

A Review of the Bilingual Advantage on the Onset of Dementia: The Knowledge Gap of Late L2 Acquisition

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ABSTRACT: There has been an ongoing controversy over the so-called “bilingual advantage,” which is the advantage bilinguals have in executive functioning compared to monolinguals. One advantage in this field is the impact of bilingualism on delaying the onset of dementia. Many previous studies have investigated lifelong bilingualism and its advantages in this syndrome, but little research has examined bilinguals who acquired their second language (L2) later in life. Results from several studies that focus on this group are inconsistent due to differences in the definitions of bilingualism, making the data incomparable. Therefore, the purpose of this review is to address whether there is evidence of a bilingual advantage in delaying the onset of dementia for late bilinguals, and to identify potential improvements in research methods. Overall, better definitions of bilingualism, including age of language acquisition, proficiency, language differences, and daily language use, are needed. Once researchers investigate late bilingual advantage more and either prove or disprove it, we can get a better understanding of the bilingual advantage in cognitive diseases and make better suggestions for L2 learning in order to eventually decrease the number of dementia patients.

KEYWORDS: Behavioral and Social Sciences, Cognitive Psychology, Bilingualism, Executive Functions, Dementia, and Age of Acquisition.

■ Introduction

Multiple studies indicate that some factors, such as a healthy diet,¹ cognitively stimulating activities,² and high levels of education,³ might prevent or delay the onset of dementia. Studies in the field have suggested that bilingualism might be one of them.⁴⁻⁶ There is an ongoing controversy on the existence of the so-called bilingual advantage in non-linguistic domains.⁵

Bilingual advantage is the advantage in executive functioning for those with the ability to speak and use two languages.⁷ Some studies report findings that support this theory,^{5,8} while some refute or partially refute it.^{7,9} For example, Bialystok *et al.* discovered through different tasks that lifelong bilingualism may have an advantage in executive functioning skills such as inhibition and working memory when compared to monolinguals.⁸ Conversely, Paap and Greenberg claim that there is no evidence of bilingual advantage over monolinguals in executive control skills since the advantages were not consistent across different tasks that indicate executive functioning skills.⁹ These inconsistencies across findings are the cause of the debate in the research field.

One of the non-linguistic factors that bilingualism might have a positive impact on is the onset of dementia.⁵ It is believed that bilingualism can delay this,⁶ but some limitations or gaps need to be better accounted for to make this claim more generalizable.¹⁰

One of the limitations is that existing research has mainly focused on lifelong bilinguals.^{5,6} Due to this, the findings of these studies might only be generalizable to certain groups. One of the populations that needs more attention is the group of late bilinguals, or bilinguals who attained their second language (L2) later in life. Increased attention on late bilinguals in

the research field will contribute to identifying what types of bilingualism provide the benefit of a delayed onset of dementia. This improvement will also contribute to the need for deeper consideration of individual differences, which is suggested by De Bruin.¹⁰ If future findings support the bilingual advantage, then suggestions can be made on L2 education for young children and older adults. Also, if these suggestions contribute to a decrease in the number of dementia patients, then it would benefit the global economy, since dementia care costs 1.3 trillion USD in 2019, and the cost is predicted to increase as years pass.¹¹

Ultimately, the purpose of this review is to summarize the findings on one of the many proposed ways of delaying dementia and to encourage accounting for different types of bilinguals in future research. In an effort to do so, this review first discusses and provides a summary of current findings around bilingualism and its impact on dementia. It also takes a look at some research that incorporated late bilinguals in their studies. The main contribution of this paper is that it offers suggestions for improvements of research methods moving forward, such as establishing a clear definition of the terms often used and generally increasing the effort put into this field of bilingual advantage.

■ Discussion

Introduction to the Bilingual Advantage Theory and Its Effect on Dementia:

Bilingual advantage influences several factors, including cognitive reserve (CR), which contributes to the delayed onset of dementia.¹² However, as previously stated, this theory is highly controversial. In order to understand the reason why this is the

case, it is important to first clearly state the definitions of bilingualism, its components, and the advantages.

What is the Bilingual Advantage? Bilingualism is the ability to speak and use two languages. The number of people with this skill is growing globally. Its benefits in communication skills and other linguistic terms are obvious, but there are non-linguistic advantages as well. In fact, bilingualism is believed to enhance executive functioning skills.¹³ However, this theory, called the bilingual advantage,⁷ is heavily debated due to the inconsistent and contradictory findings from different studies.

One of the executive functioning skills enhanced by bilingualism is inhibition, which is the ability to direct attention to one or a few important features of a stimulus while inhibiting attention to misleading or unnecessary features.¹⁴ It is believed that bilinguals have stronger inhibition skills because of their constant need to suppress one language to focus on, better comprehend, and be fluent in another.⁸ Bialystok *et al.* studied the inhibitory processes of bilinguals by assigning four trials of the Simon task to their 94 participants, where half of them were bilingual, and the other half were monolingual. They reported that young monolinguals had an average of 86.4% accuracy and 1,304 milliseconds reaction time, and that young bilinguals had an average of 97.1% accuracy and 536 milliseconds reaction time.⁸ This trend was also true, and the gap was even greater, for older participants. This data shows that bilinguals performed better on the task than their monolingual counterparts, indicating that bilinguals have more efficient inhibitory processes than monolinguals.

Carlson and Meltzoff also studied inhibition in bilinguals compared to monolinguals.¹⁴ They used an advanced version of Zelazo's Dimensional Change Card Sort (DCCS), which is a method that can assess the executive function of people of all ages.¹⁵ Fifty kindergarten children were included in the study. Bilingual participants in the study scored 3.26 on the DCCS task, while the control group scored 2.12, a difference that is statistically significant. The difference between the scores indicates that bilinguals have better or improved executive function skills.¹⁴ Since the Advanced DCCS requires inhibition to complete, it was evident that bilinguals have better inhibitory control than their monolingual peers. These two studies,^{8,14} as well as others, support the hypothesis that bilingualism leads to better inhibitory control.

Another executive function that is often studied in this field is attention. This skill involves guiding attention to and focusing on an important aspect of a stimulus, which is in part made possible by inhibitory control, which suppresses irrelevant information.¹⁶ Thus, if bilingualism boosts inhibitory control, then it would also benefit one's attention.

Task switching, the process of switching mental focus from one thing to another, is another factor of executive functioning that bilingualism can influence. Prior and MacWhinney studied whether cognitive bilingual advantage included these task-switching skills.¹⁷ Bilingual and monolingual university students performed the task-switching paradigm, which was a task adapted from another study.¹⁸ This task had three parts to it: single-task blocks (identifying the color or shape of a graph-

ic), mixed-task blocks (identifying both color and shape), and single-task blocks again. In the mixed-task blocks, participants performed both switch (alternating between color and shape) and non-switch trials. As a result, the average reaction time for bilinguals was 437.97 milliseconds, and for monolinguals was 448.8 milliseconds for the single-task blocks. For mixed-block switch tasks, bilinguals' average reaction time was 814.16 milliseconds, while that of monolinguals was 875.54 milliseconds. The trend persisted for non-switch tasks. These data show that the bilingual participants in the study had faster reaction times than monolingual participants. Thus, it can be asserted that bilinguals have lower switching costs, i.e., there is a bilingual advantage in the efficiency of switching from one task to another. Researchers attribute this advantage to bilinguals' repeated practice of switching between languages.¹⁷

It is also said that bilingualism may benefit one's working memory, which is a temporary storage for information to be held in one's mind and used for cognitive tasks.¹⁹ Based on the hypothesis that bilingualism affects executive functioning, Blom *et al.* studied the working memory of Turkish-Dutch bilingual and monolingual children from ages 4 to 6. They assigned the Dot Matrix, Odd-One-Out, and Forward and Backward Digit Recall tasks to children aged 6 and gathered their scores. Bilingual children's mean scores were 16.1, 11.8, 20.0, and 7.5, respectively. Monolingual children's mean scores were 13.6, 9.9, 18.3, and 4.0, respectively. Comparing these scores shows the trend that bilingual children score higher in all tasks, indicating that they have better short-term memory. This indicates the presence of a bilingual advantage in working memory.¹⁹ Another study also showed that loss of working memory due to old age was mitigated by bilingualism through an assessment of the Simon task.⁸ These findings support the hypothesis that bilingualism impacts executive functioning.

Another component of executive functioning is cognitive reserve (CR). CR is a hypothesis that the brain has the ability to cope with damage. It maintains the brain's health and prevents cognitive decline by using efficient networks and alternative approaches to solve problems.¹² One of the main diseases that CR copes with is dementia, as it can delay the onset of the disease, and it is argued that life experience can impact the onset of dementia through contributing to CR.¹² Researchers are exploring how bilingualism may count as one of the experiences that delay dementia. For example, Craik and colleagues conducted research with the hypothesis that lifelong bilingualism contributes to CR. They collected data on the timing of onset and diagnosis of Alzheimer's disease (AD) from 211 monolingual and bilingual AD patients. Drawing from each patient's information about their occupational, educational, and language history, 102 patients were classified as bilingual and 109 as monolingual. Their reported data show that bilinguals reported the onset of AD symptoms 5.1 years later and were diagnosed with the disease 4.3 years later, compared to monolinguals. As a result, researchers concluded that lifelong bilingualism contributes to CR.⁶ Combined with data from another study that found the same 5-year gap in bilingual and monolingual AD patients, this finding strengthens the CR hypothesis in terms of bilingual advantage.⁵

Although it seems convincing that bilingualism thus delays the onset of dementia, not all studies could replicate these findings. Chertkow *et al.* studied an even larger sample of 1842 monolingual, bilingual, and multilingual AD patients and found that the onset of AD was only 1 year later for bilinguals compared to monolinguals, a finding that is not statistically significant.²⁰ These conflicting findings make the bilingual advantage theory on dementia highly controversial.

Thus, some studies refute this claim,^{9,20} but it can be asserted that there is at least some kind of bilingual advantage in terms of executive functioning, as well as delaying the onset of dementia. The extent of this advantage remains unclear. Also, even if it is supposed that there is an advantage, the findings of the studies that support this hypothesis are often inconsistent. There are a few factors that may help explain why these inconsistencies occur.

Factors that Define Bilingualism. One of the reasons why the bilingual advantage theory is debatable is that different studies use different definitions of bilingualism. Some researchers use surveys to assess and categorize their bilingual participants,²¹ while others use tests for it.²² The examples of factors of bilingualism include proficiency, differences, and the age of acquisition (AoA) of the languages.

It is believed that proficiency plays one of the largest roles in defining bilingualism.²³ Despite this, contrasting definitions of proficiency make the results of different studies incomparable. For instance, Zied *et al.* found that balanced bilinguals have better inhibitory control when compared to unbalanced bilinguals.²² They measured this through the Stroop task,²⁴ where French- or Arabic-dominated bilinguals scored significantly lower than they did in the other language, while balanced bilinguals scored similarly on both languages. Balanced bilinguals are bilinguals who have similar levels of proficiency and daily use of both of their languages.²³

A different study by Yow and Li on balanced bilingualism showed the same trend of advantage in executive functioning, using several tasks, including the Stroop task and the task-switching task.²¹ But these findings are not necessarily replicates of each other since the researchers measured bilingual proficiency differently. Zied *et al.*²² made their participants take the Boston Naming Test in order to measure their proficiency, while Yow and Li²¹ conducted a survey where the participants self-reported their proficiency. These differences in the methods of measuring language proficiency make it hard to properly compare the findings, and thus, it leads to inconsistencies between studies.

Some studies^{7,19,25} note the similarities and differences between the languages as an important factor for defining bilingualism. These similarities and differences are often defined by which linguistic family each language belongs to. For example, English and Spanish are in the same linguistic family in a broad sense, since both are in a big family called the Indo-European language family. In contrast, English and Turkish are in different families since Turkish belongs to a linguistic family called Turkic.

Petrosyan *et al.*²⁵ focused on these linguistic families in their study. They hypothesized that multilinguals who spoke similar

languages outperformed those who spoke dissimilar languages in executive functioning. They found that among those with education, the former group of multilinguals scored 0.2, while the latter group scored 0.198. As a result, they concluded that multilinguals only outperformed monolinguals, and no major differences in executive functioning between different types of multilinguals were found.

Another study examined bilingual advantage in phonological awareness, which is strongly supported by executive functions.⁷ Researchers had three groups of participants: Spanish-English bilinguals, English monolinguals, and Chinese-English bilinguals. Their interesting finding was that in the phoneme segmentation task, where participants were required to understand the phonetic segments of words, Spanish-English bilinguals performed the best out of all groups with a mean score of 0.59. English monolinguals came second with 0.48, and Chinese-English bilinguals performed most poorly with a mean score of 0.30. Since English and Spanish are of the same linguistic family, and English and Chinese are not, there may be some advantages for bilinguals who speak similar languages.

Adding on, a study by Blom and colleagues mentioned previously showed a bilingual advantage in executive functioning, especially working memory.¹⁹ Since Turkish and Dutch are in different linguistic families, this finding might serve as evidence for better executive functioning in bilinguals who speak different kinds of languages, but no straightforward conclusion can be drawn because the study did not focus on the differences between different types of bilinguals. Thus, the answer to the question of whether similar or different languages lead to better executive functioning remains unclear.

Another factor that defines bilingualism is the age of acquisition (AoA) of the second language (L2). Different studies use different definitions of early bilingualism. For example, Soveri and her colleagues studied executive functioning skills in early bilinguals, who were, in this case, bilinguals who acquired their L2 before the age of 7. Task-switching paradigms and several other tasks showed that younger age, earlier L2 acquisition, combined with balanced use of languages, was associated with a smaller mixing cost. This can be an indicator that early L2 acquisition improves inhibition skills.²⁶

In a different study, Tao *et al.* also studied executive functioning in bilinguals but with a different definition of early and late bilinguals. They stated that bilinguals who learned their L2 at or before age 6 were early bilinguals, and those who acquired L2 at or after age 12 were late. Similar to Soveri and colleagues,²⁶ they found that early bilinguals showed better executive functioning (in this case, monitoring processes) than late bilinguals.²⁷ Although their results showcase similar conclusions, their contrasting definitions of early bilinguals make it challenging to compare the two findings.

In 2019, De Bruin¹⁰ published a review paper, communicating the need for improvements in research methods in the studies surrounding the bilingual advantage. She conveyed to other researchers in the field that, in order to facilitate further advancements in the field, there needs to be a standardized measurement of language proficiency. De Bruin also claimed that researchers need to provide a more detailed description of

their participants. This will allow for the opportunity to eliminate the inconsistencies between the studies regarding the bilingual advantage. Furthermore, the factors of bilingualism can help determine which groups of bilinguals can enjoy this benefit. So, eliminating the inconsistencies will have a huge impact on the research field. Specifically, it can determine the benefits for late bilinguals.

How Late Acquisition of L2 Impacts the Onset of Dementia:

It can be hypothesized that if early bilinguals have the bilingual advantage in delaying dementia, then late bilinguals may also have some advantage. The reason why this is an important topic to be discussed now is that among the studies that said dementia onset was delayed for bilinguals, most of them have focused on lifelong bilinguals, or bilinguals who have spoken both of their languages their whole life. As previously stated, Craik and his colleagues demonstrated in their research that bilinguals experienced Alzheimer's disease (AD) symptoms 5.1 years later than monolinguals, but they focused on the difference between lifelong bilinguals and monolinguals.⁶ Similarly, three other studies^{5,16,28} determined that bilinguals reported AD symptoms around 4 years later than monolinguals. They also concluded that due to this, bilingualism may serve as a cognitive reserve (CR), which is linked to delaying dementia onset. But again, all of these studies only compared lifelong bilinguals to monolinguals.

Because of this, there is a limitation to the generalizability of these findings. Increased diversity in the types of participants is needed. Specifically, a focus on AoA is needed, as many bilinguals these days learn their L2 at different stages in their life.

Review of Studies with a Focus on Age of Acquisition. Despite what has just been stated, there are studies that compare early and late bilinguals. One example of this is research presented by Yow and Li²¹ on executive functioning, specifically inhibition. As previously stated, through the Stroop task,²⁴ they reported that early and balanced bilinguals had better inhibition than late bilinguals. In a different study that studied executive functions' relation to CR, it was shown that inhibition is linked to CR,²⁹ which is then related to the delay of dementia onset.¹² Thus, Yow and Li's result means that early bilingualism benefits the onset of dementia more than late bilingualism does. But it is important to note that only bilinguals who acquired their L2 before the age of 7 were included in the study. So, the late bilinguals in this study may still be considered early bilinguals in other settings.

Another study that compared early and late bilinguals is by Grueso *et al.*³⁰ The participants of this research included three groups: early high-proficiency bilinguals, late high-proficiency bilinguals, and late low-proficiency bilinguals. Both the participants' proficiency and AoA were collected through a survey. Bilinguals were defined as early if they acquired their L2 before the age of 6, and late if after the age of 6. Through various tests, including the Cognitive Reserve Questionnaire, each participant's cognitive abilities were measured. Researchers found that high proficiency bilinguals outperformed those with low proficiency, and early AoA outperformed late AoA.

Specifically, in the WAIS-IV coding test, which was used to measure participants' processing speed, participants with high proficiency performed similarly (around 0.00 to 0.15) regardless of their AoA, while participants with both late AoA and low proficiency performed relatively poorly (-0.30 to 0.00). This indicates that early high proficiency bilinguals had the best, and late low proficiency bilinguals had the poorest cognitive abilities out of the three groups. The researchers concluded that proficiency overrides AoA and that bilingualism, especially for those with high proficiency, may serve as a CR. Since CR may lead to a delayed onset of dementia,¹² this result indicates that earlier AoA and higher proficiency both contribute to delaying the onset of the disease.

Similar results were found in a study that focused on multilinguals instead of bilinguals,³¹ and also in a study that compared early (AoA < age 10) and late (AoA > age 10) bilinguals in Canada.³² In the former study, where researchers used multilinguals as their participants, participants were classified into either an active or a passive multilingual group with high or low proficiency, respectively. Information on their language history and executive functioning was collected, and the data show that active multilinguals scored 0.22 units higher in executive functioning than passive multilinguals, supporting the trend of increased bilingual advantage for multilinguals with high proficiency.³¹ The latter study, which compared early and late bilinguals in Canada, also reported similar results. Using a questionnaire, participants were divided into early or late bilinguals with AoA described above. Their assessment of the flanker task showed that early bilinguals had the earliest response time of 557.9 milliseconds, while late bilinguals and monolinguals performed very similarly, with 569.8 milliseconds and 565.2 milliseconds response time, respectively. This indicates that early bilinguals with high proficiency have higher executive functioning.³² However, the methods in which each study measured their participants are a bit different, so the results might only be comparable in some cases.

Another study comparing early and late bilinguals was done by Tao *et al.*,²⁷ but the results were somewhat contradictory to what has been discussed above. This study also focused on the question of AoA, balanced bilingualism, and the impact of these factors on executive functioning. Early bilinguals were defined as bilinguals with their AoA of the L2 at or before age 6, and late bilinguals were those with AoA at or after age 12. The level of proficiency was self-reported. The researchers gathered data through the Flanker task that early bilinguals outscored late bilinguals and monolinguals, and that late bilinguals performed better than monolinguals, indicating that any extent of bilingualism had a benefit on executive functioning over monolinguals. Adding on, and surprisingly, late bilinguals showed better ability in conflict resolution, which involves inhibition skills, than early bilinguals. The researchers thus concluded that different language experiences impact executive functioning differently. These results partially contradict what has been discussed above, indicating the fragility of this research topic and the importance and necessity for further research in the field.

The differences in methods, measures, and results between studies indicate that not all of the studies are comparable or consistent with one another. Due to this, the question of whether the AoA impacts the onset of dementia remains unclear. There is another topic closely related to this field, which is the comparison solely between different types of late bilinguals and their advantages in executive functioning.

Review of Studies with a Focus on Late Bilinguals. Several studies in the field only focus on late bilinguals and the differences within the population. One example of this is research that examined how late bi- and multilinguals' proficiency and daily use of different languages impact executive functioning, especially inhibition.³³ Their participants included late bilinguals and multilinguals who acquired one or more foreign languages at or after the age of 5. All factors, including daily use and proficiency, were measured through a questionnaire, and the results showed that higher mean proficiency was related to better inhibition. This indicates how proficiency might play a larger role than AoA or daily use in terms of its impact on executive functioning skills.

There was another study that focused on better executive functioning skills among late bilinguals, specifically brain plasticity. Lin³⁴ conducted research on late bilinguals in Beijing, China, to fill the gap regarding late bilinguals and how they may affect the delay of dementia. Since neuroplasticity is linked to CR³⁵ and thus the onset of dementia,¹² Lin questioned whether late AoA of L2 affects one's neuroplasticity. After comparing groups with different language exposure levels, she concluded that those with more exposure to English (192 hours) had better brain plasticity than those with less exposure (64 hours). These numbers of hours were equivalent to the number of academic years of learning English, where 192 hours meant 3 years and 64 hours meant 1 year. This result indicates how the time commitment to learning the L2 may also impact the onset of dementia. However, the researcher cites active lifestyle and social life responsibilities of the people in the researched area as factors that might have influenced these results, so the findings of this study may only be generalizable to people in Beijing, China. Since generalizability is crucial to determining the extent of bilingual advantage, this research is insufficient to answer the question of delaying the onset of dementia.

Another research paper that supports the bilingual advantage of late bilingualism focuses on the language control abilities of bilinguals. Festman and her colleagues³⁶ studied 29 late bilinguals with different language control abilities and measured the participants' executive functioning skills. Assessments through the Wechsler Adult Intelligence Scale³⁷ and several other executive function tasks showed that those with strong control abilities performed better on most of the tasks, especially in the WAIS tests, where they scored 17.2 on the information section, while those with weaker language control abilities only scored 13.4. The same trend persisted for all the other sections. The researchers concluded that participants with stronger language control ability have an advantage over those with weaker language control ability in terms of executive functioning. CR is a part of executive functioning,

so better language control may play a role in the delay of dementia onset.

All of these different factors may indicate that late bilinguals also benefit from the bilingual advantage and the delay of dementia. But some studies refute the overall hypothesis. One of them is research done by Zahodne *et al.*³⁸ on late bilinguals who acquired their L2 in adulthood. Although their results supported that bilingualism improved basic executive functioning, they found that it was not connected to delaying cognitive decline and thus had no link to delaying dementia. They only included English-Spanish bilinguals as their participants, so their findings may not be generalizable to all, but the extent of generalizability is unclear. They concluded their research by hypothesizing that only bilinguals with higher education may exhibit an advantage in CR.

One explanation for this result differing from others may be the research methods used by researchers. In this study, researchers conducted a longitudinal study involving Cox regression, which helps examine the effect of multiple variables on the onset of a disease. In contrast, in Festman and colleagues' study, which indicated that late bilingualism may benefit executive functioning, the researchers mainly examined the data gathered from assigning multiple tests and tasks to their participants.³⁶ Since there are multiple papers mentioned previously that support these researchers' conclusion, the actual impact of bilingualism on the onset of dementia remains unclear.

Despite the need for further research, it can presumably be said that there is some kind of bilingual advantage that late bilinguals enjoy, whether it is the actual delay of dementia onset or some other factor of executive functioning. Due to the contradicting results, though, not all research in the field supports the hypothesis that any type of bilingualism has an advantage in dementia; further research on this question is needed in order to better define the extent of this proposed advantage.

Future Directions. No certain conclusion on the bilingual advantage for late AoAs can be drawn because of the inconsistencies derived from different definitions of bilingualism. These include measures of the AoA and the balancedness of bilingualism, as well as the method used to measure these factors (assessment or self-report). This showcases the need for a standard measurement of bilingualism, which is a part of the suggestions previously addressed by De Bruin in her broader review of bilingual advantage.¹⁰ De Bruin proposed that the proficiency of the languages should have a standard measurement. Adding on to this, there should be a standard measure of AoA. This is the cutoff age where a bilingual person would be defined as early or late. One possible solution would be to determine the critical period of learning two languages simultaneously and to make the age at the end of that period a cutoff.

Furthermore, it is recommended to align the definition of L2 AoA so that it really reflects the AoA of that language. In other words, AoA should be the age when the person began using that language fluently and not the age when they started learning that language. Even if this was the intention for researchers using AoA as a factor in their research, they must

make this clear to their participants, especially when collecting these data in a survey or some kind of self-report. This would allow the researchers to get their desired data on their participants. This definition of AoA was originally used by Luk and colleagues in their research on AoA's impact on cognitive control.³² They used this definition because an individual cannot be fluent in a language that they have just started learning. This way of defining AoA should be used increasingly in future studies so that all studies have a consistent measure of AoA that aligns with the participants' onset of fluency in any language.

Also, there is a very limited amount of research that considers the bilingual advantage of early and late bilinguals who speak different kinds of languages. As mentioned previously, the similarities and differences between the languages people speak may have an impact on executive functioning. For this reason, it is important to take into account various factors of bilingualism in studies.

In general, more studies need to be conducted around late bilinguals and their advantage in dementia onset in order to arrive at a clearer conclusion. This is true with all the other types of bilinguals as well. These people would include, for example, bilinguals with low proficiency or those who learned their L2 in different settings, such as at school or at home. No specific suggestions can be made since this review does not focus on those groups of bilinguals. Going back to late bilinguals, if late bilingualism can be proven to be one of the ways that delays the onset of dementia to some extent, it will have a great impact on a global scale. By encouraging learning of an L2 for both children and older adults, we can aim to reduce the risk of dementia.^{39,40} Even if the hypothesis becomes disproved, we can still encourage early L2 learning for reduced risk of dementia. Decreasing the number of dementia patients will not only improve the lives of each individual but also benefit the global economy. The cost of care for dementia is substantial for each patient, and that burden added up to 1.3 trillion USD globally in 2019, according to Wimo *et al.*¹¹ This cost is predicted to increase as time passes, so any effort to either prevent or delay dementia would be valuable.

■ Strengths and Limitations

There are several strengths to this review paper. To the author's knowledge, this is one of the first reviews that focuses on the relationship between late bilingualism and dementia. Another strength of this review is that it provides suggestions for further research that would contribute to clarifying the extent of the bilingual advantage.

As with all research, this review is not exempt from limitations. One limitation of this review is that it references existing literature that may not be generalizable. For example, Yijin Lin³⁴ conducted a study on the neuroplasticity of late adult bilinguals in Beijing, China. Although she found that a longer time commitment in language learning led to better neuroplasticity, the researcher mentioned that the findings might be influenced by social aspects of Beijing, so it is not generalizable.

This limits the ability to review thoroughly and come to a clear conclusion.

■ Conclusion

Multiple studies indicate that bilingualism might impact the onset of dementia.⁴⁻⁶ Among the studies that go in depth on bilingual advantage, many of them only take into account lifelong or early bilinguals.^{6,14} Not so many of them put an emphasis on bilinguals who acquired their L2 later in their life.^{21,32} This paper summarizes the current findings on the general bilingual advantage on the onset of dementia and then reviews papers that focused on late bilingualism and dementia.^{34,36} In conclusion, the extent to which late bilingualism has an impact on the onset of dementia remains unclear and highly debatable.

In order to advance our knowledge about the bilingual advantage, a more detailed definition of bilingualism is needed, especially the AoA. This includes both establishing the standard age cutoff for early and late bilinguals, as well as determining which stage of language learning should be considered as the AoA. By improving the definition of AoA, the extent of late bilingualism's impact on the onset of dementia can be better examined. This will contribute to the possibility of decreasing the number of dementia patients because if this advantage for late bilinguals can be proven, then L2 learning can be encouraged at any stage of one's life. Even if future research disproves this advantage, L2 education from earlier on in life can be encouraged more. Reducing the number of dementia cases will decrease the hardship of both patients and caregivers, improve public health,⁴¹ and benefit the global economy.¹¹

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