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Benefits of second language education to cognitive skills and overall brain function

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Abstract

We are living in a time and space where you constantly need to improve yourself. Numerous seminars, diverse courses, various trainings, and everlasting efforts. All of them serve the same purpose: our mental and intellectual improvement. When one examines those attempts closely, foreign language education will be one of some others in the foreground. Nowadays, people have the urge to acquire at least one foreign language and consider it as a must for educational and business purposes since it brings a large number of profits. Engaging with people from different countries and cultures and carrying your business to a more global and international environment are a few examples of benefits of L2 education. Likewise, attaining higher education abroad would give any learner a new perspective and a more widened horizon because, as Federico Fellini says, "a different language is a different vision of life." However, there are even more significant benefits of L2 education apart from these. In fact, learning a second language helps to improve cognitive skills such as intelligence and memory, while diminishing risks of developing brain-related diseases such as dementia and Alzheimer's.

Keywords: *Foreign language, Learning, Cognitive skills, Intelligence, Memory*

1. Introduction and methodology

In this research, we would like to cover how the brain functions through briefly explaining some major terms such as neuroplasticity and localization of function; how Second Language Acquisition (SLA) helps cognitive skills in regards to the brain-language relationship; how L2 education benefits to young brains; and how bilingualism can help adult brains in light of lowering the risks of brain aging.

Cognitive skills are the core abilities that the brain needs to reason, remember, and learn and, that is to say, such skills are pretty much everything that a human being needs to function by all means. As these skills work together, they comprehend the input and carry it to the knowledge store that the person applies in everyday life.

The brain plays the most crucial roles in one's major functions in the body. It carries primary and sensory functions some of which are speech, senses, coordinating muscle movement, and digestion. Every task that our body performs,

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everything that we store in our memory, every word we utter, every decision we make and many more limitless things that we perform are carried out by our brain. Our brains make it possible for us to use language to hear, speak, read, write, and understand.

With the revision and analysis of the major articles related to the benefits of second language learning we will understand this issue further and in more details.

2. Brain function

In order to recognize the benefits of L2 education, one needs to understand the way the human brain functions and what happens when the brain acquires language.

What the brain firstly does is processing information and this process starts at the individual brain cells followed by their interaction with other neighboring brain cells. Lise Menn, in her book called *Psycholinguistics: Introduction and Applications*, likens these interactions to the telephone system and says: "Millions of connections—superimposed onto geographic space—facilitate the interactions between you and your best friend, and your family across the country" (Menn, 2017).

The brain processes information by the nerve cells or neurons that carry the information to the parts that will help our body to process. So while you read, remember, or count, you make thousands of neural events taking place which is simply anything that is happening in a single brain cell. In a single neural event, information is being carried through complex branches. Information is brought by dendrites into the neuron, and the axon sends information to the next neuron in line. The near contact points between dendrites and axons are called synapses that receive neurotransmitter molecules from the tip of the axon if they perceive some event to cause one neuron to become active. By these events, active neurons release neurotransmitter molecules and send them to the neighboring neurons. In this way, each neuron carries activity to many others.

After all these events, if you happen to learn something—which means that it is going to stay in your brain, the information that is being processed should change your brain to some extent. So every time you learn something, the experience makes tiny changes "in the strengths of the synaptic connections between some of your neurons" (Menn and Dronkers, 2017). Since you have millions of connections, you do not forget anything by these changes but strengthen these synaptic connections. That means, more activation or, in another saying, more learning will make your brain even stronger and you will most probably have better memory indications.

3. Localization of function

As mentioned above, our brain is specialized in some functions. These functions are divided into two which are the motor and sensory functions. First of all, the brain is divided into two hemispheres which are called the right and the left hemispheres, connected by the corpus callosum which coordinates two hemispheres. Each hemisphere is divided into four lobes which are frontal, temporal, parietal, and occipital lobe. Frontal lobe controls our motor functions and movements while parietal lobe functions for the sense of touch. The temporal lobe is involved in auditory frequencies while occipital lobe has primary visual cortex. In addition, there are major parts of the brain which are called cerebrum, cerebellum, brainstem, and diencephalon. Each of them involves vital functions. The cerebrum controls higher functions such as reasoning, speech, senses like seeing and hearing. The cerebellum coordinates muscle movement that helps maintain the body's balance and posture. Brainstem holds spinal cord that contains midbrain, pons, and medulla oblongata. Again, these areas are very important as they are responsible for movement, senses, vital body functions like digestion and sleep. Last but not least, diencephalon has several structures as well: thalamus, hypothalamus and pituitary gland. These are responsible for governing sensation, energy, and weight regulations.

4. How the brain processes language

We happen to process language learning via activation and memory. As we start having listening experience of language from the moment we are born, these experiences make changes in the brain as mentioned above, and every time we hear an utterance or speech sound, we link it to the similar ones that are stored in our memory. As you learn any word, you do not only learn the sequence of that specific word but also store and link the information to the ones you already placed in your brain. When we save enough stimulating event to recall in our memory, we start producing speech. This idea is called the unselective linking idea.

Take a two-year-old kid as an example. This kid already stored two years of listening experience of the words of, let's assume, his first language. When he hears the verb 'take', he first hears it on the phonetic level and sees the face of

people saying the word. What he also does is to activate the connotations in his memory as he probably has a year of babbling experience. Besides with the visual and oral experience and context, his brain uses motor impulses to get the right oral plot to produce the word correctly in the right sequence. So every time he hears the word, he will activate the connotations in his memory and eventually start to produce speech.

5. Learning from aphasia

Aphasia, a language disorder, is a good indicator of brain-language relationship. The idea of localization of function, specific areas of the brain complying specific functions, can be understood through aphasia as two representative surgeons indicated two main areas for comprehension and production of language.

The first thing that can come to the mind about brain disorders will probably be the strokes that become to happen unexpectedly. Strokes can cause injuries in different parts of the brain and that affects different body functions. For example, if one loses his ability to produce the language, it means that the part of the brain which functions for that particular ability is damaged.

Aphasia is a language disorder that results from a brain injury. The surgeon called Pierre Paul Broca had a patient who could understand the language he heard but had problems with articulating speech. When Broca had this patient for the autopsy, he saw a lesion in the lower part of the frontal lobe. He concluded that the left frontal lobe was important for the ability to speak. Thus, this type of language disorder is called Broca's aphasia.

Likewise, another surgeon called Carl Wernicke described one of his patients who produced speech with no problems but had problems with understanding the language besides the fact that his speech did not make any sense. When this patient came for the autopsy, Wernicke noted "softening in the posterior part of the superior (upper) temporal gyrus, an area that later came to be known as Wernicke's area" (Menn, 2017). Therefore, difficulty with language comprehension is known as Wernicke's aphasia.

6. L2 learning and neuroplasticity

The ability of the brain changing and improving constantly by experience is called brain plasticity. Through this ability, the brain can adjust its physical structure according to the changes caused by experience. To give an illustration of these changes, increased volume of the posterior hippocampus of London taxi drivers is a considerable indicator since this area of the brain is essential for spatial memory (Maguire *et al*., 2000). This idea can also be explained through the case of deaf or blind people. For instance, in deaf people, neurons that are used for sound sensation are used for advancing visual language, and on the contrary, the area for advancing sounds increases over the area that normally advance vision in blind people (Menn, 2017), which additionally specifies the brain's ability to recover itself to some extent.

A study, namely, *Second-Language Learning and Changes in the Brain*, revealed learning-related changes through using event-related brain potentials (ERPs). In the experiment, it was concluded that "L2 instruction can result in changes in the brain's electrical activity, in the location of this activity within the brain, and in the structure of the learners' brains" (Osterhout *et al*., 2008) during the L2 acquisition, depending on syntactic and semantic processes and grammaticalization.

As a matter of fact, L2 learning can cause structural changes such as increasing grey matter volume (GMV) and cortical thickness (CT) since language learning is a great experience for a human's brain. Mechelli and his colleagues conducted a study to analyze the gray matter volume (GMV) in language learners and found it to be greater in the left parietal lobule (IPL) of bilinguals rather than monolinguals in relation to the age of learning and proficiency factor (Mechelli *et al*., 2004). Likewise, in a study proposed by Luk et al., it was clearly implied that bilingual adults had greater white matter (WM) integrity which again shows the direct impact of bilingualism on the brain through the idea of neuroplasticity (Luk *et al*., 2011).

7. Benefits of L2 education to young brains

In today's education system, foreign language education is present from primary school onwards in the curriculum of most schools. Besides preparing children for a better future that holds opportunities, learning a foreign language will help children to provide a common language with their peers from different national backgrounds.

Children are known to be more capable of acquiring a new language than adults due to their heightened neuroplasticity. As mentioned above, even though both hemispheres work in collaboration in terms of complying any function, the left

hemisphere holds most of the functions that are responsible for the language. However, this works differently for the children until puberty with regard to critical age hypothesis which implies the connection between language learning and age and claims that there is an ideal time period to acquire any language. So until the puberty, the brain of children uses both hemispheres to acquire language and stores any secondary language at the same place with their mother tongue, thus, having native-like commands of any foreign language they learned. The study that examined mono—and bilingual babies across two age groups—younger 4-6 months and older 9-12 months, showed that the left hemispheres of older babies showed more and earlier activity towards language than younger babies (Petitto *et al*., 2012) which is an indicator of the left hemisphere taking over the language acquisition as children grow older.

Not only easy acquisition is an advantage, but also the way the brain develops is another benefit for bilingual children. The change caused by bilingualism alters the structure of the brain, thus, improving particular cognitive functions. Many studies confirm the cognitive boost, longer attention span, better memory indications, higher scores on tests, and the self-esteem caused by bilingualism in children.

For example, a study conducted by Bain in order to measure the cognitive benefits of being bilingual on 11-year-old monolinguals and bilinguals of French-English in 1974. These children were matched on IQ level, academic performance, and socioeconomic status. Bilinguals outperformed monolinguals in solving problems that are based on logical operations and in describing emotional expressions of characters depicted in the portraits. Bain's deduction was that "the bilingual child has greater cognitive plasticity than his unilingual counterpart" and it also revealed bilingual children's superior performance in rule discovery tasks (Bain, 1974).

Study of Cummins and Mulcahy on three different children groups that are Ukrainian-English bilinguals, Ukrainian L2 learners, and English monolinguals. The participants from the first and third grades were matched on socioeconomic status, non-verbal IQ, gender, and age and they were given metalinguistic tests. Through the test results, Cummins and Mulcahy analyzed their ability to assess linguistic structures and find ambiguities besides with comprehending "the arbitrary nature of linguistic labels" (Cummins and Mulcahy, 1978) and finally found that bilingual children outperformed monolinguals on most tasks.

8. Changes in neurological processing and structure

Since knowing two languages activate both languages every time you think and respond, a bilingual should always figure out what to think and say in either language which can cause tip-of-the-tongue states in some cases due to the interference of one language to another. So being bilingual requires the need of controlling language use at any given time. Developing this need, adjusting the switch between two languages, improves the *executive functions*—controlling cognitive processes and behavior. Correspondingly, the areas of the brain that holds and controls such functions change and improve. Due to these reasons, children are believed to be better at solving problems and managing conflicts that are also deducted from many studies.

Two studies were made to report the performance of mono- and bilingual children from two different age groups. 56 children who were at the age of 5 were given a Simon type task—manipulating their working memory and conflict resolutions, they were asked to compare some conditions. Bilingual children responded faster to the ones that were based on rules and made more accurate choices between the conditions that did/not include conflict. Researchers concluded that this was due to the bilinguals' improved executive functions which helped them respond to controversial issues accurately. In the second study, 125 children who were 5 and 7 years old were exposed to some visuospatial span tasks that manipulated other elements of executive functions that consisted of "simultaneous or sequential presentation of items" (Morales *et al*., 2013). Bilinguals, again, predominated rather than monolinguals as they had a better ability of control and could ignore distraction.

Another study that revealed the benefits of bilingualism in intelligence was conducted by Landry on children in grades 1, 4 and 6. He compared the ones who attended Foreign Language in the Elementary School program to the one who attended regular school programs. These children were given the Torrance Tests of Creative Thinking and the results showed that for 6th graders there was a significant benefit for learning a foreign language as Landry indicated that a foreign language experience contributes to the ability to task-switching tasks and executive functions (Landry, 1974).

The first study to analyze non-verbal ability by using cognitive tasks rather than intelligence tests were made by Bialystok. He compared balanced bilinguals, partial bilinguals and monolinguals "on non-verbal tasks that varied in their demands for analysis and control" (Bialystok and Majumder, 1998). The relationship between bilingualism and the development of cognitive processes in problem-solving. Balanced bilinguals performed better than the other two

groups when they had to solve problems that required the ability to control more which, again, proves the contribution of bilingualism to the executive functions.

Changes that are recorded through some brain imaging techniques also show where and to what extent the activation takes place when a bilingual person is asked to switch between two languages. For example, an fMRI study proposed by Hernandez, Martinez, and Kohnert tracked down the changes in the brain when Spanish-English bilingual participants were asked to name pictures in Spanish and English. They recorded increased activation in the dorsolateral prefrontal cortex (DLPFC), a region that is responsible for executive functions. Along with it, they also found this switch being connected with some structures such as bilateral super marginal gyri and left inferior frontal gyrus (left-IFG) that also involve cognitive control (Hernandez *et al*., 2000).

As for some other benefits, white and grey matter volume alteration in the brain depending on bilingualism can be said to hold great importance. For children, being proficient in the second language, besides with early language acquisition, is found to increase gray matter volume in the left inferior parietal cortex (Mechelli *et al*., 2004). Similarly, some studies showed that white matter volume is found to be increasing in bilingual children (Mohades *et al*., 2012).

9. Benefits of L2 education to adult brains

Not only L2 education has numerous advantages for children, but it also holds many advantages for adults. Globalization, even simultaneously, is applied in many business areas and it entails communicational involvement with people from different national backgrounds. Therefore, knowing at least one foreign language is one of the requirements that one can encounter very often while applying for a job or an educational program. However, these advantages are not only limited to the ones we can benefit in business life. Foreign language education can improve cognitive skills, memory, and overall brain function. Apart from these, learning a second language seems to protect the brain aging and correspondingly it can lower the risks of developing a brain-based disease such as Alzheimer's disease or dementia.

As it is defined earlier, cognitive skills are the overall mental abilities that we need to carry out any task such as sleeping, digestion, regulating muscle control, reasoning, and so on. In light of this information, cognitive aging means that these cognitive skills deteriorate as we grow older. This process can cause reduced neuronal membrane integrity, distorted or changed normal metabolic functions, even death or loss of neurons since it includes oxidative stress detriment, wane of free radical detoxification, and loss of mitochondrial function (Tosato *et al*., 2007). Furthermore, late researches indicate that some areas of the brain like gray matter, white matter or hippocampus are more endangered in the aging process (Daffner, 2010).

Cognitive aging is considered as normal aging and pathological aging but when the deterioration reaches to a severe level, it leads to dementia or memory loss. Some studies have shown that slight cognitive impairment caused by Alzheimer's disease can start 10 years before the diagnosis (La Rue and Jarvik, 1987). Therefore, many adults or elderly people who are considered mentally healthy may be developing cognitive impairment or decline. However, in both cases, the indicators of cognitive aging including memory loss, decrease in executive functions, insufficient working memory, poor language use, and decelerate information processing (Antoniou *et al*., 2013).

Even though cognitive aging is a natural process that all human beings eventually experience, keeping the brain healthy and actively engaged is something that we can achieve to some extent. The cautions we take before adulthood can save and ease the latter phases of life. Notably, second language learning has been stated to serve to this purpose by many researches which indicate how bilinguals perform better than their counterparts when it comes to learning strategies, solving problems, attention regulation, and conflict management besides with declining cognitive aging (Wenguang and Baoguo, 2011).

Luo *et al*. found in his research that adult bilinguals have shown superior spatial working memory (WM) indicators rather than verbal WM comparing to their monolingual peers, implying superior executive functions (Luo *et al*., 2013). Significantly, a study on 814 healthy old participants has revealed a remarkable benefit of L2 learning: As a result of different cognitive tests, controlling some variables like age, gender, age, place of birth, and education level, they concluded for the first time that cognitive skills will increase depending on the number of languages the participants use regularly (Kavé *et al*., 2008). It is also suggested as a result of studies that more proficiency in a foreign language will provide more protection against cognitive decline and that the earlier the language is acquired, the stronger the protection will be (Perquin *et al*., 2013).

Another study conducted by Bak and his colleagues investigated 853 participants who are at the age of 70. All the participants were found to speak English before the age of 11 and 262 of them learned another language as well. After applying some cognitive tests, they compared the results with their own test results at the age of 11 and found that the

ones who became proficient in multiple languages have superior and remarkable cognitive ability, specifically in general intelligence and reading (Bak *et al*., 2014).

10. Bilingualism against alzheimer's disease

Second language learning, as a brain and cognitive health protector, is discovered to postpone the onset of dementia and Alzheimer's by recent researches. Snowdon *et al*. (1996) found that language ability of people who were introduced to English at the age of 19-27 and were ranking ages 78-92 at the time, was in negative correlation with Alzheimer's disease (AD). This negative correlation was found in some cerebral areas such as frontal, temporal, and parietal lobe as a result of an autopsy study (Guzmán-Vélez and Tranel, 2015). The innovational study was put forward by Canadian scientists Bialystok, Craik, and Freeman. They analyzed 184 patients who were suffering from different kinds of dementia, 70% having AD, in Toronto hospital. After the study, they, for the first time, suggested that L2 learning has a positive effect on pathological aging as they found that bilinguals who were diagnosed with AD were generally diagnosed four years later than the monolinguals. So the age of diagnosis for bilinguals 75.5 years and it was 71.4 years for monolinguals (Bialystok *et al*., 2007). Later in 2010, the same team conducted the research with a greater number of patients with AD. This time they took many other factors into consideration including language level, profession, gender, national background, and some other factors. In the end, they not only reached the earlier result but also found that bilingual and multilingual patients had onset time delayed up to five years (Bialystok et al., 2010).

Proficiency level in a foreign language is found to affect the onset age of AD as well. In a study on 44 English-Spanish bilingual elderly subjects, Gollan *et al.* found that the one with higher proficiency is less likely to experience the symptoms of AD or any kinds of dementia (Gollan *et al*., 2011).

11. Conclusion

All things considered, learning a second language may benefit cognitive skills and can delay the onset of brain aging. Cognitive skills are vital for carrying out any task and every task is performed via our brain. The significant relationship between the brain and language is crucial to explain how processing language is one of the hardest tasks our brain can ever perform. Aphasia, for example, indicates this significant relationship by showing how specific areas that are damaged can cause impairment in either comprehending or using language. Besides, the great activation caused by switching languages that recorded through some brain imaging techniques reveals the terrific effort when using languages. Making our brain actively engaged, using language is an ultimate exercise to the brain, therefore keeping it more healthy and perceptive.

Our brain is more plastic than we think and adjusting itself accordingly, its physical structure changes through our experience. Since learning a second language is an arduous exercise, it results in a greater size of the hippocampus, higher density of grey matter, bigger size of white matter and some other physical changes that contribute to a brain that is mentally sharp and flexible.

The benefits of bilingualism start from early childhood to elderliness. Children have the advantage of heightened neuroplasticity that helps them acquire language easily and have native-like commands. Because they use both hemispheres until puberty, they store all languages in the same place. Moreover, a bilingual brain develops differently by constantly improving cognitive functions, thus have a longer attention span, sharper memory, better problem-solving skills and managing conflict.

Adults benefit from second language learning to a great extent as well. For many years, scientists believed that most brain development has been completed in the early years of your life so that the brain is mostly immutable by adulthood. However, it has changed over the last 20 years, "decades, studies on animals and humans have found that the brain continues to form new neural connections throughout life" (Parker-Pope, 2014). This means that we can always increase the potential of our brain and make it healthier. Deterioration of cognitive skills due to aging requires a more actively engaged brain if one wants a healthy life. Many researchers have highlighted how bilingual adults profit stronger working memory and executive functions than their counterparts. Bilingualism, as protection against aging, has been found to delay the onset of dementia up to five years which is notably better than medication which can delay symptoms by only 6-12 months.

People from all age groups should be encouraged to learn a foreign language as to benefit a healthy brain, so a healthy and a good quality of life. Today, people generally apply for some brain training courses but learning a language will definitely pay off all the effort. Parents and adults should be informed about the advantages of L2 and the nature of cognitive decline as to give enough importance to the issue.

References

Antoniou, M., Gunasekera, G.M. and Wong, P.C.M. (2013). Foreign language training as cognitive therapy for age-related cognitive decline: a hypothesis for future research. *Neuroscience & Biobehavioral Reviews*. 37(10), 2689-2698

Bain, B. (1974). Bilingualism and cognition: Toward a general theory. In S. T. Carey (ed.), *Bilingualism, biculturalism, and education.* Edmonton, Canada: University of Alberta. 119–128.

Bak, T.H., Nissan, J.J., Allerhand, M.M. and Deary, I.J. (2014). Does Bilingualism Influence Cognitive Aging?. *Annals of Neurology*. 75(6), 959-963.

Bialystok, E. and S. Majumder (1998). The relationship between bilingualism and the development of cognitive processes in problem solving. *Applied Psycholinguistics*. 19.

Bialystok, E., Craik, F.I.M. and Freedman, M. (2007). Bilingualism as a protection against the onset of symptoms of dementia. Neuropsychologia. 45(2), 459-464.

Cummins, J. & Mulcahy, R. (1978). Orientation to language in Ukrainian-English bilingual children. *Child Development*. 49, 1239-1242.

Daffner, K.R. (2010). Promoting successful cognitive aging: a comprehensive review. *Journal of Alzheimer's Disease*. 19(4) ,1101.

Guzmán-Vélez, E. and Tranel, D. (2015). Does bilingualism contribute to cognitive reserve? Cognitive and neural perspectives. *Neuropsychology*.. 29(1) , 139-150.

Gollan, T.H., Salmon, D.P., Montoya, R.I. and Galasko, D.R. (2011). Degree of Bilingualism Predicts Age of Diagnosis of Alzheimer's Disease in Low-Education but not in Highly-Educated Hispanics. *Neuropsychologia*. 49(14), 3826-3830.

Hernandez, A. E., Martinez, A. and Kohnert, K. (2000). In search of the language switch: An fMRI study of picture naming in Spanish-English bilinguals. *Brain and Language*. 73(3), 421–431.

Kavé, G., Eyal, N., Shorek, A. and Cohen-Mansfield, J. (2008). Multilingualism and cognitive state in the oldest old. *Psychology and Aging*. 23(1), 70-78.

Luo, L., Craik, F.I.M., Moreno, S. and Bialystok, E. (2013). Bilingualism interacts with domain in a working memory task: evidence from aging. *Psychology and Aging*. 28(1), 28-34.

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

Landry, R. G. (1974). A comparison of second language learners and monolinguals on divergent thinking tasks at the elementary school level. *The Modern Language Journal*. 58, 10–15.

La Rue, A. and Jarvik, L.F. (1987). Cognitive function and prediction of dementia in old age. *The International Journal of Aging & Human Development*. 25(2) 79-89.

Menn, L. (2017). *Psycholinguistics: Introduction and applications.* 2nd Edition, (N. F. Dronkers, Contributor). Plural Publishing.

Maguire, E.A., Gadian, D.G., Johnsrude, I.S., Good, C.D., Ashburner, J., Frackowiak and R.S., Frith, C.D. (2000). Navigation-related structural change in the hippocampi of taxi drivers. *Proceedings of the National Academy of Sciences*. 97(8), 4398-4403.

Morales, J., Calvo, A. and Bialystok, E. (2013). Working memory development in monolingual and bilingual children *Journal of Experimental Child Psychology*. 114(2), 187-202.

Mohades, S. G., Struys, E., Van Schuerbeek, P., Mondt, K., Van De Craen, P. and Luypaert, R. (2012). DTI reveals structural differences in white matter tracts between bilingual and monolingual children. *Brain Research*. 1435, 72–80.

Mechelli, A., Crinion, J.T., Noppeney, U., O'Doherty, J., Ashburner, J., Frackowiak, R.S. and Price, C.J. (2004). Neurolinguistics: structural plasticity in the bilingual brain . *Nature*. 431(7010) 757-757.

Osterhout, L., Poliakov, A., Inoue, K., McLaughlin, J., Valentine, G., Pitkanen, I., Hirschensohn, J. (2008). Second-language learning and changes in the brain. *Journal of Neurolinguistics*. 21(6), 509–521.

Snowdon, D.A., Kemper, S.J., Mortimer, J.A., *et al.* (1996). Linguistic ability in early life and cognitive function and Alzheimer's disease in late life: Findings from the Nun Study. *JAMA.* 275, 528-532.

Petitto, L.A., Berens, M.S., Kovelman, I., Dubins, M.H., Jasinska, K. and Shalinsky, M. (2012). The "Perceptual Wedge Hypothesis" as the basis for bilingual babies' phonetic processing advantage: New insights from fNIRS brain imaging In *Brain and Language*. pp. 130-143.

Perquin, M., Vaillant, M., Schuller, A.-M., Pastore, J., Dartigues, J.F., Lair, M.L. and Diederich, N. (2013). Lifelong Exposure to Multilingualism: New Evidence to Support Cognitive Reserve Hypothesis. *PLoS ONE.* 8(4) e62030.

Parker-Pope, T. (2014). Do Brain Workouts Work? Science Isn't Sure. *The New York Times*.

Tosato, M., Zamboni, V., Ferrini, A. and Cesari, M. (2007). The aging process and potential interventions to extend life expectancy . *Clinical Interventions in Aging.* 2(3), 401-412.

Wenguang, H. and Baoguo, C. (2011). The Influence of Language on Cognition: Based on the Analysis of Bilingual Cognition Advantage. *Advances in Psychological Science.* 19(11), 1615-1624.

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