



The Bilingual Brain: Exploring the Impact on Cognitive Health and Resilience

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Abstract: This paper explores the multifaceted and intertwined relationship between bilingualism, cognitive reserve hypothesis, cognitive plasticity, and cognitive health. Studies have shown that being a bilingual who is continuously in control of two languages has a noticeable impact on cognitive performance. While bilingualism may not impact all stages of cognition, bilinguals tend to excel especially in tests requiring creativity, memory, and other executive functions. Furthermore, the article also delves into the impact that Cognitive Reserve Hypothesis (CRH) has on cognitive plasticity and the result of said impact. Through synthesis of empirical studies, medical evidence, and neuroimaging reports, this paper showcased the interplay between bilingualism and the efficiency and plasticity of cognitive processes.

Keywords: Bilingualism, Cognitive Reserve Hypothesis (CRH), Cognitive Neuroplasticity.

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1 Introduction

Research in the field of bilingualism goes way back in time up to the 1950s delving into its intertwined link to different domains and aspects of human life, body, and lifestyle. Recently, interest has spiked in the domain of investigating the measures of brain adaptation with aging and neurodegenerative diseases in relation to bilingualism. Scholars' efforts resulted in a link between brain plasticity and the development of the cognitive

reserve hypothesis (CRH) being induced by bilingualism. The CRH suggests that individuals with more enriched brains are less likely to know a quick decline in cognitive functions and they show less symptoms of brain dementia. The CRH swivels on cognitive plasticity. This latter entails the brain's ability to reorganize its pathways and connections in response to neurological damage. Studies suggest that bilingualism interferes with the said processes by claiming that bilinguals have palpable advantages in cognitive functions such as improved attention control, task-switching, and memory performance (Gold et al., 2013; Perquin et al., 2013; Woumans et al., 2015). These tasks are mastered as a result of the bilingual's continuous need to monitor and switch between languages, which engages and strengthens cognitive networks and performance. This article is therefore an attempt to contribute to the body of literature by exploring the cognitive benefits of bilingualism for speakers who are continuously controlling and using two different languages.

The study is significantly important because, first, it explores the intricate relationship between cognitive reserve, cognitive plasticity, and the potential cognitive benefits of bilingualism. Second, it synthesizes existing literature to provide a deep understanding of how bilingualism can contribute to cognitive health and act as a shield against cognitive decline and neurodegenerative diseases. Lastly, it deeply delves into fundamental and foundational principles of cognitive reserve hypothesis and cognitive plasticity examining their roles in cognitive performance in direct relationship with bilingualism. **Title 2**

Background

With almost half the people in the world being bilingual, bilingualism is considered a widespread phenomenon. It is no longer the exception but rather an accepted fact. Studies of bilingualism date back to the early 20th century when Peal and Lambert (1962) conducted a study comparing French-English bilingual children to French monolingual children. Their work paved the way to build an understanding of the several measures of bilingual's influence on cognitive development.

According to Peal and Lambert's work, results indicated that indeed there is a difference between monolingual and bilingual cognitive abilities and performances. They found that bilingual children tended to outperform their monolingual counterparts on tasks requiring cognitive control. Thanks to their groundbreaking work, more research and inquiry were channeled towards discovering and investigating the cognitive advantages and impacts of bilingualism.

As more research was conducted in the field, scholars began to recognize that bilingualism is not a mere linguistic ability that is as simple as choosing what language comforts the speaker more, but it also has profound tangible, and recognizable cognitive implications. The Cognitive Reserve Hypothesis in the late 1980s emerged to explain that the complex cognitive processes and the bifurcation of cognitive performance allow some people to cope better with neurodegenerative diseases and show late onset of dementia.

A. Historical perspective on bilingualism

1. Background on Bilingualism

Bilingualism is a phenomenon that has long existed in the history of mankind. It is safe to say that no one society is genuinely monolingual and no one language is uniquely intact and strictly independent of other languages. Bilingualism is a complex phenomenon that has multiple definitions; however, they all share the same fundamental principle suggesting that bilingualism is a speaker's ability to speak two languages frequently and with a native-like mastery. It is also a challenge to strictly decide on its percentage around the world. However, according to Grosjean (2024), he estimates that around 43% of people in world are bilinguals. That is approximately 3.3 billion people speak two or more languages. "Bilingualism has been and is nearer to the normal situation than most people are willing to believe" (Lewis, 1976 as cited in Adebile, R. 2010). These statistics suggest that more than half the world's population speaks more than one language.

There have been several reasons that supported the spread of bilingualism in the world, among which we find the movement of people for different urgent reasons, political reasons and cultural and educational factors. One of the major results that surfaces when people move around the world regardless of the reason is language contact. That is to say, no matter what the motives are that encouraged and forced people to move around the world be it political, industrial, military, etc., the result, language wise, has been the same. That's several patterns of bilingualism and even new languages may emerge once a group of people from one place migrate to another place with different linguistic backgrounds. The state-of-art is that being the hosting nation or the migrating/invading one, there are always chances for both groups to end up learning each other's languages.

Other reasons that are considered major in the spread of bilingualism are intermarriage and education. The movements of people across borders facilitated the meeting and the marriage of people from different nationalities. The result is that a couple will be speaking parts of each other's language, and their babies will be perfectly bilingual. Education as well has immensely contributed to this scene. The educational system usually has one dominant or first language that is taught to students throughout their educational journey. Therefore, children of immigrants will have the chance to learn another language besides the one they use at home, as well as a chance to learn a third and maybe even a fourth foreign language depending on the education policy of the resident country.

This worldwide spread did not go unnoticed and has granted itself a body of deep well-detailed studies of its implications on bilingual speakers and their cognitive abilities. There are several

researchers who have demonstrated that bilingualism indeed offers diverse, strong, and complex mental processes to the bilingual brain (Bialystok, 2017; Costa et al., 2008; Marian et al., 2007). Peal & Lambert (as cited in Takakuwa, 2000) conducted an experiment where they studied a group of ten-year-olds divided into subgroups: bilingual and monolingual. The two subgroups were required to sit for 18 different tests to measure their intelligence. The results forecasted that the bilingual group outperformed the monolingual one by 83 percent. It was also proven by pieces of research by Scott, Kessler, Quinn, and Carringer (as cited in Al-Amri, 2013) that bilingualism promoted both intelligence and creativity enabling bilingual children to perform much more complex tasks with high levels of imagination and cognitive flexibility. They have also shown that bilingual children harness an ability to transfer their decontextualized linguistic skills and knowledge from one language to another facilitating language use and communication, while monolingual children are limited to familiar contexts in their mother tongue.

B. Cognitive Theories Related to Bilingualism.

1. The Cognitive Reserve Hypothesis

Bilingualism is a domain that is familiar with intensive research and knows extensive dwelling in its paths, hence, there are theories manifesting the effect of bilingualism on diverse aspects of our life and existence including our cognition and brain.

The concept of Cognitive Reserve Hypothesis (CRH) was first introduced in 1992 by Yaakov Stern. It entails that certain factors and the surrounding environment impact individuals' cognitive performance and the influence that aging related diseases have on their cognitive abilities. Due to several methods of examinations, studies have been able to detect the relationship between cognitive reserve and neural plasticity in brain structures. With age, people usually face different types of diseases and neurodegenerative illnesses resulting in a decrease in cognitive capacity and functions, which sometimes lead to cognitive impairment or dementia. According to CRH, the brain is capable of compensating for the loss of brain cells and other dysfunctions by engaging in preexisting cognitive processing strategies. This operation usually calls for a certain level of cognitive plasticity. This latter showcases the brain's ability to compensate for damage by reorganizing and forming new neural connections.

In the same path, CRH suggests that brains who were noticeably active in diverse cognitive processes before a certain neurodegenerative disease actually are the ones who perform better and show better preservation strategies and adaptation techniques. It suggests that engaging in intellectually stimulating activities, such as ones that require extra efforts from the brain throughout one's life, can build resilience in the brain's wirings and cognition and protect it

against cognitive decline and neurological disorders. In other words, protecting one's brain health entails engaging in different cognitively demanding activities. A study by Bialystok, Fergus & Craik (2006) suggests that intellectually engaging activities such as learning new skills, languages, engaging in critical thinking, and pursuing higher education have all been associated with increasing the cognitive reserve. These findings are based on the effect that mental and cognitive load that the brain undergoes to fulfill and perform such tasks guarantees a continuous and non-stopping practice and usage of the cognitive functions. This latter promotes better cognitive health and has substantial effects in fighting against the fast increase of dysfunctional cognitive performance.

Research in this domain has suggested that bilingual individuals may have some indicators of delayed onset neurodegenerative diseases mainly Alzheimer's symptoms compared to monolingual individuals. Studies have shown that the constant mental effort involved in switching between languages may contribute to increased cognitive reserve (Luk, G., & Bialystok, E. 2013). Bilingualism has been found to enhance cognitive control and attention, which are key components of executive function offering a possible explanation for the observed protective effects of bilingualism against Alzheimer's. This is due to the assumption that the use of the pre-existing neural networks through activities that demand high level of mental effort, for example using a second language regularly, is efficient in fostering the cognitive reserve. Researchers, such as Hijmans (2011), have proposed that neural pathways that are used to manage a secondary language may also operate as a form of compensatory mechanism, allowing for a longer lifespan of the cognitive functions and performance and are better at nudging cognitive pathological diseases.

Studies have shown that there are other factors that might have an impact in the enhancement of CRH (Chertkow et al., 2010; Perquin et al., 2013). The idea of cognitive reserve was the result of clinical observations regarding the severity of dementia at death. This factor has been found to be immensely important and at the same time associated with the occupational attainment and educational achievements of the patients. For example, the higher the level of education of the patients and the more cognitively demanding the jobs they have, the less severe clinical symptoms of dementia they demonstrate. This result was attained as a comparison to people with less education and less cognitively demanding jobs. To this end, several factors, namely bilingualism, education and occupation are directly associated with slower rates of

cognitive decline, and CRH brings into play compensation mechanisms which hinder the onset of clinical cognitive decline in patients with neurodegenerative diseases namely Alzheimer's.

2. The Neuroplasticity of the Bilingual Brain

Advancement in medicine and in neuroimaging techniques have contributed immensely to the studies of cognition, brain, and the impacts that several factors have on brain plasticity among which we have bilingualism. Research by Abutalebi and Green (2008) has manifested that bilingualism can lead to structural and functional changes in the brain. They found out that bilingualism emphasizes more involvement and efforts of multiple brain regions in managing language selection and switching. Therefore, bilingual individuals exhibit enhanced cognitive abilities and executive control compared to monolinguals. This result entails that the cognitive control exhibited during language production suggests that bilingualism can contribute to the development of cognitive skills.

These results mean that bilingual brains may exhibit greater neuroplasticity in order to adapt to the demands of managing two languages. There have also been several studies conducted to investigate the potential benefits and impacts of bilingualism in mitigating age-related cognitive decline (Bialystok et al., 2007; Chertkow et al., 2010; Gold et al., 2013; Perquin et al., 2013; Woumans et al., 2015). Diverse results suggested that the concept of neurocognitive reserve claims that, by all the aforementioned benefits and advantages of bilingualism, has the ability to enhance cognitive functions throughout one's life leading to a delay of the onset of cognitive impairments such as Alzheimer's disease. This finding sparked interest in delving into bilingualism research as a protective means against cognitive aging.

The brain's plasticity, which is the capacity to change in response to experiences and environmental demands, was tangibly observed as results of an analysis of the Anterior Cingulate Cortex (ACC) which is implicated in several cognitive functions. This area appeared to undergo noticeable modifications in bilingual brains, which were results to the continuous need to manage and switch between two languages. The graph below by Mechelle (2004) demonstrates the structural changes with the increase of Grey-matter density in the ACC that was observed in bilingual individuals in comparison to monolinguals.

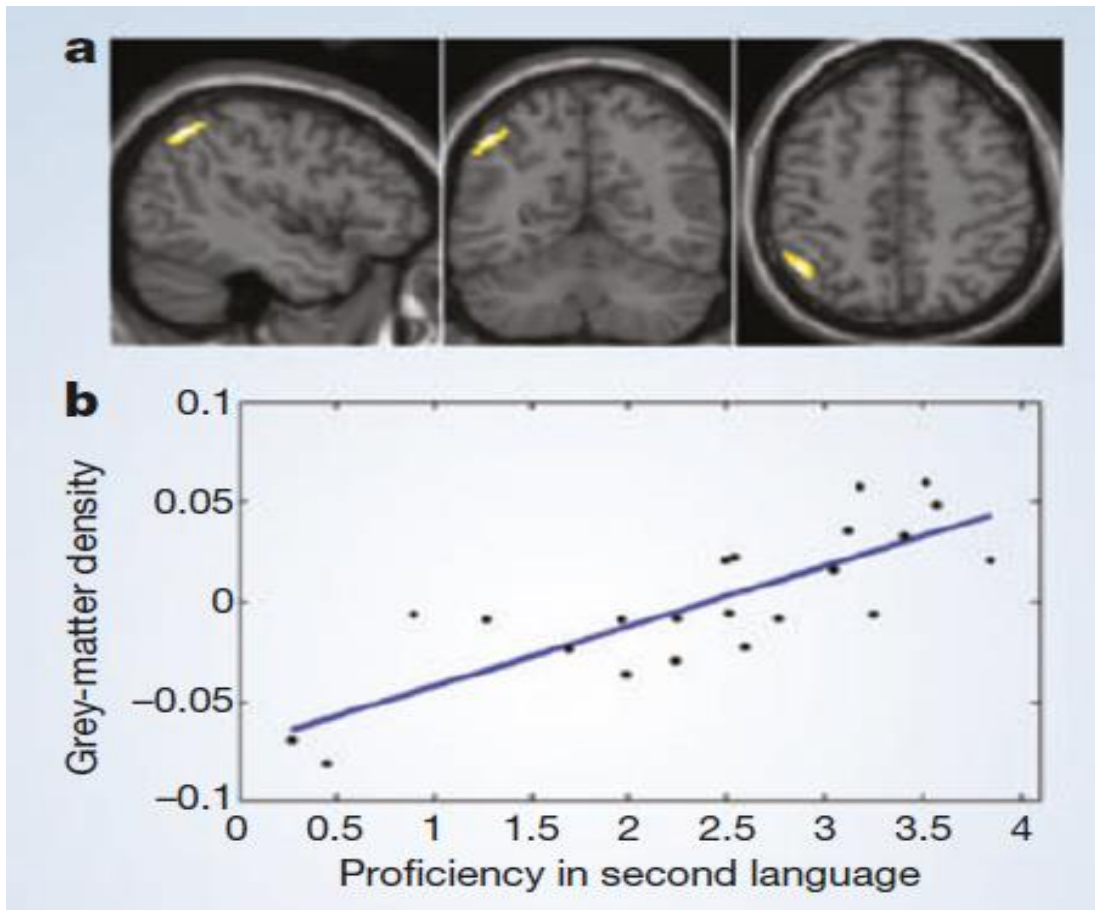


Figure 1 Structural reorganization in the bilingual brain by (Mechelli et al., 2004).

An addition to the Anterior Cingulate Cortex (ACC), there are other regions that were observed to be involved in language processing and executive functions that also show signs of neuroplasticity in bilinguals. Dorsolateral prefrontal cortex (DLPFC), which is responsible for working memory and cognitive flexibility, also knows extensive altered activation patterns in bilingual brains during language tasks (Luk et al., 2011). This fact also implies that bilingual brains do not only adapt structurally but also, they function differently when engaging in language related tasks. The dynamic interplay between these brain regions showcases the remarkable brain ability to rewire itself, when necessary, in response to demands of managing multiple languages.

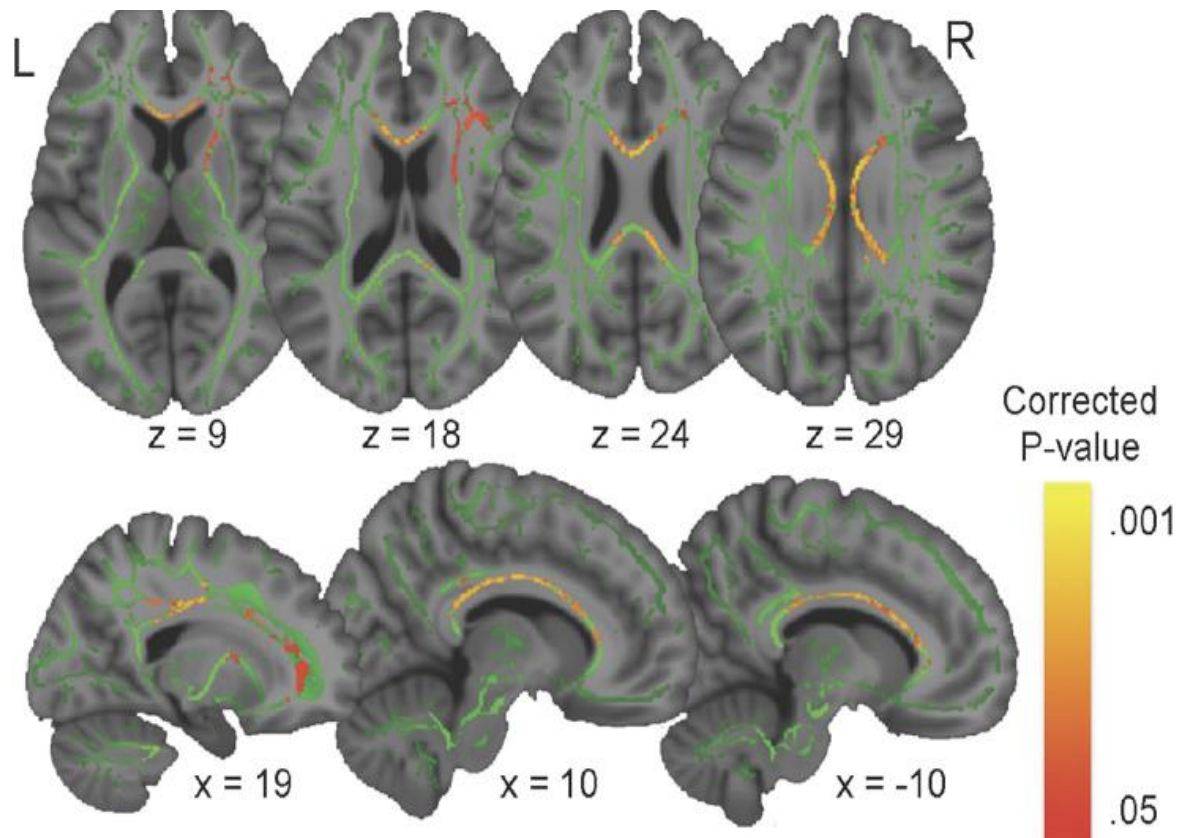


Figure 2 Group Differences in FA and RD by (Luk et al., 2011).

In this figure by Luk et al., (2011) we can see that this scan focuses on Fractional Anisotropy (FA). This latter demonstrates the organization of structures and brain connections. It suggests that bilingual people's brains compared to monolinguals' have better structured connections. This is shown by the red orange color in certain areas of the brain, such as the Corpus Callosum which connects the two sides of the brain. As a result, when comparing bilingual and monolingual brains we can physically notice the difference and conclude that bilinguals have more organized and structured connections than monolinguals.

C. Previous Research on Cognitive Benefits

As cognition is not a concept that renders itself easily to definitions, Flavell, Miller and Miller (as cited in Takakuwa, 2000) has framed it as a mental process that incubates several other characteristics including knowledge, intelligence, thinking, imagining, creating, generating plans and strategies, reasoning, inferring, problem-solving, conceptualizing, classifying, etc....this set of processes and operations is strictly complex in its nature and can be independently impacted and influenced by the acquisition of another language. The brain's ability to stretch new paths while developing each ability is intensified when it is supported and strengthened through creating deeper and more complex pathways for a second language.

The “cognitive development” concept was first introduced by Piaget in attempts to illustrate the impact that the environment can have on human knowledge. He tried to demonstrate that learners can absorb knowledge from their environment and build on it. This knowledge can be used to unify and strengthen the pre-existing schemata which in turn will assist in generating new knowledge. This operation takes several circular and repetitive steps of assimilation, accommodation, and feedback providing results in the endless enhancement of learning process. (Huitt & Hummel, 2003).

Based on the definition given above, there is a deep and interlinked relationship between bilingualism and cognitive development. Bilingualism signifies mainly the individual’s ability to classify, memorize, and create messages in a language that is different from his first. These processes are easily reinforced by a process of assimilation of syntax, semantics, and communication functions of the L2. Hence, resulting in a direct impact on the cognitive functions of the learning operation and leaving behind much more developed pathways that impact cognitive abilities of the individual.

According to Lauchlan, Parisi & Fadda (2012) bilingualism has tangible and direct impact on the development of several departments and areas of cognition such as: selective attention, problem-solving and creative thinking, and working memory. Learners’ selective attention observantly sharpened by their ability to speak two languages. Bialystok (2001) argued that bilingual children have developed an ability to utilize their perception in a deterministic manner and choose the appropriate options from a range of various distractions. She claims that bilinguals develop a skill to analyze the context and use their perception of the meaning deterministically to decide which word or object is best fit to adapt to the context.

Likewise, Bialystok (2001) conducted a piece of research that concerned monolingual and bilingual children’s ability to make decisions in different circumstances. Both groups scored relatively the same when the required task was simple; they were asked to estimate the proportion of candies in a bowl. Once, the task included more challenges and distractions, bilingual children manifested and demonstrated elevated ability in focusing, analyzing, and determining the right number of objects with similar characteristics. The complex task properly manifested the bilingual children developed cognitive ability in decision-making and working under stress and distractions.

Similarly, according to Lauchlan et al., (2012) bilinguals have shown a remarkable mental flexibility that utterly impacted their problem-solving skills and their ability to come up with creative phrases, objects, and solutions. It is thanks to this ability of mental flexibility that

bilinguals are able to break down standards that exist in their mother tongue, analyze them, generalize them and find out more options. This fact grants them the capacity to think faster and out of the box and take into consideration different factors and aspects of the context and make choices accordingly. Carringer (as cited in Al-Amri, 2013) concluded that “bilingualism promoted creative ability in all aspects such as verbal and figural fluency, flexibility and originality” (Al-Amri, 2013, p.4).

Based on Grundy’s (2023) work on the role of bilingualism in neurodegenerative diseases, he found that being a bilingual helps build resilience to the effects of Alzheimer's disease. He also concluded that bilingualism has a major role in delaying symptoms, slowing progression, and maintaining cognitive functioning in the face of Alzheimer's disease. This fact also relates to bilingualism acting as a reserve factor and has the ability to decrease the rate of cognitive decline and Alzheimer symptoms (Voits 2023). Furthermore, ‘Bilingualism has been shown to enhance attention and cognitive control in both children (Bialystok, 2001) and older adults (Bialystok, Craik, Klein, & Viswanathan 2004; Bialystok, Craik, & Ryan, 2006)’ Bialystok (2007). The juggling between two languages and the exercises of cognitive performance in order to manage these languages lead to strengthening the cognitive processes and neural networks and at the same time function as a protection against cognitive decline, hence, enhancing the executive control and cognitive abilities.

Supporting the same claims, Bialystok (2006) conducted a study on 184 patients who were referred to a Memory Clinic suffering from cognitive complaints and showing symptoms of dementia. 51% of these patients were bilinguals. These latter showed symptoms of dementia 4 years later than monolinguals. Valenzuela and Sachdev (2006b) conducted a review of a study on longitudinal cognitive change factors. This review was based on a sample of 18 studies involving more than 47,000 individuals. This study resulted in the conclusion that higher levels of behavioral brain reserve were related to decreased rates of cognitive decline. The behavioral brain reserve factors mentioned are assumed here to relate to higher level of education, occupation, and other factors. This clearly suggests the importance and impact of higher education, namely bilingualism, on sustaining more adequate cognitive functions.

In conclusion, as it is observed, bilingualism has its impact maintained on different levels of cognition. And it undeniably produces positive effects in various cognitive domains such as knowledge, reasoning, problem-solving, executive functions, and memory. Studies have supported these claims by showing the results of tests done by children and by adults (Bialystok, 2001). The human brain would, given its complex nature, undergo profound and fascinating

adaptations and changes in response to different factors and experiences, and bilingualism being one of them. It leaves a remarkable positive touch as proved by neuroimaging studies and cognitive assessments.

D. Method

This article synthesizes its findings from various and diverse studies investigating the impact of bilingualism on cognition. The studies included were selected based on their focus on bilingual individuals and patients with mental dementia, specifically Alzheimer's. The selection criteria encompass studies published in peer reviewed journals, books regarding bilingualism, and medical articles tackling the impact of continuous alternation between languages on cognitive plasticity and resilience.

The reviewed studies contain diverse participant populations, including children, adults, and older adults with various intellectual levels. Inclusion criteria for participants varied across studies but generally included individuals who were bilinguals, held cognitively demanding jobs, showed neurological or cognitive disorders. It also included monolingual participants for the sake of comparison. The exclusion criteria involved the proficiency level in a second language, ensuring that participants did not fall below a specific threshold.

Data collection methods employed in the reviewed studies ranged from standardized cognitive assessments to neuroimaging techniques. Commonly used cognitive measures included tasks assessing executive functions, creativity, working memory, and attention. Some studies utilized neuroimaging methods, such as functional magnetic resonance imaging (fMRI) to examine patient's Anterior Cingulate Cortex (ACC) and Fractional Anisotropy (FA), to decide on brain activity and depict patterns associated with bilingualism regarding the size of the grey matter and plasticity of neurons and the cognitive performance. Specific analytical techniques varied across studies in order to analyze the data, but they often included longitudinal analysis to examine the changes in cognitive performance over time which successfully helped in detecting and exploring the relationship between bilingualism and cognitive outcome.

E. Discussion

In the light of the enormous body of research conducted in the field of bilingualism and cognition, it is established that bilingualism has undeniable positive influence on the health of the brain and cognitive performance. It actively contributes to the shaping of the brain and shields it from diseases.

For the brain to function at its best, it must entertain some level of plasticity which guarantees its ability to adapt to neurological damage and continue to function and perform its tasks properly. Individuals with more brain activities, namely mentally demanding jobs, higher education, and bilingual abilities, tend to cope with brain pathologies in a remarkable fashion and exhibit a lower risk of developing neurodegenerative clinical symptoms. The graph below by Jeon. M et al., (2020) demonstrates all the cognitive performances and tasks that exist in the cognition alongside with the ones that are affected by bilingualism and assimilated or accommodated in order to improve the schemata, hence, resulted in the development of the entire cognition.

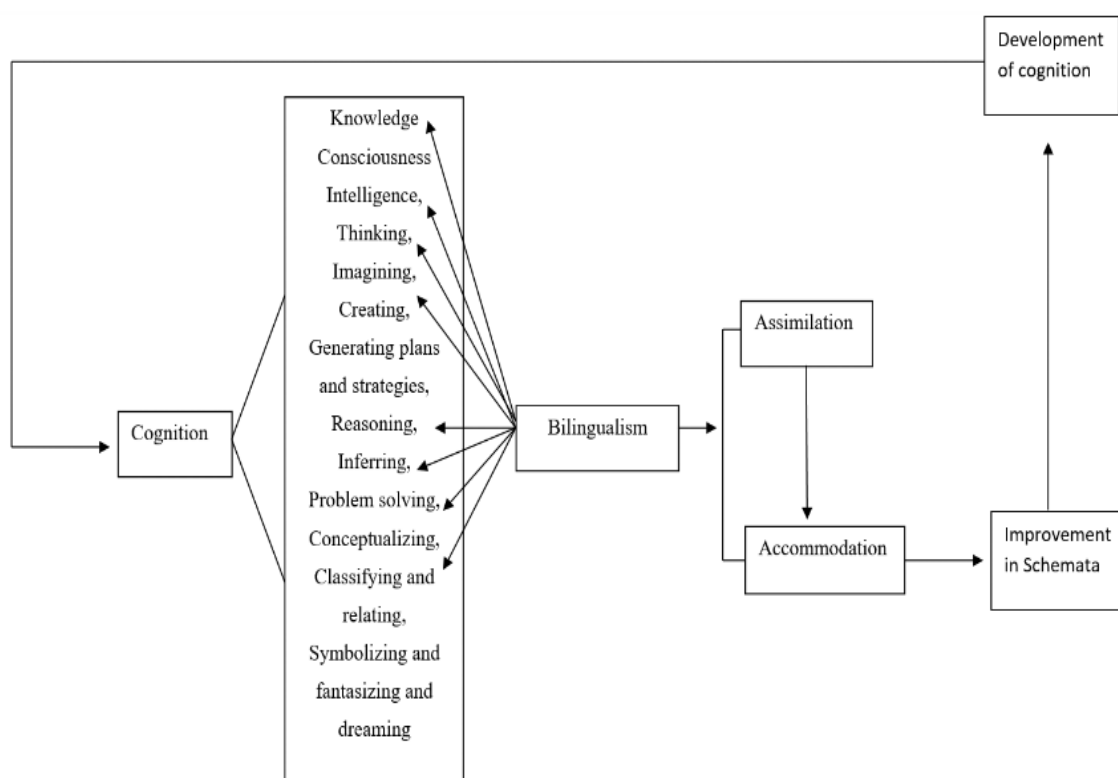


Figure 1. The influence of bilingualism in the cognitive development of human beings

From: Bilingualism And the Cognitive Development in Second Language Speakers (Jeon. M et al., 2020)

This ability to reorganize and form new connections flexibly assists in activating cognitive reserve which allows the brain to successfully adapt to neurological damage and pathologies as Alzheimer's. It is thanks to CRH that the brain maintains its cognitive abilities despite brain damage. There is a noticeable interplay between brain impairment and cognitive function. CRH plays a pivotal role in mitigating the progression of the symptoms of impairment and dementia. Since the operation of creating new neurons and new connections is a continuous lifelong process, bilingualism has played a significant role in inducing new pathways. It occupies the

role of sensory stimuli that urges forming new synapses, influencing learnings, memory formation, executive function enhancement, and cognitive function. Bilingualism is highlighted as a factor that can positively influence the cognitive reserve which promotes cognitive plasticity; potentially acting as a protective factor against cognitive decline.

The implications of bilingualism's effect on cognitive reserve and plasticity are remarkable, that is why its role needs to be taken more into consideration. Bilingualism can function as a protective measure that lessens the implications of managing cognitive decline associated with aging and neurological diseases like Alzheimer's. Consequently, a deeper enhanced understanding of the impact bilingualism can be essential for developing strategies that prevent and hinder the quickened decline and offer a slightly longer opportunity to longer utilize brain functions at their best.

Conclusion

In conclusion, this review comprehensively explores the intertwined connections between cognitive reserve, cognitive plasticity, and the potential cognitive benefits of bilingualism. The Cognitive Reserve Hypothesis (CRH) provides a framework that sheds light on the impacts that cognitive occupation and education contribute to cognitive resilient against cognitive decline and dementia. All along where cognitive plasticity functions as a vivid mainstay maintaining function amidst challenges. Bilingualism shows potential breakthrough for promoting cognitive health, with advantages in executive functions and memory performance observed in bilinguals. This paper suggests that bilingualism plays an immensely important role in promoting and strengthening cognitive control and neural efficiency through the constant demand of managing and switching between two languages leading to creating new pathways and transmission in the brain. This has a significant implication for the resilience of the brain against aging and neurodegenerative diseases.

However, there is an ongoing debate and lack of consensus regarding the specifics of cognitive reserve and its mechanisms tackling which part of the brain exactly is directly influenced by the bilingual factors. Also, there are other factors to be considered in research in this realm such as the age of acquiring the second language and the degree of fluency along with the degree to which the positive effects of bilingualism could be observable.

Thus, more and deeper research needs to be conducted investigating the different aspects of the cognitive reserve, its characteristics and mechanisms including how different environments and experiences impact its development. Also, investigating the different aspects of bilingualism (e.g., age of acquisition and language proficiency) and manners by which they influence the

different spheres of cognition. A longitudinal study can be efficient as to track the impact of bilingualism on the progression of neurodegenerative diseases.

As seen, there is a vivid interaction between cognitive reserve, cognitive plasticity, and the benefits of bilingualism in mitigating cognitive decline and potentially protecting against neurodegenerative diseases like Alzheimer's. However, there is as well an urging need for more detailed research to grant a better understanding of the mechanisms involved in maintaining cognitive health.

References:

Abutalebi, J., & Green, D. W. (2008). Control mechanisms in bilingual language production: Neural evidence from language switching studies. *Language and cognitive processes*, 23(4), 557-582.

Adebile, R. (2010). The Origin, Notions, Extent and Outcome Of Bilingualism: Implication For Effective Teaching And Learning Of English Language In Nigerian Junior Secondary Schools. *Academic Leadership: The Online Journal*, 8(4), 71.

Al-Amri, M. (2013). Effects of Bilingualism on Personality, Cognitive and Educational Beyond language (pp. 182-218). Port Chester, NY, USA: Cambridge University Press.

Bialystok E, Craik FI, Freedman M. Bilingualism as a protection against the onset of symptoms of dementia. *Neuropsychologia*. 2007 Jan 28;45(2):459-64. doi: 10.1016/j.neuropsychologia.2006.10.009. Epub 2006 Nov 27. PMID: 17125807.

Bialystok, E. (2001). *Bilingualism in development: Language, literacy, and cognition*. New York: Cambridge University Press.

Bialystok, E., Craik, F. I. M., & Ryan, J. (2006). Executive control in a modified anti-saccade task: Effects of aging and bilingualism. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 32, 1341–1354.

Bialystok, E., Craik, F. I. M., Klein, R., & Viswanathan, M. (2004). Bilingualism, aging, and cognitive control: Evidence from the Simon task. *Psychology and Aging*, 19, 290–303.

Chertkow, H., Whitehead, V., Phillips, N., Wolfson, C., Atherton, J., & Bergman, H. (2010). Multilingualism (but not always bilingualism) delays the onset of Alzheimer disease: Evidence from a bilingual community. *Alzheimer Disease & Associated Disorders*, 24(2), 118–125.

Costa, A., Hernández, M., & Sebastián-Gallés, N. (2008). Bilingualism aids conflict resolution: Evidence from the ANT task. *Cognition*, 106(1), 59–86.

Gold, B. T., Kim, C., Johnson, N. F., Kryscio, R. J., & Smith, C. D. (2013). Lifelong bilingualism maintains neural efficiency for cognitive control in aging. *The Journal of Neuroscience*, 33(2), 387–396.

Grosjean, F. (2024). The statistics of bilingualism. In *On Bilinguals and Bilingualism* (pp. 138-147). Cambridge University Press. <https://doi.org/10.1017/9781009210409.010>

Hijmans, C. T., Grootenhuis, M. A., Oosterlaan, J., Heijboer, H., Peters, M., & Fijnevandraat, K. (2011). Neurocognitive deficits in children with sickle cell disease are associated with the severity of anemia. *Pediatric blood & cancer*, 57(2), 297-302.

Huitt, W., & Hummel, J. (2003). Piaget's Theory of Cognitive Development. Educational Psychology Interactive, Valdosta, GA: Valdosta State University.

<http://www.edpsycinteractive.org/topics/cognition/piaget.html>

Jeon, M., Centeno, E. G., Morejón, S. M., & Peña, M. A. (2020). Bilingualism and the cognitive development in second language speakers. *Journal of Science and Research: Revista Ciencia e Investigación*, 5(3), 126-133. <https://doi.org/10.5281/zenodo.3926941>

Lauchlan, F., Parisi, M., & Fadda, R. (2012). Bilingualism in Sardinia and Scotland: Exploring the Cognitive Benefits of Speaking a Minority Language. *International Journal of Bilingualism*, 17(1), 43-56, doi: 10.1177/1367006911429622

Lewis, E.G. (1976). Bilingualism and bilingual education: The ancient world to the Renaissance. In J. Fishman (Ed.). *Bilingual Education: An International Sociological Perspective* (pp. 150-200). Rowley, MA: Newbury House

Luk, G., & Bialystok, E. (2013). Bilingualism is not a categorical variable: Interaction between language proficiency and usage. *Journal of Cognitive Psychology*, 25(5), 605-621.

Luk, G., Bialystok, E., Craik, F. I., & Grady, C. L. (2011). Lifelong bilingualism maintains white matter integrity in older adults. *Journal of Neuroscience*, 31(46), 16808-16813.

Luk, G., Grundy, J. G., & Anderson, J. A. (2023). Understanding Language and Cognition through Bilingualism. *Understanding Language and Cognition through Bilingualism*, 1-400.

Marian, V., Blumenfeld, H. K., & Kaushanskaya, M. (2007). The language experience and proficiency questionnaire (LEAP-Q): Assessing language profiles in bilinguals and multilinguals. *Journal of Speech, Language, and Hearing Research*, 50(4), 940-967.

Mechelli, A., Crinion, J. T., Noppeney, U., O'Doherty, J., Ashburner, J., Frackowiak, R. S., & Price, C. J. (2004). Structural plasticity in the bilingual brain. *Nature*, 431(7010), 757-757. of Bilingualism on cognitive control in the simon task: evidence from MEG. *Neuroimage*, 24(2005), 40-49. Doi: 10.1016/j.neuroimage.2004.09.044

Perquin, M., Vaillant, M., Schuller, A. M., Pastore, J., Dartigues, J. F., Lair, M. L., Bongard, V., & Diederich, N. (2013). Lifelong exposure to multilingualism: New evidence to support cognitive reserve hypothesis. *PLOS ONE*, 8(4), e62030.

Scarmeas, N., & Stern, Y. (2004). Cognitive reserve: implications for diagnosis and prevention of Alzheimer's disease. *Current neurology and neuroscience reports*, 4, 374-380. Takakuwa, M. (2000). What's wrong with the concept of cognitive development in studies of Bilingualism? *Bilingual review, PRISMA*. 25(3), 225-236. Retrieved from:

<http://search.proquest.com/docview/201172281/664EDA7A565240B1PQ/1?accountid=351>

Valenzuela, M. J., & Sachdev, P. (2006a). Brain reserve and dementia: A systematic review. *Psychological Medicine*, 36, 441-454.

Valenzuela, M. J., & Sachdev, P. (2006b). Brain reserve and cognitive decline: A non-parametric systematic review. *Psychological Medicine*, 36, 1065-1073.

Voits T: Role of bilingualism in neurodegenerative disease II. Beyond Alzheimer's. In: Luk G, Anderson JAE, Grundy J. *Understanding Language and Cognition through Bilingualism: In honor of Ellen Bialystok*, 2023. John Benjamins Publishing Company p. 357-373

Woumans, E., Santens, P., Sieben, A., Versijpt, J., Stevens, M., & Duyck, W. (2015). Bilingualism delays clinical manifestation of Alzheimer's disease. *Bilingualism: Language and Cognition*, 18(3), 568-574.