

Multilingualism as cognitive reserve: delaying the onset of dementia in the elderly

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Multilingualism can be advantageous for an individual. It is thought to contribute to their cognitive reserve, the ability to resist brain damage. As such, there is evidence it might delay cognitive decline and dementia. The evidence comes from two types of studies. Firstly, studies comparing ages of onset of dementia show that there is a delay of 3-6 years in the appearance of symptoms in multilinguals, compared to monolinguals. This suggests multilingualism could enhance the brain's ability to deal with decline. Secondly, studies comparing neuropathology in elderly participants with the same cognitive performance found multilinguals have higher levels of atrophy and damage in the brain than monolinguals. This further suggests multilingualism increases the brain's resilience to damage. However, in both cases more research is needed to confirm multilingualism does indeed delay the onset of dementia, as confounding factors have been identified in both types of studies.

Introduction

The issue on the possible advantages and disadvantages of multilingualism on the individual has long been debated. One of the proposed advantages is its influence on cognitive reserve (CR), or the ability to resist to brain damage (Stern, 2002), thus protecting against cognitive decline in the elderly (Bialystok, Craik, & Freedman, 2007). According to the Cognitive Reserve Theory (Stern, 2002), behavior remains consistent for a longer period of time in people with higher CR. It is suggested that the inherent cognitive abilities and physical, social, and intellectual activity increase the resilience of the brain. However, CR does not delay or protect from the development or acquisition of neuropathology. For instance, Lawton, Gasquoin, and Weimer (2015) found no difference in proportion of dementia diagnosis among monolinguals and bilinguals. Instead, CR may delay the time at which the pathology influences cognitive abilities, thus the onset of behavioral symptoms.

Cognitive reserve and its effects have been studied on a range of brain disorders such as schizophrenia (Barnett, Salmond, Jones, and Sahakian, 2006) and multiple sclerosis (Sumowski, Chiaravalloti, Wylie, and DeLuca, 2009), but especially on cognitive impairment and dementia, whose incidence among Dutch elderly is rising (van Bussel et al., 2017). Dementia stands for a collection of symptoms caused by neurodegenerative diseases that affect cognitive abilities in the (elder) individual ("Dementia", 2017). Symptoms may include memory loss, impairment of language and problem solving, hallucinations, personality changes ("Dementia", 2017).

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Given the large social, medical and economic burden that is dementia in present-day society (Robertson, Savva, & Kenny, 2013), it is of interest to gain a better understanding of how common traits among individuals might provide a protective, or at least delaying, effect against it. One of these traits is multilingualism, meaning being fluent in two or more languages (Hakuta, Cummins, Edwards, & Obler, 2003). Multilingualism is more prevalent worldwide than monolingualism (Hakuta et al., 2003). In Europe, more than half of the population uses at least two languages; 25% is able to speak at least three, and 10% at least four (“Europeans and their Languages”, 2012).

Recently, it was observed that multilinguals develop clinical dementia symptoms later than monolinguals (Alladi et al., 2013; Bialystok et al., 2007; Craik, Bialystok, & Freedman, 2010). Furthermore, brain imaging shows that, at an equal level of cognitive decline, multilinguals have greater neuropathology than monolinguals (Gold, Johnson, and Powell, 2013; Luk, Bialystok, Craik, & Grady, 2011; Schweizer, Ware, Fischer, Craik, & Bialystok, 2012). Therefore, it is proposed that multilingualism contributes to the individual’s CR, delaying the onset of various forms of dementia, such as Alzheimer’s Disease (AD), Vascular Dementia (VaD), and Frontotemporal Dementia (FTD). If this proves to be true, it not only contributes to the growing body of advantages of multilingualism; it can also lead to further understanding of the multilingual brain and of dementia.

There are two main types of correlational studies used to demonstrate that multilingualism contributes to the individual’s CR, delaying the onset of dementia: those that compare ages of onset of dementia, and those that relate the severity of the symptoms to brain neuropathology.

Onset of dementia in monolinguals compared to multilinguals

The onset of dementia in monolinguals and multilinguals has been compared in various studies. This has led to the observation that, in general, the appearance of symptoms of cognitive decline and the subsequent diagnosis of dementia are delayed in multilinguals compared to monolinguals (Bialystok et al., 2007; Alladi et al., 2013). There can be up to 4-5 years of delay for individuals with AD, as confirmed by various studies (Bialystok et al., 2007; Chertkow, Whitehead, Phillips, Wolfson, Atherton, & Bergman, 2010; Craik et al., 2010). However, there is less evidence and agreement on the delay in other types of dementia, ranging from 3 to 6 years (Alladi et al., 2013; Bialystok et al., 2007). Bialystok and colleagues (2007) were the first to report these findings, after analyzing the medical records of 184 patients, of which 132 with probable AD, and 52 with dementia due to other neurodegenerative disorders and cerebrovascular disease. Half of the patients were monolinguals, the other half bilingual. They found out that the delay in onset of cognitive symptoms in bilinguals compared to monolinguals was significant: a difference of 4.3 years for patients with probable AD, and 3.5 years for the other patients. Furthermore, there was no significant difference in the MMSE scores, indicating that the patients had similar levels of impairment at the initial clinical visit, when they were diagnosed.

However, 90% of bilinguals in Bialystok and colleagues’ study (2007) were immigrants, while most monolinguals were not. The different life experience of the two groups could therefore have been a confounding factor that influenced the age of onset of dementia. Chertkow and colleagues (2010) repeated Bialystok and colleagues’ research, focusing mostly on non-immigrants instead. They found a 1.0-year delay in dementia onset, and a 0.9-year delay in diagnosis in multilinguals compared to monolinguals, both not significant differences. Instead, a significant delay of 5.1 years, was found in the immigrant sub-cohort. Craik and colleagues (2010) also reported similar results, with multilingual immigrants scoring on average a higher delay in dementia onset than multilingual non-immigrants. Even

though in their case the difference was not significant, it is still important to consider that immigration status and the life experience it brings may be confounding factors in this hypothesis.

Alladi and colleagues (2013) analyzed the results of 648 participants with dementia, of which 60% multilingual (26% bilinguals, the rest speaking three or more languages). Upon comparing the age of dementia onset, on average multilinguals showed symptoms 4.5 years later than monolinguals. Interestingly, there was also a significant difference in onset between monolinguals and multilinguals based on the type of dementia. Indeed, the difference was of 3.2 years in individuals with AD, 6.0 in FTD, and 3.7 in VaD. These suggest that multilingualism could positively affect brain areas involved with executive functions, which are especially affected in FTD, as well as hippocampal areas, which are instead prevalently affected in AD. As Bak, Nissan, Allerhand, and Deary (2014) explain, multilinguals have to constantly deal with two or more languages, therefore need to select, monitor, and suppress linguistic information when needed. Thus, frontal executive functions are engaged more, at least in lifelong multilinguals, and in those using multiple languages frequently (Soveri, Rodriguez-Fornells, and Laine, 2011). The areas involved in dealing with multiple languages are more developed, for example showing higher white matter integrity (Bialystok, Craik, & Luk, 2012), which could explain the different delays in neuropathology in these areas seen in AD and in FTD. Furthermore, the delay in VaD onset between monolinguals and multilinguals suggests the cerebrovascular system could benefit from multilingualism, however it has not been looked into yet.

Differences in the number of languages spoken

Alladi and colleagues (2013) did not find a significant difference in onset of dementia between people speaking two, three, four or more languages. On the other hand, two studies (Bak et al., 2014; Kavé, Eyal, Shorek & Cohen-Mansfield, 2008) found a positive correlation between the number of languages spoken and cognitive state in the elderly. While it could be evidence of multilingualism as CR, another possible explanation is that knowing more than two languages correlates with higher intelligence or education, which contribute to CR and improve cognitive state. However, this is unlikely, as both studies controlled for education, intelligence and other demographic variables (Bak et al., 2014; Kavé et al., 2008).

Comparison of neuropathology in elderly monolinguals and multilinguals

The delay in onset of symptoms in dementia has also been suggested by neuropathology studies. Schweizer and colleagues (2012) measured brain atrophy in CT scans of bilingual and monolingual individuals with AD. When matched on cognitive performance, degree of clinical severity, and education, bilinguals showed higher levels of brain atrophy than monolinguals. This further suggests that multilingualism increases the brain's resilience to damage, as the atrophy caused less impairment in cognitive abilities in bilinguals than monolinguals.

Gold, Johnson, and Powell (2013) instead looked into White Matter (WM) integrity and Gray Matter (GM) volume in monolinguals and lifelong bilinguals elderly people. When matched for level of cognitive functioning, there were no significant differences in GM volume between monolinguals and bilinguals. However, bilinguals showed lower WM integrity, depending on lower Fractional Anisotropy (FA) and higher Radial Diffusivity (RD) compared to monolinguals. It appears that neurodegeneration, either because of loss of WM integrity or brain atrophy, impairs cognitive functioning less in bilinguals than monolinguals, indeed suggesting multilingualism increases CR.

In a different set-up, Luk and colleagues (2011) found that healthy elderly bilinguals maintain a higher WM connectivity and integrity than healthy monolinguals matched on age and gender. Olsen and colleagues (2015) came to the same results in their study. Both suggest that WM integrity “could provide a reserve factor, to compensate for deteriorating gray matter” (Luk et al., 2011, p. 16812).

While more evidence comes from studies on the delay of dementia in multilinguals compared to monolinguals, the number of studies on differences in neuropathology is not satisfactory, especially those comparing groups with matched levels of cognitive function.

Possible mechanisms of multilingualism as cognitive reserve

There are various theories that try to explain how multilingualism contributes to CR, and how it delays the insurgence of cognitive decline. Schweizer and colleagues (2012) suggest that factors related to CR may modify brain function, for example by increasing blood supply or connectivity between neurons in certain areas. The result is better-supplied areas and strengthened pathways that are better able to compensate for damages to the brain. It is also proposed that the benefits of multilingualism come from the need for bilinguals to inhibit one language in favor of the other, and to constantly switch between them (Bialystok et al., 2012). Therefore, constantly experiencing two or more languages may influence the course of dementia, as these people challenge their brains in ways monolinguals do not (Guzmán-Vélez, & Tranel, 2015). Indeed, while multilingualism does not influence the accumulation of pathology, it enables the brain to function despite accumulated pathology (Bialystok et al., 2007).

Arguments against multilingualism as cognitive reserve

Whether multilingualism or other factors that explain it contribute to CR is still under debate. Multilingualism affects cognition, therefore it is suggested that the difference in dementia onset may be due to a different baseline of cognitive ability between the two groups (Bak et al., 2014). Further, it can be argued that it is not multilingualism that specifically contributes to CR, but other factors like education, immigration status, literacy and occupation (Gollan, Salmon, Montoya, & Galasko, 2011). However, these factors were taken into account in the discussed studies (Bialystok et al., 2007; Alladi et al., 2013). Bilinguals in Bialystok and colleagues’ study (2007) had significantly fewer years of education compared to monolinguals. Alladi and colleagues (2013) also observed that being illiterate did not affect the delay, further suggesting that the effects of multilingualism on CR cannot be explained by education and literacy only.

Of note, Gollan and colleagues (2011) found a significant delay in bilinguals with low education, but not in those with high education: this suggests an upper limit to which multilingualism and CR can delay dementia. Until a certain threshold, multilingualism contributes effectively to delaying dementia onset. However, when education and other life experiences or skills contribute already, multilingualism does not increase CR further.

Conclusion

As seen, multilingualism contributes to an increase in CR, which in turn delays the onset of dementia in the elderly. This has been demonstrated through studies on the onset of dementia, however there is a lot of variation among the results. There is agreement that multilinguals individuals show a significant delay in dementia onset, although the amount of delay is not consistent among studies and across dementia types. Future research should focus on determining such differences.

Neuropathology studies also indicate that multilinguals suffer the effects of WM and GM atrophy less than their monolingual peers. However, more research is needed to confirm that the differences are indeed due to the number of languages spoken, and not other factors.

Generally, most studies controlled for variables such as education and intelligence, supporting the idea that these are not confounding factors. However, there are still doubts, especially regarding immigration status, and most studies did not include age of acquisition (Chertkow et al., 2010). It is possible that these influence the way individuals use the multiple languages they know. Immigrants may need to switch between languages more frequently than non-immigrants or use them more in general. Frequency of use should also be taken into account, as it affects areas involved in attention and switching (Gold, Johnson, Kryscio, and Smith, 2013).

Finally, it would be interesting to set up a longitudinal experiment to see whether brain areas involved in multilingualism are less affected by age-related brain damage. Areas that are more active in multilinguals than monolinguals should be identified as the individuals are young. Then, results should be compared to the various types of dementia manifested later in life. For instance, if the frontal lobe is more active in multilinguals than monolinguals, and that correlated with a difference in FTD onset between the two groups, it could further support the idea that multilingualism and not other cognitive abilities increase CR. Similarly, hippocampal and medial temporal lobe activities could be monitored in both groups, and then later related to the incidence and age of onset of AD.

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