that there is no evidence that bilingualism protects from cognitive decline or dementia. The retrospective studies they detected could not be analyzed for effect sizes, since

Table 2 An overview of the retrospective and cross-sectional studies on bilingualism and its effect on the delay of the onset of AD

| Study | Objective | Number of subjects | Main outcome measures | Results |
|-------------------------------|--|---|--|--|
| Alladi et al ⁴¹ | To determine the association between bilingualism and age at onset of dementia and its subtypes, taking into account potential confounding factors | 648 patients with dementia (391 bilinguals, 257 monolinguals) | The Mini-Mental State Examination, Addenbrooke's Cognitive Examination – revised, the Clinical Dementia Rating scale, and clinical examination | The findings indicate that bilingual patients developed dementia 4.5 years later than the monolingual ones; there is a bilingual advantage in those who are illiterate |
| Bialystok et al ²⁶ | To examine the effect of lifelong bilingualism on maintaining cognitive functioning and delaying the onset of symptoms of dementia in old age | 184 patients with cognitive impairments, out of whom 132 had probable AD; 51% were bilinguals | Clinical examination, Mini-Mental State Examination, and interviews | The findings suggest that the bilinguals may develop symptoms of dementia 4 years later than monolinguals with no effect on its progression |
| Bialystok et al ⁴² | To explore the effects of bilingualism on the age of onset and progression of MCI and AD | 149 patients (74 MCI patients and 75 AD patients) | Three executive function tests from the D-KEFS battery, questionnaires, and interviews | The results confirm that bilingual patients are several years older than comparable monolinguals at both age of symptom onset and date of first clinic visit |
| Clare et al ⁴³ | To investigate whether bilingualism contributes to the increased cognitive reserve or not | 86 patients (37 bilingual and 49 monolingual patients) | Standardized neuropsychological tests and questionnaires | The results show that there was a nonsignificant difference in age at the time of diagnosis between bilinguals and monolinguals; bilingual Welsh/English speakers with AD did not show a clear advantage in executive function over monolingual English speakers, but retained some benefits in inhibition and management of response conflict |
| Craik et al ⁴⁴ | To prove that lifelong bilingualism is a further factor contributing to cognitive reserve | 211 consecutive patients diagnosed with probable AD (102 bilinguals, 109 monolinguals) | Clinical examination, Mini-Mental State Examination, and interviews | The results reveal that the bilingual patients had been diagnosed 4.3 years later and had reported the onset of symptoms 5.1 years later than the monolingual patients |
| Gollan et al ⁴⁵ | To explore the relationship between bilingual language proficiency and onset of probable AD | 44 Spanish–English bilinguals with probable AD | Boston Naming Test | The findings indicate that bilingualism along a continuum enhances cognitive reserve; significant effects were only attained in low-education groups |
| Ossher et al ⁴⁶ | To examine the effect of bilingualism on aMCI | 111 patients with aMCI (71 monolinguals, 40 bilinguals) | Battery of neuropsychological tests, and questionnaires about their language and social background | The results show that only individuals diagnosed with single-domain aMCI demonstrated a later age of diagnosis for bilinguals (M =79.4 years) than monolinguals (M =74.9 years) |
| Woumans et al ⁴⁷ | To explore the effects of bilingualism on the clinical manifestation of AD | 69 monolinguals and 65 bilinguals diagnosed with probable AD | Clinical examination, Mini-Mental State Examination, screening blood tests, neuroimaging, and self-reports | Results indicate a significant delay for bilinguals of 4.6 years in manifestation and 4.8 years in diagnosis |

Abbreviations: AD, Alzheimer's disease; MCI, mild cognitive impairment; D-KEFS, Delis–Kaplan Executive Function System; aMCI, amnesic mild cognitive impairment.

they incline to confounding by education or cultural differences in presentation to dementia services. This seems to be caused by shortcomings in the conception and assessment of bilinguals and confounding variables.⁵⁵ The most conflicting factors appear to be immigration status, education, group heterogeneity, or social factors.⁵⁶ In prospective studies, bilingualism is usually connected with a higher level of formal education. However, in retrospective studies, there is no consensus on this issue. In some studies,^{26,44,45} monolingual groups have higher mean scores on education than bilingual

groups. In addition, Fuller-Thomson and Kuh⁵⁷ point out that immigrants usually have less morbidity and mortality. Therefore, more research should be performed on bilingualism in a nonimmigrant population and their cognitive decline. In addition, all the demographic data about the participants' background, for example, education, occupation, or immigrant status, should be properly collected.

Thus, the authors of this mini-review agree with Strauss⁵⁸ that although both types of the studies arrive at conflicting conclusions on bilingualism and its impact on the delay of

the onset of dementia, one thing seems to be sure; speaking or learning another language cannot cause any harm. Furthermore, Bak¹⁴ adds that it has no side effects, and Bialystok et al⁵² emphasize its important role in the reduction of potential costs, both for humans and national economy.

The limitations of this review study involve the use of insufficient and different methodologies, especially in the retrospective studies. This might result in the overestimated effects of the findings, which may have an adverse impact on the validity of these reviewed studies.^{59,60}

Conclusion

Although the findings of this mini-review did not arrive at any revolutionary conclusions, they suggest that more research should be conducted on bilingualism and its impact on the delay of the onset of dementia, since the brain studies have brought positive findings as far as the enhancement of cognitive reserve is concerned.

In addition, Kurdziel et al⁶¹ say, learning throughout aging is necessary because older individuals who keep mentally and physically active are less likely to be cognitively impaired and depressed.

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Disclosure

The authors report no conflicts of interest in this work.

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