

The Effects of Early Onset Bilingualism on Executive Function in Adolescents

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ABSTRACT

The researcher aims to explore how bilingualism from an early age affects teenagers' ability to control their thoughts and actions, also known as executive function, specifically when it comes to inhibitory control. The researcher observed a group of 30 high school students from the suburbs and divided them into three categories. The first group are students who only speak one language, the second group are those who started learning a second language early on, and the last group are those who began learning a second language later in life. To evaluate their ability to ignore irrelevant information, the researcher used a test called the Stroop Task. The results were relevant and interesting as the early bilinguals performed better than their peers, showing significantly stronger inhibitory control. This suggests that managing two languages from a young age actually improves how flexible the brains are. Also, the researcher found that the monolingual students had the weakest inhibitory control, with the late-onset bilinguals falling somewhere in the middle. The findings also highlight how being bilingual from an early age might give individuals an advantage in terms of protecting their brains against cognitive decline as they get older, like dementia. Of course, more research is needed to fully understand all the factors at play, such as socioeconomic status and genetics. However, this study truly emphasizes the potential benefits of bilingualism for cognitive health throughout individuals' lives. It highlights the importance of promoting bilingual environments in our globalized society, not only for cultural and communicative reasons but also for the cognitive advantages it can offer.

Introduction

The phenomenon of bilingualism, characterized by an individual's capacity to communicate fluently in two languages, is increasingly common all around the world. Today, it is believed that around 50 percent of the Earth's population has bilingual abilities. The occurrence of bilingualism is due mainly to the growing globalization and cultural exchanges that blend and share languages among varied populations. At present, the phenomenon of bilingualism is widely represented in society, and, therefore, it is crucial to study all the aspects and outcomes associated with bilingualism, including the cognitive and neurological results of bilingual experience. Recently, the growing body of research explores the influence of bilingualism on the human brain and cognitive domain. The scholarly article conducted by Liu and Wu is one of the groundbreaking works in this direction. Lu et al. also discovered that bilingual persons who developed dementia early had a slower disease progression than their monolingual counterparts. This may suggest some bilingualism-related "cognitive preservation" effect. Bilingualism may benefit cognition by structuring cognitive reserve and neuroplasticity in various ways.

One of the essential cognitive processes related to bilingualism is inhibitory control – the ability of the selected aspects of attention, suppression of irrelevant responses, and flexibility in changing actions. As indicated, for example, two languages use two proficient language systems, which must simultaneously be less

learned, and one non-dominant must be ignored. Inhibitory control is strongly associated with “cognitive control” abilities – all are relying on the frontal and prefrontal neural networks in charge of higher executive functioning.

Additionally, along with inhibitory control, bilingualism is related to advantages in metacognitive and metalinguistic abilities. Metacognition refers to higher-order thinking, which includes higher-order processes such as planning, monitoring, and assessing one’s cognitive process. It has frequently been observed that bilinguals outperform monolinguals in assessments of cognitive abilities. As bilinguals have to handle two systems often and make choices consciously about which one to use, it is not surprising that they also have better metacognitive skills. Furthermore, bilinguals’ metalinguistic awareness is equally improved due to the characteristics mentioned prior. Metalinguistic awareness is the ability to contemplate and change linguistic aspects, and bilinguals’ capacity in this can even be exhibited at an early age. It enables them to investigate the structure and function of language which formulates the relationship of understanding between the two languages.

While there is a growing body of evidence focusing on the cognitive advantages of being bilingual, a clear gap persists in understanding how and when these benefits manifest throughout a person's life. The issue of how bilingualism acquired at different life stages, or the age at which a second language is learned, affects cognitive development remains largely unexplored up until today. Thus, this led the researcher to investigate the effects of bilingualism on cognitive processes and brain structure of adolescents, as it is considered the key to gaining a fuller picture of how speaking multiple languages shapes individuals' mental landscape. A further study of bilingualism is relevant to explore the reasons why individuals who speak two languages often demonstrate a cognitive advantage. And so, the researcher is actively engaged in studying this topic, as it represents a critical area of investigation, particularly relevant in today's globalized world. Through this perspective, the exploration of bilingualism goes beyond an academic pursuit; it becomes a transformative journey towards unlocking the vast human potential within an interconnected society.

Related Literature

There are recent studies in the field of cognitive psychology and neuroscience that are significant to validate and support this present study. These are placed considerable importance on revealing the advantages linked to bilingualism. One of these notable studies is the research conducted by Bialystok et al. (2004) and Costa et al. (2008) has focused on the enhanced executive control observed in individuals who are fluent in more than one language. This heightened executive control encompasses superior abilities in attention management, problem-solving, and efficient task-switching.

Luk et al. (2011) pursued momentous research. Their research revealed the striking benefits of bilingualism. This benefit exhibits the capacity to postpone dementia symptoms' commencement. Such a revelation instills hope. That hope lies in the domain of cognitive health study. This investigation provides proposals. These proposals state that bilingualism may exert tremendous sway. The study presents bilingualism as an entity. This entity has the ability to protect cognitive functioning. The protection of cognitive function can be realized. It is realized as one navigates the course of aging. The value of this hallmark cannot be amplified enough. In the preservation of cognitive health during aging. This assertion is of supreme importance. It is to be stressed emphatically.

Even with progress made in grasping the cognitive benefits of bilingualism, a significant gap in knowledge remains about the impact of when an individual learns a second language, but it lacks information. This specifically highlights the need for more wide-ranging research. The research aims to determine if cognitive advantages linked to bilingualism are significantly impacted by learning a second language early in childhood. Alternatively, it could be later in life.

This line of inquiry is intellectually intriguing. Additionally, it holds practical importance. Insights garnered from such research can shape educational policies. It can also mold language learning initiatives. This

will allow us to fully harness the cognitive benefits of bilingualism. Comprehension of optimal timing and strategies for acquiring language is crucial. This will maximize the advantages bestowed by becoming bilingual. It will enhance educational experiences for individuals of all ages.

Methods

The objective of this exploration is to delve into how being bilingual influences cognitive functions. It analyzes decision-making skills with the use of a methodology known as the Stroop Task. An investigation was conducted in a suburban high school. The initiation step was embarked upon by the researcher and the survey was distributed. This was done to gather details regarding students' age. Details about students' familiarity with languages were collected as well. The competence with which they conversed in a secondary language was also assessed. The last piece of information collected was when the learning of that language commenced. This survey also helped the researcher gather contact information for organizing the experimental sessions. From the responses, the researcher selected 30 participants, categorizing them based on their language skills into monolinguals, early-onset bilinguals, and late-onset bilinguals. All participants were native English speakers, but the bilinguals varied in their second languages.

The experiment involved the Stroop Task, which measures cognitive control. This task includes two types of stimuli: congruent (where the word's meaning matches its color, e.g., "red" written in red) and incongruent (where the word's meaning conflicts with its color, e.g., "blue" written in red). Participants were asked to identify the color of the ink, rather than the word itself. The researcher recorded the time it took participants to accurately complete each task. This study seeks to understand whether bilingualism influences cognitive control, as demonstrated through performance on the Stroop Task. Specifically, it explores whether individuals who speak multiple languages are better at managing conflicting information, a skill reflected in quicker and more accurate task completion.

Results

In examining the impact of bilingualism on cognitive task performance, this analysis delves into the completion times of participants across different linguistic backgrounds when subjected to congruent and incongruent stimuli. The data, plotted on graphs with the y-axis representing task completion time in seconds, reveals intriguing patterns among monolinguals, late-onset bilinguals, and early-onset bilinguals.

Monolingual ($n=11$) participants exhibited a slightly longer completion time for tasks involving congruent stimuli, averaging at 13.287 seconds. In contrast, late-onset bilinguals ($n=10$) recorded a marginally lower average time of 12.897 seconds, while early-onset bilinguals ($n=10$) demonstrated the quickest response, with an average completion time of 12.454 seconds. Despite the observable differences in performance, the variation in completion times among the groups for congruent stimuli did not reach statistical significance, indicating that the linguistic background did not markedly affect the task performance in this aspect.

However, the scenario shifts when considering the performance on incongruent stimuli. Here, the variations in data notably align with the findings from Liu and Wu's study, showcasing a significant differentiation in task completion times. Early-onset bilinguals led with the fastest average time of 18.786 seconds, underscoring their superior ability to manage conflicting information. Conversely, late-onset bilinguals and monolinguals lagged behind, with mean times of 24.684 seconds and 28.765 seconds, respectively. This reality emphasizes cognitive flexibility. Also, it highlights enhanced executive control among early-onset bilinguals. These individuals can navigate as they can in the presence of incongruent stimuli. They achieve this effectively as they are more so than late-onset bilingual counterparts who exceed the skills of monolingual ones.

Further analysis of the Stroop interference phenomenon is presented, which evaluates the delay in reaction time and measures the interval between congruent and incongruent stimuli. Also, it furnishes strong evidence supporting the cognitive benefits associated with bilingualism. Both monolingual and bilingual individuals were observed. It was noticed that monolingual people experienced substantial delays. Interference time averaged around 16.7 seconds for them. On the other hand, a contrast was visible with early-onset bilinguals. Bilinguals encountered much less interference. The delay for them was roughly 6.332 seconds. This fact underscores their capacity to effectively manage cognitive conflicts. These findings provide robust support for certain ideas. They support the belief that bilingualism boosts cognitive control. Furthermore, they indicate bilingualism enhances cognitive flexibility.

The study sheds light on the complex effect bilingualism has on cognitive performance. Especially in tasks that require managing conflicting information. In-depth analysis provides insights into the intricate impact of bilingualism on cognitive performance. Particularly critical in tasks which involve processing conflicting information. Learning more about this is of utmost importance. The study highlights the influence of bilingualism on cognitive performance. Particularly in tasks that need to deal with conflicting information. Gaining more insights into this phenomenon is critical. Exploring the bilingualism paradox shines a light on cognitive performance, particularly in managing conflicting information. A deeper understanding of this occurrence is important.

This knowledge has the potential to shape educational approaches. It can enhance strategies for improving cognitive skills. Understanding more about this area is important. Insights into this can significantly inform and improve educational strategies. This can enhance cognitive skills in learners.

Congruent Stimuli (Means)

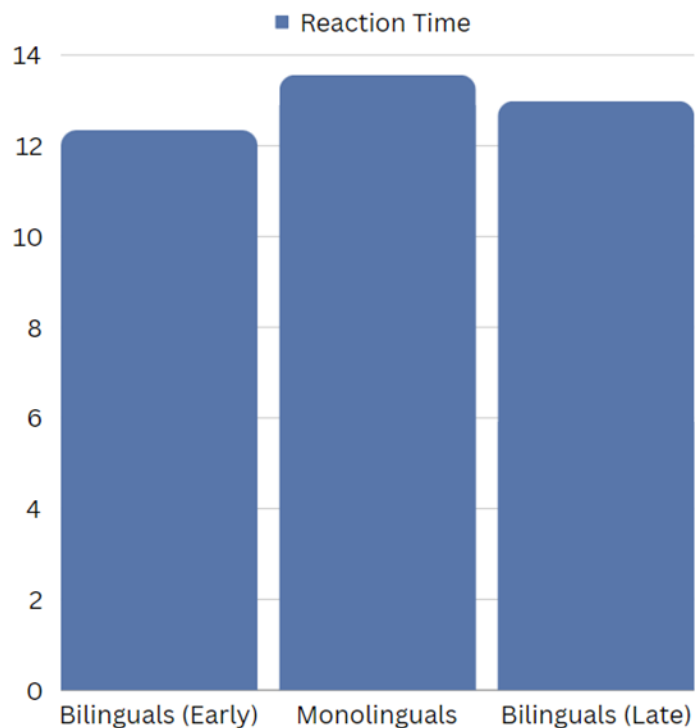


Figure 1.

It is observed that the monolinguals (n=11) have the highest reaction time among the three congruent stimuli in terms of measuring executive functions. Moreover, there is a slight difference in reaction time between early and late bilinguals. stimuli. In the study conducted by Bialystok Craik, Klein and Viswanathan (2004) an investigation was undertaken into the impact of bilingualism on cognitive control. They utilized the Simon task to elucidate executive functions. Their findings suggest a compelling proposition in which Bilingual individuals may engage in cognitive processes distinctively. They demonstrate greater proficiency in cognitive control compared to monolingual counterparts. Conversely, Paap Johnson and Sawi (2015) present a counter-argument as they contest the prevailing notion of a universal bilingual advantage in executive functioning. They advocate for nuanced interpretation when they describe the caution against oversimplified generalizations. Also, they assert that any perceived advantage may depend on specific contextual factors. In their study, they revealed the multifaceted nature of bilingualism's influence on reaction times and cognitive control.

As in the previous figure, monolinguals have the highest reaction time among the three congruent stimuli in terms of measuring executive functions. Moreover, there is a slight difference in reaction time between early and late bilinguals. stimuli. In studying how bilingual children navigate executive control across different cultures (Bialystok & Viswanathan 2009). One study reveals how bilinguals handle conflicting tasks better (Costa et al. 2009). These studies reveal subtle differences in reaction times between monolinguals and bilinguals during tests of executive functions. They highlight how language skills and cognitive control interact intricately with relevant insights into these complex dynamics in an accessible way.

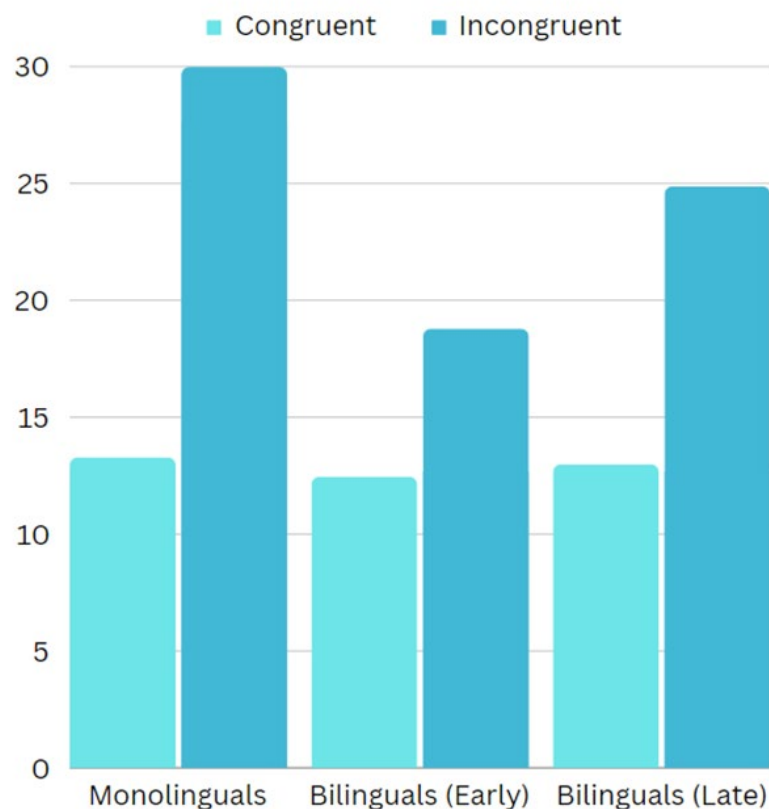


Figure 2.

It is noticed that there is an increase in the incongruent means across the types.

Table 1.

	Congruent (sec)	Incongruent (sec)
Monolinguals	13.381	29.124
Bilinguals (Early)	12.454	19.337
Bilinguals (Late)	12.989	24.879

Discussions

The researcher has carried out a detailed study with the aim of investigating how bilingualism affects cognitive performance. This happened in various language tasks specifically. This study focuses on measuring task completion times. The times of individuals from different linguistic backgrounds were measured. They were presented with congruent and incongruent stimuli. The results found are visually represented by using graphs. Here, the y-axis is for the time taken. This time was needed to finish the task and is measured in seconds.

Data shows significant results among the three groups. These are monolinguals, late-onset bilinguals, and early-onset bilinguals. The trends offer an important perspective. They reveal how language skills and bilingualism influence thinking processing.

In tasks dealing with congruent stimuli, fascinating findings were observed. Monolingual participants had a slightly longer finish time. It averaged at 13.287 seconds. On the other hand, late-onset bilinguals indicated a slightly lower average duration. Their time was 12.897 seconds. Early-onset bilinguals, however, showed the fastest reaction. Their average finish time was 12.454 seconds. Despite noticeable differences in performance, the variation in completion times among the groups for congruent stimuli did not reach statistical significance, suggesting that linguistic background does not markedly affect task performance in this context.

However, the scenario shifts when examining performance on incongruent stimuli. Here, the variations in data notably align with findings from previous studies, showcasing a significant differentiation in task completion times. Early-onset bilinguals led with the fastest average time of 18.786 seconds, highlighting their superior ability to manage conflicting information. Conversely, late-onset bilinguals and monolinguals trailed behind, with mean times of 24.684 seconds and 28.765 seconds, respectively. This disparity emphasizes the cognitive flexibility and enhanced executive control among early-onset bilinguals, enabling them to navigate incongruent stimuli more efficiently than their late-onset and monolingual counterparts.

Further analysis into Stroop interference, which measures the delay in reaction time between congruent and incongruent stimuli, reinforces the cognitive advantage of bilingualism. Monolingual participants exhibited the most substantial delay, with an average interference time of approximately 16.7 seconds. In stark contrast, early-onset bilinguals encountered the least interference, showcasing their adeptness at mitigating cognitive conflict and reinforcing the argument for bilingualism as a facilitator of enhanced cognitive control and flexibility.

This examination underscores the nuanced impact of bilingualism on cognitive performance, particularly in tasks requiring the management of conflicting information. The findings advocate for a deeper understanding of how early language exposure and bilingualism can confer cognitive advantages, potentially informing educational strategies and cognitive training methodologies.

Conclusion

Global dementia cases have risen drastically within the past few years with no effective treatment. Yet, it has been seen in studies such as Liu and Wu's (2021), that the preservation of executive functions such as inhibitory control is induced by early-onset bilingualism. Executive function undergoes significant changes during aging, meaning it is a vital indicator of cognitive preservation. The findings from this study indicate that early-onset bilingualism strengthens and induces inhibitory functions at an earlier age. These inhibitory functions appear to be strengthened throughout adolescence, as the early-onset bilingual participants had strengthened their inhibitory control beyond their monolingual and late-onset bilingual peers. However, there remain several limitations within the experiment including the interference of participants' environment. External factors including educational background, health conditions, and genetics can impact an individual's cognitive development (Drago et al., 2020). These factors were not accounted for within the experiment, meaning that variances across the data could be correlated with external factors beyond an individual's bilingualism. Furthermore, the study accounts primarily for an individual's inhibitory control and not other aspects of executive functions, meaning it may not indicate the full development of one's executive function. Understanding the relationship between early-onset bilingualism and executive functions remains vital, as it serves as a potential skill that can preserve cognitive function and slow the progression of neurological diseases such as dementia.

Limitations

Although the study managed to collect statistically significant data, there were certain limitations. The study only had thirty-one participants, which is a significantly smaller sample size in comparison to prior studies. Since the study has a relatively small sample size, the findings may not apply to larger populations. Furthermore, since the study primarily obtained adolescent participants from one high school, the findings may not be fully applicable to adolescents in different regions or areas. As such, the small participant sample size as well as the area of participant collection hinder the applicability of the study to varying regions and larger populations.

Furthermore, participants' prior education and knowledge of the Stroop Task were not considered or asked via the survey. While the participants were not stated the explicit cognitive task they were to undergo for the study, rather they were told it would be a quick cognitive exam, there was still a probability of the participants having existing knowledge or practice with doing the task. If a participant had prior knowledge of the exam, it may have skewed the results as the participant would have likely been able to complete the exam faster.

Lastly, the participant's level of language proficiency was not tested. In the survey, the participants were asked if they spoke a second language and what their level of proficiency was. However, there could have been a possibility of bias, in which the participant over or underestimated their level of proficiency to be deemed as bilingual. This lack of clarification could indicate that several participants could have been misidentified as bilingual or monolingual.

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