

# *Review on Inhibition Abilities in Bilingualism Through Cognitive Tasks Analysis*

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**Abstract:** Research into the possible influence of bilinguals on cognitive function and brain structure has experienced a significant surge in recent years. For decades, whether mastering a second language has any universal benefits for executive function has been a fiercely debated issue in science. Contradictory results may be attributed to various elements, such as differences in the study population, criteria for defining bilingual abilities, or differences in experimental tasks. This article reviews several literature to investigate the research questions. Some studies focus on executive function (EF), which refers to a set of cognitive processes that regulate thinking and behavior from top to bottom. The normal parts of EF are inhibition, updating, and task shifting. In this article, we reviewed inhibition abilities in bilingualism by analyzing three cognitive tasks, including the Flanker task, Simon task, and the Stroop task, to examine whether there are cognitive advantages in bilinguals. Bilingual ability is related to the performance of various tasks, especially those that evaluate children's executive function. These tasks are typically interpreted as inhibition tests, thus related to the initial explanation that evaluating inhibition plays a key role in distinguishing bilingual and monolingual cognition. The aim of the article is to analyze how bilinguals perform on inhibition through the above cognitive tasks and find that there is insufficient evidence to directly prove that bilingualism has cognitive advantages on inhibition.

**Keywords:** Inhibition, bilingualism, executive function, cognitive tasks

## 1. Introduction

Research into the possible influence of bilinguals on cognitive function and brain structure has experienced a significant surge in recent years. What was once a modest increase in citations for "bilingualism" between 2000 and 2010 has evolved into a substantial upward trend that persists to this day [1]. Bilingualism is a broad and complex concept, encompassing various forms and configurations, similar to heritage language acquisition. The term 'bilingual' is often loosely used to include multiple languages, as demonstrated by Batia and Ritchie in an introduction section of a book [2].

A substantial body of research has extensively documented the cognitive development benefits of bilingualism for children. However, it is worth noting that some studies have failed to find such positive outcomes. Contradictory results may be attributed to various elements, such as differences in the study population, criteria for defining bilingual abilities, or differences in experimental tasks.

Indeed, Given the significant differences between different studies and bilingual experiences, the breadth of the results is not surprising [3]. The heightened interest in this area of study can be attributed, in part, to the controversy surrounding some of its key assertions, sparking vigorous debate within the academic literature. The core of this debate lies in whether sustained two-language management practices are associated with enhanced performance in a range of nonverbal cognitive tasks typically linked with executive function (EF) [1].

Some studies focus on executive function (EF), which refers to a set of cognitive processes that regulate thinking and behavior from top to bottom. The normal parts of EF are inhibition (the ability to concentrate on target information without interference from unrelated information), update (the ability to retain and absorb new information in working memory), and task transfer (the ability to maintain flexibility in switching between different psychological rules or tasks) [4]. Bilingual ability is related to the performance of various tasks, especially those that evaluate children's executive function, including Flanker, Simon, and Stroop tasks. These tasks are typically interpreted as inhibition tests, thus related to the initial explanation that evaluating inhibition plays a key role in distinguishing bilingual and monolingual cognition [5]. Over the years, many researchers have illustrated that bilinguals Perform better than monolinguals in task execution. In contrast, other researchers have revealed no executive-function benefits in bilinguals compared with monolinguals. However, an issue with several researches is that their sample sizes are relatively too small. Consequently, to varying degrees, results are often influenced by other factors, such as socioeconomic status, geographic background, and educational background [6]. In addition, Bruin et al. pointed out a serious publication bias: articles that support the theory of bilingual advantages tend to be published than articles that do not support bilingual advantage, which leads to doubts about the effectiveness of any reviews or meta-analyses of published literature [7]. In this article, firstly, we will define inhibition, and explain several cognitive tasks that measure inhibition skills, including Flanker, Simon, and Stroop tasks. Secondly, we will investigate why bilingualism may relate to inhibition. Finally, we will examine how bilinguals perform on inhibition.

## **2. Inhibition**

### **2.1. Definition**

Inhibition refers to the ability to suppress or control inappropriate or irrelevant responses, thoughts, or impulses. It is an important aspect of executive function and plays a significant part in various cognitive tasks, such as attention, decision-making, and problem-solving. Inhibition specifically relates to the control of language responses, particularly in bilinguals. The early main explanation of this study was the inhibitory effect, which is consistent with the theoretical stance that the growth of inhibition is crucial for cognitive development. This explanation is consistent with Green's inhibitory control model (bilingual effect mechanism), which suggests that bilingual language processing is based on an attention system, namely a supervised attention system, that suppresses unwanted language so that processing can occur in the target language [5,8].

### **2.2. Flanker task**

Several studies have utilized a version of the flanker task introduced by Eriksen and Eriksen in 1974 to identify the components of executive function affected by bilingualism. The flank task has been widely used to evaluate children's inhibition skills. Park et al. conducted a two-year longitudinal study on the development of language and executive function in children, involving 82 typically developing school-age children- 41 English monolinguals (20 males) and 41 English-Spanish bilinguals (23 males) [4]. They were instructed to press the left or right button corresponding to the direction of the middle target while ignoring surrounding stimuli to improve accuracy and speed. Recorded accuracy

and response time. Comparable inhibitory skills were found between monolinguals and bilinguals in first grade instead of second grade, which is significant as it is consistent with existing literature on this topic. The results of the first year have consistency with previous studies, which did not find any advantages of bilingualism in childhood inhibition. However, the results of the second year have consistency with many other studies that suggest the advantage of bilingualism in inhibiting childhood. Therefore, an incorrect conclusion was drawn regarding the influence of bilinguals on inhibitory control.

### 2.3. Simon task

The Simon task is comparable to the flank task, but is applied less frequently in studies. Similar to the flank task, the inconsistency experiment in Simon's task introduces a clue that disturbs the correct reaction. Stimulus is linked with specific keys, and each response key is located on one side of the display monitor. The stimulus is displayed on one side of the monitor, so half of the time, the location of the stimulus display corresponds to the position of the response key (consistent test), while the other half of the time does not correspond (inconsistent test) [5]. In the classic Simon task scenario, participants respond to blue squares by right-clicking or red squares by left-clicking. When a blue square appears on the left side (requiring a right click) or a red square appears on the right side (requiring a left click), a conflict occurs. The Simon task is conceptualized in the dimension overlap model, characterized by the absence of overlap between the perception dimensions of the same stimulus (stimulus color and stimulus position). On the contrary, for the purpose of response rules, there is an overlap between unrelated stimulus dimensions (e.g., stimulus position: right, left) and related response dimensions (e.g., right-click, left-click) [9]. Effort is needed to pay attention and control in order to inhibit any tendency to stand on the same side as the stimulus is presented. The study has discovered that bilingual children with different levels of bilingualism (second language ability) between the ages of 5, 5.5, 6, 7, and 5-9 perform better than monolingual children, with higher levels of bilingualism resulting in better performance [5].

### 2.4. Stroop task

In the classic Stroop task scenario, color words will appear. Participants need to state the color of the ink as soon as possible. When 'red' is written in red ink, there is consistency; However, when 'blue' is written in red ink, inconsistencies and conflicts may arise. The classic Stroop task involves two stimulus dimensions: the color ink of words (e.g., red, blue) and the meaning of words (e.g., red, blue). According to the dimension overlap model, the conflict between two dimensions of the same stimulus (i.e., Stimulus-Stimulus conflict) stems from the perceptual level of word representation (blue, green) and is solved at the perceptual level. The bilingual advantage is not consistent among young people; However, Stroop-type advantages are more common among young bilingual adults. In numerous studies targeting young bilingual participants, significant cognitive Stroop advantages have been observed, and the performance of bilinguals on spatial Stroop tasks is related to conflict resolution in auditory word comprehension processes [9].

## 3. Factors affecting the bilingual advantages

Many research have supported that bilingualism may be linked with enhanced inhibitory control, although the evidence is not consistent across all studies. Research has shown that bilinguals demonstrate improved performance on tasks requiring the suppression of unrelated information or the inhibition of inappropriate responses [10]. This advantage has been attributed to the constant practice of managing competing linguistic stimuli and the need for selective attention in bilingual individuals [11,12]. Other research was unable to replicate these results, suggesting that the bilingual

advantage in inhibition may be smaller or even non-existent [9,12]. Some research has found that bilingual individuals do not differ from monolinguals in terms of their ability to inhibit distracting information or to suppress unwanted responses [13]. These studies support that the bilingual advantage in inhibition may be context-dependent or limited to specific types of inhibitory tasks. The existence of publication bias implies that studies with positive findings are much more likely and easier to be published and reported in the literature, while studies with null or negative results may be overlooked or underreported [9,12,13]. This bias could lead to an overestimation of the bilingual advantage in inhibitory control. While some studies suggest that bilingualism is associated with enhanced inhibitory control, the evidence is not consistent across all studies. The bilingual advantage in inhibition may be more complex than previously thought, and factors such as sample characteristics and publication bias should be carefully considered when interpreting the literature on this topic.

### 3.1. Age of acquisition

Early bilingualism has been found to enhance inhibitory control abilities. For instance, some researchers found that compared to their monolingual peers, bilingual children performed better on tasks that require inhibition, such as the Stroop task [4,14]. As children grow older, the bilingual advantage in inhibition seems to become more pronounced. Adi-Japha et al. found that bilingual children demonstrated greater cognitive flexibility, which is a key component of inhibitory control, in their drawings [3,4]. Furthermore, a longitudinal study revealed that bilingual children outperformed monolingual children in inhibition tasks when they were six years old but not when they were five years old [3,4,14]. The bilingual advantage in inhibition may be attributed to the constant need for language suppression and interference resolution in bilingual individuals. Bilingualism requires the suppression of one language and the activation of another, which necessitates the engagement of inhibitory control mechanisms [3,4]. Consequently, bilingual individuals may develop more robust inhibitory control abilities to manage the linguistic competition and demands of bilingual language processing. The literature suggests that bilingualism can have a certain influence on the growth of inhibitory control across different age groups. The bilingual advantage in inhibition seems to become more significant as children grow older, possibly due to the increased demands on inhibition linked with bilingual language processing.

### 3.2. Brain outcomes

Recent research has shown a significant positive relationship between language experience level and cognitive and brain outcomes. Psycholinguistic studies have shown that even if the unused language is not recognized, these two languages remain active in the bilingual brain. Bilinguals rarely make invasive errors from nontarget languages, indicating that inhibitory control plays a crucial role in excluding non-target languages during processing. Brain imaging evidence suggests that overlapping networks are used for both language and nonverbal selection. It is believed that lifelong bilinguals have rich experience in deploying inhibition in language processing, and they can enhance these processes, which are shared to some extent with nonverbal cognitive networks. This explanation is that this enhanced inhibition process can be summarized as applicable under any circumstances where it is advantageous to select an information source while suppressing attention to sources of competition. According to Braver, Barch, and colleagues' goal maintenance theory of prefrontal control function, cognitive operations are controlled through sustained neuronal activity patterns in working memory, which maintain the expected outcomes of perception and action in a highly accessible form. This is achieved by generating an Activation signal for bias processing in progress towards areas related to the current targets [1]. Desimone and Duncan stated that there is sustained local competition in the form of mutually inhibitory interactions at various levels of the brain, from

sensation to action. They believe that top-down excitation signals from the prefrontal cortex will bias the outcome of this competition toward target-related perceptions and behaviors [15].

#### 4. Bilinguals' performance on inhibition tasks

Based on previous research, an analysis of bilingual performance on Flanker, Simon, and Stroop tasks that measure inhibition skills can be conducted. Park et al. discovered that over time, bilingual children demonstrate better development in inhibitory control compared to monolingual children, leading to observed advantages for bilinguals by Year 2 [4]. In the literature on executive function (EF) in bilingual individuals, inhibition has received significant attention as the cognitive skill most likely to benefit from bilingual experience. Studies generally report faster and more accurate performance by bilingual children on tasks requiring inhibition. It is noteworthy that similar findings have been reported for young adult bilinguals using a version of the flanker task across different countries, language groups, and cultures [4]. The study by Bialystok et al. showed that bilinguals have better performance on controlled processing, and bilinguals slow down the decrease in cognitive control ability in the elderly. This study used two experiments to compare the Simon test scores of middle-aged and elderly monolinguals and bilingual individuals. The findings indicate that under conditions that require more inhibition and working memory, bilinguals have much faster reaction times than monolinguals, suggesting that bilinguals have stronger inhibition and working memory abilities [10]. The study also suggests that bilinguals perform better than monolinguals in recognizing font colors through the Stroop color naming task [16]. Additionally, Bialystok et al. investigated the youth with the Stroop task and discovered that bilinguals had a smaller Stroop effect [17]. In the Simon task, bilinguals' response times were shorter to conflict tasks than young monolinguals. In the Flanker task, bilingual superior effect was also illustrated by middle-aged bilinguals [18].

Bilinguals demonstrate superior performance compared to monolinguals in certain tasks and under specific conditions. However, the concept of inhibition alone does not fully explain the cognitive differences between these two groups, as detailed below. Hilchey and Klein argued against a simplistic inhibitory view and instead proposed that bilinguals possess a processing advantage stemming from "a general executive system that improves in efficiency owing to the need to monitor linguistic representations competing for selection" [1]. This advantage manifests as an overall increase in processing speed, but it extends beyond mere speed enhancement. Furthermore, studies have shown that bilingual benefits are not typically observed in Simon tasks and Flanker tasks with minimal conflict and executive function demands.

Additionally, research has indicated that the processing speed advantage seen in bilingual individuals is attributed to fewer abnormally long response times, indicating better attentional control rather than simply faster processing. For instance, Carlson and Meltzoff discovered no significant difference in performance on the flanker task among monolinguals, bilinguals or those attending a language immersion program at age six; however, they did observe improved performance by bilingual individuals on other conflict tasks within their battery of tests [19]. In studies involving children, it was found that conditions requiring resolution of conflict, such as those present in Simon or Stroop tasks, led to better performance by bilingual children compared to monolingual children. Conversely, when situations required inhibition of a response, all children performed similarly [1]. Similarly, Gathercole et al. provided data from a large and diverse sample that covers all age groups from three years old to the elderly, representing four different language "configurations" based on English community language dominance and native language [20, 21, 22]. The study revealed that monolinguals and English-dominant participants generally performed better in the task, although this was only true for some of the comparisons. However, it is worth noting that the sample structure related to language configuration is largely uncontrolled, with no information provided about

participants' social class, education, or other relevant details, except for the fact that monolinguals come from England and all other groups come from Wales [5].

## 5. Conclusion

In this article, firstly, we explain the definition of inhibition and list three cognitive tasks, including Flanker, Simon, and Stroop tasks, that are used to measure inhibition skills. Secondly, we find that bilinguals are required to switch between two languages constantly, and this improves their ability to ignore distracting information and focus on the task at hand. In addition, evidence from neuroimaging studies also supports our findings. Finally, we analyze how bilinguals perform on inhibition through the above cognitive tasks and find that there is insufficient evidence to prove that bilingualism has cognitive advantages on inhibition directly. This article reviews several kinds of literature to investigate the research questions. Our results further support findings suggesting that bilingualism relates to inhibition and bilinguals perform better than monolinguals on some extent of cognitive tasks, but Bilingual ability does not have a universal cognitive advantage. Due to the lack of valid statistical analysis, our finding has some limitations to a certain degree. Except for uncontrolled socioeconomic status, educational background or other distracting information, other confounding variables still exist. For example, the theory of bilingual advantage may be due to publication bias towards research with positive outcomes rather than research with zero or negative impact. In conclusion, the bilingual advantage in inhibition may be more complex than previously thought, and factors such as sample characteristics, and publication bias should be carefully considered. After all, future research examining the long-term influences of bilinguals on the development of inhibition is needed to provide a more detailed understanding of this relationship while considering socioeconomic status, educational background, publication bias, and other relevant information as confounding variables. Further study can be conducted with valid data and statistical analysis to confirm our results.

## References

- [1] Bialystok, E., & Craik, F. I. M. (2022). How does bilingualism modify cognitive function? attention to the mechanism. *Psychonomic Bulletin & Review*, 29(4), 1246–1269. <https://doi.org/10.3758/s13423-022-02057-5>
- [2] Bhatia, T. K., & Ritchie, W. C. (2006). *The Handbook of Bilingualism*. Blackwell.
- [3] Bialystok, E. (2015). Bilingualism and the development of Executive Function: The role of attention. *Child Development Perspectives*, 9(2), 117–121. <https://doi.org/10.1111/cdep.12116>
- [4] Park, J., Ellis Weismer, S., & Kaushanskaya, M. (2018). Changes in executive function over time in bilingual and monolingual school-aged children. *Developmental Psychology*, 54(10), 1842–1853. <https://doi.org/10.1037/dev0000562>
- [5] Bialystok, E. (2017). The bilingual adaptation: How minds accommodate experience. *Psychological Bulletin*, 143(3), 233–262. <https://doi.org/10.1037/bul0000099>
- [6] Nichols, E. S., Wild, C. J., Stojanowski, B., Battista, M. E., & Owen, A. M. (2020). Bilingualism affords no general cognitive advantages: A population study of executive function in 11,000 people. *Psychological Science*, 31(5), 548–567. <https://doi.org/10.1177/0956797620903113>
- [7] de Bruin, A., Treccani, B., & Della Sala, S. (2014). Cognitive advantage in bilingualism. *Psychological Science*, 26(1), 99–107. <https://doi.org/10.1177/0956797614557866>
- [8] GREEN, D. W. (1998). Mental control of the bilingual lexico-semantic system. *Bilingualism: Language and Cognition*, 1(2), 67–81. <https://doi.org/10.1017/s1366728998000133>
- [9] BLUMENFELD, H. K., & MARIAN, V. (2013). Cognitive control in bilinguals: Advantages in stimulus–stimulus inhibition. *Bilingualism: Language and Cognition*, 17(3), 610–629. <https://doi.org/10.1017/s1366728913000564>
- [10] Liao, Y. (2024). Cognitive benefits of bilingualism across the lifespan. *Lecture Notes on Language and Literature*, 7(3). <https://doi.org/10.23977/langl.2024.070318>
- [11] Dianchun, L. (2022). Bilingualism is good for training for mind—discuss with reference to different age groups. *Frontiers in Educational Research*, 5(19). <https://doi.org/10.25236/fer.2022.051916>
- [12] Sebastian-Galles, N., & Santolin, C. (2020). Bilingual acquisition: The early steps. *Annual Review of Developmental Psychology*, 2(1), 47–68. <https://doi.org/10.1146/annurev-devpsych-013119-023724>

- [13] Stevens, W. D., Khan, N., Anderson, J. A. E., Grady, C. L., & Bialystok, E. (2023). A neural mechanism of cognitive reserve: The case of bilingualism. *NeuroImage*, 281, 120365. <https://doi.org/10.1016/j.neuroimage.2023.120365>
- [14] Festman, J., Rodriguez-Fornells, A., & Münte, T. F. (2010). Individual differences in control of language interference in late bilinguals are mainly related to general executive abilities. *Behavioral and Brain Functions*, 6(1), 5. <https://doi.org/10.1186/1744-9081-6-5>
- [15] Desimone, R. (1995). Neural mechanisms of selective visual attention. *Annual Review of Neuroscience*, 18(1), 193–222. <https://doi.org/10.1146/annurev.neuro.18.1.193>
- [16] Coderre, E. L., & van Heuven, W. J. (2014). The effect of script similarity on executive control in Bilinguals. *Frontiers in Psychology*, 5. <https://doi.org/10.3389/fpsyg.2014.01070>
- [17] Bialystok, E., Craik, F., & Luk, G. (2008). Cognitive control and lexical access in younger and older bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 34(4), 859–873. <https://doi.org/10.1037/0278-7393.34.4.859>
- [18] Emmorey, K., Luk, G., Pyers, J. E., & Bialystok, E. (2008). The source of enhanced cognitive control in Bilinguals. *Psychological Science*, 19(12), 1201–1206. <https://doi.org/10.1111/j.1467-9280.2008.02224.x>
- [19] Carlson, S. M., & Meltzoff, A. N. (2008). Bilingual experience and executive functioning in young children. *Developmental Science*, 11(2), 282–298. <https://doi.org/10.1111/j.1467-7687.2008.00675.x>
- [20] Gathercole, V. C., Thomas, E. M., Kennedy, I., Prys, C., Young, N., Viñas Guasch, N., Roberts, E. J., Hughes, E. K., & Jones, L. (2014). Does language dominance affect cognitive performance in bilinguals? lifespan evidence from preschoolers through older adults on card sorting, Simon, and metalinguistic tasks. *Frontiers in Psychology*, 5. <https://doi.org/10.3389/fpsyg.2014.00011>
- [21] BRITO, N. H., MURPHY, E. R., VAIDYA, C., & BARR, R. (2015). Do bilingual advantages in attentional control influence memory encoding during a divided attention task? *Bilingualism: Language and Cognition*, 19(3), 621–629. <https://doi.org/10.1017/s1366728915000851>
- [22] Dash, T., Berroir, P., Joannette, Y., & Ansaldo, A. I. (2019). Alerting, orienting, and executive control: The effect of bilingualism and age on the subcomponents of attention. *Frontiers in Neurology*, 10. <https://doi.org/10.3389/fneur.2019.01122>