Bilingual Brains: Neural Plasticity and Cognitive Development

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Abstract

This research paper examines the current literature on the neural plasticity and cognitive development of bilinguals. I specifically investigated how the brain development of bilinguals compares to that of monolinguals and how neural plasticity influences cognitive development. Studies have shown that bilinguals have enhanced cognitive abilities, and neuroscience can justify that. My paper aims to encourage multilingual families to raise bilingual children and teach their children two languages from the very beginning.

Introduction

"Many parents feel they have no choice but to get on the smart baby bandwagon" (Shin, 2013). In light of Shin's discussion on how multilingual families should raise their children, neuroscience research suggests a vast amount of benefits in raising a child as bilingual. Studies have shown that bilinguals have enhanced cognitive abilities, and neuroscience can justify that. I would like to investigate the following questions: How does brain development of bilinguals compare to that of monolinguals? How does neural plasticity influence cognitive development? In this paper, I will delineate the purpose and significance of my project, provide an overview of basic neuroscience concepts involved in my project, synthesize the research on this topic to propose why families should raise bilingual children, and address the future directions in this field, including a brief proposal for what I would like to contribute to the field.

Purpose and Significance

Both my personal interests and what I have learned through my coursework have fueled my interest in the neuroscience of bilinguals. My personal interests stem from classes I have taken at Stanford and my language acquisition story. After taking an introductory neuroscience class, I became interested in developmental neurobiology because I would like to further understand how our brains develop, what can go awry during this process, and how our biology influences our behavior and social development. Prior to taking this class on bilingualism, I had always

been interested in language acquisition, and the process of acquiring two languages simultaneously was tantalizing. This interest ignited because of my language acquisition story. I was never formally taught my second language, yet I learned a sufficient amount throughout my childhood in order to categorize myself as bilingual. A speech pathologist advised my parents against teaching my twin brother and me a second language because my brother had a language comprehension disorder, and the second language would interfere with his ability to fully acquire his first. Although they never spoke the language to us, they spoke it amongst themselves. As a precocious child, I made active efforts to learn the language at age 5 by consistently listening to their conversations. My brother and I received relatively the same exposure to the language, yet I could fully comprehend and speak the language years later and he could not. I would like to examine the neural processes and our brain development from the time I acquired my second language. This case is especially fascinating because we are twins, so the differences in our brain development will be quite remarkable.

Sarah Shin, professor of education at the University of Maryland Baltimore County, and her research on multilingual families greatly inspired my topic. She raises the questions, "What does it take to raise children bilingually in monolingual societies? […] Could bilingual input confuse children?" (Shin, 2013). I sought to delve deeper into those questions by examining what neuroscientists and psychologists have researched about bilinguals. Shin discusses in great depth about simultaneous and successive bilinguals and the different approaches parents take in raising bilingual children. As aforementioned, neuroscience research can help corroborate the views that she offered because strong correlations between our biology and behavior exhibit very plausible findings. Additionally, Shin addresses the linguistic mismatch hypothesis, the notion that bilingual input confuses children, which is a highly held belief by doctors, speech therapists, teachers, and counselors in monolingual societies. She refutes that hypothesis, and my research on neuroscience and psychology can justify her stance.

Introduction of Neuroscience Concepts

In order to gain a clear understanding of the neuroscience research on bilinguals, I will introduce fundamental neuroscience concepts by defining key terms and describing the areas of the brain that are involved with language (Fernald, 2015).

Neural plasticity involves changes in neural pathways and synapses due to changes in behavior, environment, neural processes, thinking, and emotion. Grey matter is unmyelinated axons and cell bodies and is responsible for decision-making, self-control, muscle control, and language. The axon is responsible for carrying signals from the cell body to the axon terminals.

Myelin is the fatty protein that covers the axons and makes action potentials travel faster. Action potentials occur when a neuron sends information down an axon, away from the cell body. Lastly, functional magnetic resonance imaging, or fMRI, measures brain activity by detecting associated changes in blood flow. If blood flow is high in a specific region of the brain, the neurons are using plenty of oxygen, which means that the brain is active in that area. Transcranial magnetic stimulation, or TMS, uses magnetic fields to stimulate nerve cells so that they are "turned off." This evaluates whether a specific region of the brain is required to generate a particular behavior.

A hemisphere of the brain is divided into four regions: the frontal lobe, parietal lobe, temporal lobe, and occipital lobe. Each lobe is involved with language. An area in the frontal lobe, called Broca's area, is responsible for production of language. Another area in the temporal lobe, called Wernicke's area, is responsible for comprehension of language. These two areas are connected by the arcuate fasciculus, which is a track of white matter that carries information in both directions. A widespread myth about bilingual brains is that one region of the brain is associated with one language and, another region is associated with the other. Neuroscientist Cathy Price (2012) debunks this myth with the fMRI data in Figure 1, showing that bilinguals activate the same general brain areas no matter what language they use.

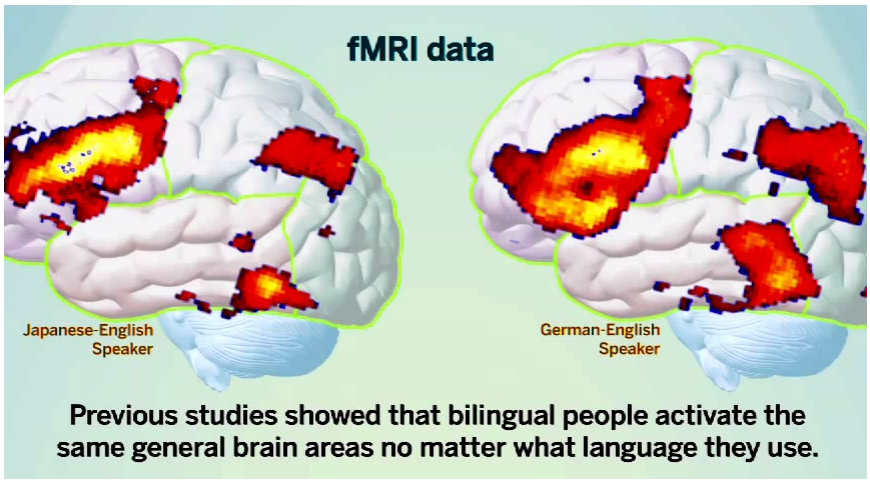

FIGURE 1. fMRI data of brain activation in bilinguals (image from Price, 2012).

Additionally, Price's (2012) most recent research involved measuring brain activity after showing subjects word pairs with similar meaning. Results showed increased activity in the left caudate when speakers shifted from one language to another (Figure 2).

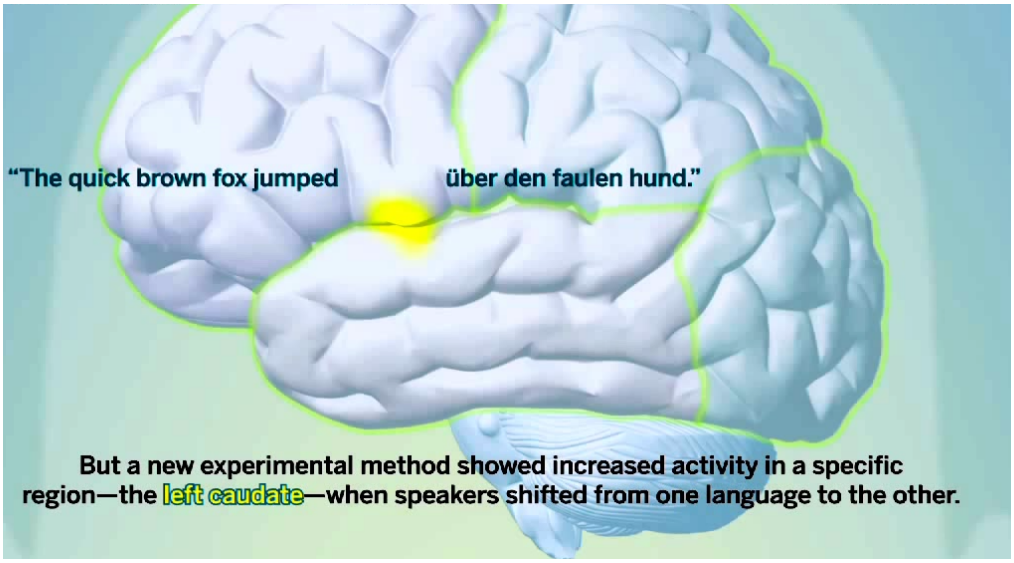

FIGURE 2. Brain activity when bilinguals switch languages (image from Price, 2012).

Cognitive Development

One of the most groundbreaking discoveries in the field of bilingualism is the enhanced cognitive development of bilinguals. The neural pathways that are strengthened from knowing two languages do not strictly pertain to language, but several cognitive functions as well. Studies have shown that bilinguals have a stronger ability to block out distractions, have better attention and cognition, and can prioritize, analyze, focus, sort, and organize much more effectively than monolinguals ("Language", 2013). Neuroscientist Sam Wang (2011) has found that bilinguals have a better theory of mind, which is the ability to understand what is on another person's mind. He has also found that dementia is delayed for an average of about four years for bilinguals over monolinguals. Other studies have corroborated that notion, as they mentioned that speaking multiple languages is the best way to keep the brain active and combat loss of cognitive function and memory ("Language", 2013). Many psychologists have suggested crossword puzzles and other mental exercises in order to keep the brain active, but speaking multiple languages seems to be the most efficient method because we use language in nearly every minute of every day. Also, a researcher stated that if language is the key to human intelligence, then bilingualism must be the key to increasing intelligence ("Language", 2013). Research has shown that knowing two languages is optimal "exercise" for the brain and can positively impact one's cognitive development. More research has been conducted on very young children, revealing astounding findings about simultaneous bilinguals.

Shin (2013) stated that more research is conducted on simultaneous bilinguals than successive because they are more intriguing subjects. In the notorious Dimensional Change Card Sorting experiment, researchers studied both bilinguals and monolinguals under 4 years of age (Gleitman, Gross, Reisberg, 2010). In this experiment, the children were given a deck of cards that consisted of different shapes and colors (Figure 3) and were ordered to sort the deck of cards on one dimension (e.g. color). Then, they were asked to re-sort the cards by the other dimension (e.g. shape).

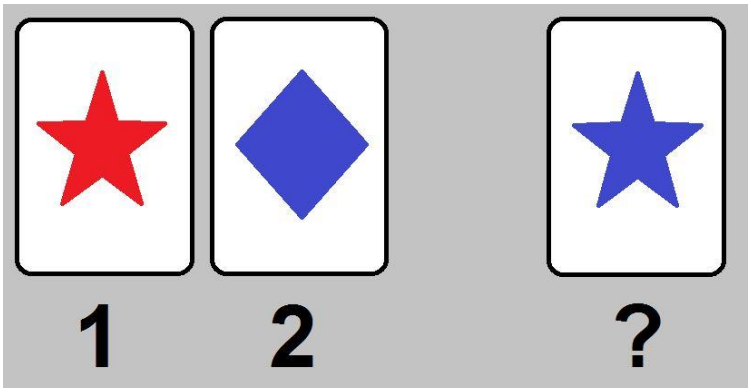

FIGURE 4. Dimensional change card sorting (image from Gleitman et al., 2010).

Both monolinguals and bilinguals could easily perform either of those sorts with no difficulty, but monolinguals tended to slow down and make mistakes when trying to switch in the re-sorting phase of the experiment while bilinguals performed much more accurately and efficiently. A bilingual must constantly inhibit everything they know about language B when they are hearing or speaking language A. This has a general effect on developing cognition, and bilinguals generally achieve cognitive flexibility at an earlier than expected age. This aligns with the finding that 7-month-old simultaneous bilinguals can effectively acquire and process incompatible linguistic patterns that their monolingual peers cannot. Bilinguals ultimately have better inhibitory control for ignoring perceptual information than monolinguals do.

Neural Plasticity

As aforementioned, neuroscience can justify the findings that bilinguals have enhanced cognitive development. In a neurolinguistics study conducted by Andrea Mechelli (2004), she found that proficiency in a second language and age at which the second language was acquired affect grey-matter density. As shown in the data in Figure 4, there is a

strong correlation between brain structure and proficiency in second language and the age of acquisition.

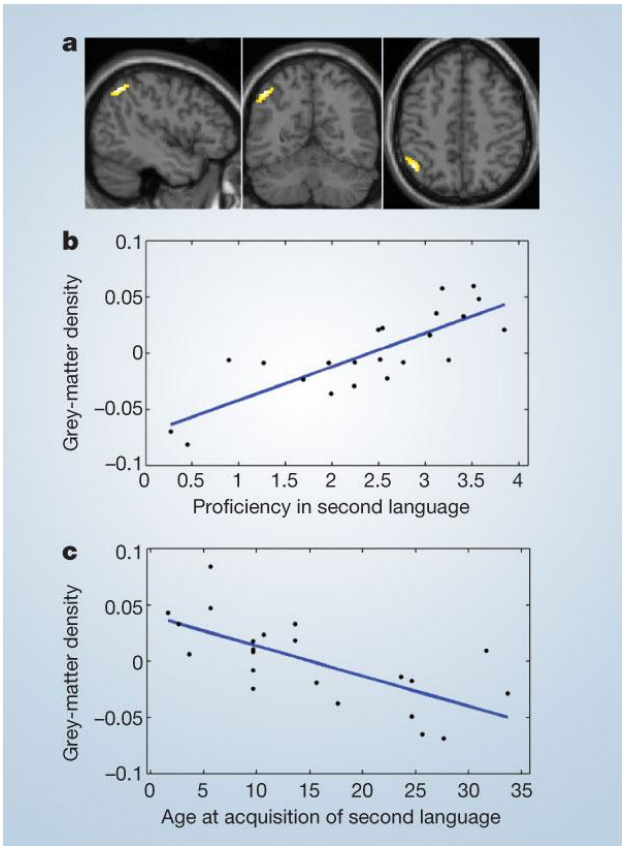

FIGURE 4. Grey matter density in bilinguals (image from Mechelli, 2004).

Figure 4a shows an increased density of grey matter in the left inferior parietal cortex. Figure 4b shows that the more proficient one is in a second language, the more grey matter that one has. Figure 4c shows that the earlier one acquires a second language, the more grey matter one has—proving the case that simultaneous bilinguals have stronger cognitive abilities than successive bilinguals.

Neuroscience research on bilinguals ultimately makes the case for strengthened pathways in the brains and improved neural efficiency. The brain networks for both languages are always active, which results in strengthened pathways in the brain. Additionally, bilingual brains are faster, as demonstrated by the children in the Dimensional Card Change Sorting experiment.

My Take on Multilingual Families

Shin (2013) is adamant about raising children as bilinguals, and I wholeheartedly support her based on my research, what I have learned through my coursework, and my own experience. My research on neural plasticity and cognitive development in bilinguals is irrefutable evidence for the advantages of raising bilingual children. Although being bilingual comes with some impediments, the advantages far outweigh them. Bilinguals in our monolingual society may carry a negative stigma throughout their schooling, but they have cognitive abilities that monolinguals will struggle to attain. Furthermore, their aging and longevity will be much less of a burden to them than monolinguals.

Having done this research, I would like to impress upon my parents and my brother's speech pathologist the benefits of growing up bilingual. Furthermore, I would like to project this research to the parents of my Filipino friends and relatives. Filipinos who were born in America, or born in the Philippines and grew up here, mostly do not know the Filipino language. From my experiences, I am inferring that Filipino-American parents do not teach their children Tagalog because it is merely unnecessary in America. Nearly all Filipino-American adults know both English and Tagalog because they are both official languages in the Philippines, and everyone is educated in English in the Philippines as well. Since they are very proficient English speakers, they have justification for teaching their children only the societal language. Moreover, my grandmother seems to express some shame in the language. According to her, the language is stigmatized in America, and English is highly regarded everywhere in the world. Although she may be true, my research proves that knowledge of any second language can enhance cognitive development and have plenty of long-term benefits. Additionally, in class discussions on revitalization and endangered languages, we were offered prophetic warnings from readings that English is the "killer language". I am worried that this trend is impacting Filipino-American parents' thoughts about raising bilingual children. Once their generation passes, the existence of Tagalog in America will diminish. Although there will always be a conspicuous presence of Tagalog in the homeland, future generations in America will have fewer opportunities to learn the language.

I ultimately suggest that multilingual families should raise their children as bilinguals, and they should start teaching their children two languages from the very beginning. If parents are not able to give their children full exposure to two languages, I recommend enrolling children in immersion schools. Lastly, parents must be aware of the omnipotence of the English language and continue to use their second languages with their children so that they can maintain them for future generations.

Further Directions and Conclusion

My paper will hopefully provide insight for multilingual families on raising bilingual children, as the research evidently shows that it is highly

beneficial to know two languages. There are many unanswered or widely debated questions about bilingualism, and neuroscience can provide us with answers. As I have stressed on numerous occasions, the advantages of being bilingual far outweigh the disadvantages. It is up to our generation to maintain the languages that we speak. Prior to Stanford, I underestimated the power of language, especially the power of knowing two languages. Language is our means of navigating through the world and discovering new ideas. History, culture, and traditions are embedded in language, and when we lose a language, we lose the history, culture, and traditions buried in it. Being bilingual may distinguish us from the majority of our monolingual peers as competent users of two languages. Ultimately, being bilingual means having a much broader perspective of the world due to the wealth of knowledge that exists in the languages that we speak…and it means having more grey matter, too!

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