

Navigating the Mind's Bilingual Maze: Understanding Cognitive Advantages Across Variables

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Abstract: It is widely held that bilinguals hold cognitive advantages in working memory compared to monolinguals; however, is there really a conclusive argument? The present study delves into the intriguing relationship between bilingualism and working memory, exploring the debate of potential cognitive advantages that bilinguals might possess. By analyzing seminal works, key studies supporting bilingual advantage, and perspectives challenging this view, this paper synthesizes findings regarding bilingualism's cognitive benefits beyond language processing, delineating its significant contributions and its methodological and conceptual limitations. Additionally, the study considers the potential implications of bilingual advantage in education and in addressing neurodegenerative diseases. It identifies substantive gaps in the current understanding, including a lack of standardization in experimental designs and reporting standards and a limited focus on confounding variables.

Keywords: Bilingualism, Cognitive Advantages, Attentional Control, Alerting, Working Memory

1. Introduction

In an increasingly interconnected and globalized world, the ability to speak multiple languages has become an extremely important skill, enabling communication across diverse groups of people and opening doors to global job markets. For years, anecdotal evidence and cultural assumptions suggested a certain cognitive dexterity among individuals who navigate daily life through more than one linguistic framework. However, it was not until groundbreaking researchers like Ellen Bialystok took it upon themselves to delve into the realm of empirical science that these assumptions began to acquire a firm scholarly foundation. With a focus on various cognitive tasks, from attentional control to decision-making processes, researchers have worked diligently to unravel the layers of complexity that constitute the bilingual mind.

While the early years of bilingualism research were often heralded as a groundbreaking era that promised to deliver clear answers to long-standing questions, the reality has proven far more nuanced.

Numerous studies have demonstrated the cognitive benefits of bilingualism, including superior problem-solving abilities and enhanced attentional control. Yet, there exists a noticeable variation in research methodologies, sample selections, and reporting standards across studies. The result is a complex, occasionally conflicting, body of literature that offers significant insights but leaves many questions unanswered.

Consequently, this literature review aims to critically examine the existing body of work on the cognitive benefits associated with bilingualism. From the pioneering works of the late 20th century to the modern research of the 21st, both the landmark studies and the controversial findings that have shaped the academic discourse are scrutinized. The review identifies gaps in the research, such as the lack of standardization in experimental designs and reporting, as well as the limited number of confounding variables examined. In doing so, a way is paved for a new, more comprehensive approach to studying bilingualism—one that is sensitive to the nuances and complexities that define this fascinating area of research.

2. Research

2.1. Seminal Works

The research paper done in 1999 by Ellen Bialystok [1] marked a significant cornerstone in investigating the bilingual difference in working memory. In the paper, Bialystok hypothesizes that control (selective attention) is a component of language processing that develops earlier in bilingual children than in monolingual children. To test this, Bialystok conducted experiments with preschool children, categorizing them into younger and older groups based on age. The experiment involved administering the change card sort task and the moving word task, which tests children's accuracy in performing tasks with/without the presence of distractions. The findings of Bialystok's research indicated that bilingual children demonstrated an advanced ability to eliminate information inconsistent with the task, thus revealing a higher level of attentional control. This pioneering study established that bilingual individuals possess a cognitive advantage in control over monolingual individuals, spiking further research on this topic.

In 2004, another foundational work by Bialystok, Craik, Klein, and Viswanathan [2] provided further evidence that bilingualism brings advantages in cognition. The research extended its participants from children to adults, aiming to explore whether attentional control in bilingual adults exceeded that of monolingual adults and whether bilingualism attenuates the negative effects of aging on cognitive control. In the experiment, 40 participants composed of two language groups and two age groups are asked to complete the Simon task, where participants respond to a visual stimulus (e.g., pressing the left/right shift key) based on a specific attribute (e.g., color) while ignoring its spatial location. The outcome of this study supported Bialystok's earlier findings, revealing that bilingual adults indeed exhibited superior performance in both the congruent and incongruent tasks.

2.2. Key Studies

Many papers further investigated the bilingual advantage in working memory after the publication of seminal works, replicating, or trying new experiments; most of the papers aligned with the original results, demonstrating a bilingual advantage in working memory. Anat Prior and Tamar H. Gollan's work in 2011 [3] aimed to establish a correlation between language-switching frequency and task-switching costs among bilinguals. Using Spanish-English and Mandarin-English bilinguals, this study delved into the specific relationship between language-switching and task-switching costs. Using a non-linguistic task-switching experiment, the study shows that bilinguals who frequently switched between languages in their daily lives experienced reduced costs when switching tasks; specifically, Spanish-English bilinguals displayed lower task-switching costs compared to Mandarin-English

bilinguals, who possess almost the same task-switching cost than monolinguals. Although this study suggested certain limitations in bilingual advantages, it strengthened the notion that proficient language-switchers possess enhanced task-switching skills and, thus, better cognitive flexibility.

Julia Morales, Alejandra Calvo, and Ellen Bialystok's work in 2013 [4] also significantly contribute to the understanding of working memory development in bilingual individuals. This study encompassed two experiments involving young children. The first experiment replicated the Simon-type task to assess children's conflict resolution skills; the results demonstrated that bilingual children exhibited faster response times and higher accuracy. The second experiment includes a non-linguistic frog-matrices task, which focused on children's visuospatial span. It reveals that bilinguals outperform monolinguals, obtaining a higher accuracy, especially on the harder, sequential presentation task, which requires another executive function demand (in this case, remembering the sequence of information). This research reiterated the advantage of working memory in bilingual individuals, particularly in tasks requiring executive function.

Another piece of work that supports bilingual advantage is Costa, Hernandez, and Sebastian-Galles's paper in 2008 [5]. This study examined whether bilingualism's cognitive benefits extended beyond language processing, specifically in alerting, orienting, and executive control. Costa et al. employed the attentional network task (ANT), which involved various cues, such as central arrows pointing left or right, flanked by congruent or incongruent arrows in the periphery. Participants were asked to identify the arrow direction in the middle. The result showed that bilinguals responded faster to the alerting effect and also had a faster reaction time to both congruent and incongruent effects (bilinguals exhibited an especially shorter amount of time in incongruent trials). This indicated that bilingualism not only conferred advantages in language-related functions but also significantly impacted broader cognitive domains.

Additionally, Kaushanskaya and Marian's work in 2009 [6] provides insight into whether bilingualism brings a linguistic cognitive advantage, specifically in novel word learning. In the experiment, bilinguals (both English-Mandarin bilinguals and English-Spanish bilinguals) and monolingual participants went through procedures of novel vocabulary learning and testing. The study notes that, unlike the results previous studies demonstrated, different groups of bilinguals demonstrated an equal advantage over monolinguals in novel word learning across different tests (recall/recognition) and across different delaying periods (immediate/one-week delay). Kaushanskaya et al. discussed that bilinguals exhibited a clear advantage on cognitive and linguistics tasks despite further research required to fully understand the mechanisms behind this advantage.

2.3. Different Works and Perspectives

While numerous studies have reported a cognitive advantage for bilingual individuals, a countervailing body of research has cast skepticism on these findings. Jon Andoni Duñabeitia et al.'s paper in 2011 [7], for instance, introduced some critical concerns on the current studies conducted on this topic, including methodological concerns on sample size and sample selection, statistical concerns related to the analyses reported, and theoretical issues related to the inconsistency of the results across tasks and groups of participants. Andoni Duñabeitia et al. further underscored the need for self-critique among researchers and an unbiased peer-reviewing system, advocating for equal consideration of both advantageous and non-advantageous findings.

Building on this foundational work, further research extended the scrutiny to potential bias in experimental, as well as publication, processes in various studies and found nuances that might lead to inaccurate results. Angela de Bruin, Barbara Treccani, and Sergio Della Sala's meta-analysis in 2015 [8] discovered the presence of publication bias in previous studies; that is, a researcher is more likely to publish a significant result and conceal an insignificant result. Conducting a meta-analysis of all the conference abstracts from 1999 to 2012 on the topic of bilingualism and executive control,

de Bruin et al. discovered that while 63% of the studies supporting a bilingual advantage were published, only 38 of 104 (38%) conference abstracts found a result supporting the bilingual advantage, with 45% exhibiting mixed results, and 16% indicating no difference or a monolingual advantage. The profound discrepancy is a clear sign of publication bias; de Bruin et al., therefore, argued that there is still no conclusive evidence suggesting a bilingual's advantage in working memory and stresses the need for unbiased publication practices.

Another group of skeptics employed physiological devices to replicate the previous studies but yielded inconsequential outcomes. Shanna Kousaie and Natalie A. Phillips, in their works in 2012 [9] and in 2017 [10], conducted the Simon task, the Stroop task, and the flanker task and measured both the participants' behaviors (reaction time, accuracy rate, etc.) and their Event-Related Potentials (ERPs) using electroencephalography (EEG). The 2012 study demonstrated a difference between monolinguals and bilinguals in ERP measures that is inconsistent among different tasks (namely, a smaller Stroop effect and a larger Simon effect), but no behavioral distinctions across all tasks; the 2017 study, however, showcased a bilingual advantage in Stroop task behaviorally, yet unveils no significant differences in EEG measures between language groups. The studies collectively reveal that traditional experiments show almost no (1 out of 6 experiments) bilingual cognitive advantage behaviorally and demonstrated a divergence in EEG results, challenging the conventional assertions of a bilingual cognitive advantage.

Paap, Johnson, and Sawi's work in 2015 [11] critically challenges the traditional view from a comprehensive perspective, scrutinizing aspects including methodology, publication bias, statistical biases, and neuroscientific evidence. Besides affirming de Bruin's argument that positive findings are overrepresented through bias in peer review, Paap et al. highlight instances where researchers irresponsibly manipulate insignificant results by "deciding to collect more data when results are not significant" or "rounding off a p-value greater than .050 to a value $\leq .05$ ". Paap et al. also highlight the potential effect of type 1 error, suggesting that a large number of studies with small numbers of participants could lead to a significant number of false positives. In the realm of neuroscience data, the paper cautions against the overinterpretation of Event-related Brain Potentials (ERPs), claiming that ERPs couldn't reflect cognitive advantages but might be driven by non-linguistic processes. Lastly, he suggested that random assignment of participants to language groups in quasi-experimental designs could introduce confounding variables such as Socioemotional Status (SES), which could interact with bilingualism and lead to biased interpretations.

3. Discussion

3.1. Combining Findings

The findings across the reviewed studies present an intricate relationship between bilingualism and working memory. The pioneering work of Bialystok [1] laid the foundation for the cognitive advantages of bilingualism. Bialystok's experiments introduced the concept of attentional control and, through testing on children in a moving word task and a dimensional change card sort task, revealed that bilinguals performed better than their monolingual counterparts in control tasks, where bilinguals exhibit significantly greater accuracy. This initial study laid the foundation for further explorations into the working memory difference between bilinguals and monolinguals within different age groups and among different tasks.

Building upon this framework, a large number of subsequent works have reinforced the idea of the bilingual advantage in working memory, conducting different experiments across various age groups. Bialystok et al. [2], for instance, expanded the cognitive benefit from children to adults by conducting a Simon task with middle-aged (30 to 54 years old) and older (60 to 88 years old) participants. Besides confirming the bilingual cognitive advantage across different age groups, Bialystok et al. suggested

in this study that a greater advantage exists among older people and implied the potential of bilingualism serving as a cognitive buffer, delaying the onset of age-related declines in working memory and executive functioning. Additionally, Costa et al. [5] conducted the Attentional Network Task (ANT) with younger adults (17 to 32 years old), revealing a bilingual advantage in alerting and executive control, where they exhibited less reaction time and better response accuracy. Kaushanskava et al.'s novel word learning experiment [6] showcased that bilinguals remember new, unfamiliar words more accurately in both immediate and delayed testing situations and in both recall and recognition tasks; A. Prior and T. H. Gollan [3] conducted a task-switching experiment on monolingual and different bilingual groups, explaining that some bilinguals exhibited better task-switching abilities over monolinguals despite stressing the importance of Socioeconomic Status (SES) that may account for the non-uniform task-switching abilities across different bilingual populations.

With the development of neuroscience instruments such as Event-Related Potentials (ERP) and electroencephalography (EEG), skepticism began to arise regarding the reliability of previous studies. Some researchers encounter different results, facilitating them to argue that the bilingual advantage in working memory barely exists. Kousain, S. & Phillips, N. A [9], for instance, tried to replicate the Stroop, Simon, and Erikson flanker task with electrophysiological recordings. Although recordings demonstrated a slight, inconsistent difference between bilinguals and monolinguals, behaviorally, there were no significant differences between the two language groups in any of the tasks. Kousaie, S., & Phillips, N. A. [10], further research on the same topic, showed a slight nuance with bilingual elders exhibiting better behavioral and electrophysiological performance in a Stroop task. However, it still reveals an electrophysiological-limited advantage in Simon and Flanker tasks, casting doubt on the previous experimental results and conclusions.

Another group of skeptics indicated that the statistical bias may account for the dominance of papers suggesting a bilingual advantage in working memory. Jon Andoni Duñabeitia et al. [7] built the foundation of this argument in 2011, claiming the existence of a publication bias due to a biased current peer-review system. Angela de Bruin et al. [8] endorsed this argument with a meta-analysis of previous experimental abstracts, showing that 63% of the published studies, but only 38% of conference abstracts, had a significant result that showed a bilingual advantage. Paap, K. R., Johnson, H. A., & Sawi, O. [11] also agreed that many experiments and conference abstracts show non-significant results of bilingual advantages and were not published due to biased writers or editors. Furthermore, Paap, K. R., Johnson, H. A., & Sawi, O. [11] conducted a study on previous experimenters, pointing that a considerable portion of researchers committed to confirmation bias, where they irresponsibly modified data so that it exhibited the favored result which confirms the researchers' hypothesis. Paap et al. also raised methodological concerns and doubts about neuroscience data, highlighting the necessity of scrutinizing experimental designs and controlling for potential biases, underscoring the importance of maintaining scientific rigor and critically evaluating the robustness of the observed effects.

As the nuances of these findings delved more profoundly, one emerging consensus is the significance of balanced language usage. Researchers underscore that the cognitive benefits of bilingualism are more pronounced when both languages are used proficiently and regularly [12]. This suggests that effective bilingual education strategies should go beyond language instruction within the classroom, emphasizing real-world, balanced language engagement. However, the disagreement between researchers about whether bilingualism provides cognitive benefits will increase as more studies are conducted, and we will continually gain a more comprehensive portrait of the intricate relationship between bilingualism and working memory. Can bilingualism offer cognitive advantages, or would it be a false consensus? Ongoing research will undoubtedly refine our understanding, necessitating meticulous attention to methodological nuances and potential confounds. As we

navigate this intellectual terrain, we are poised to unlock the full potential of bilingualism as a cognitive enhancer.

3.2. Further Implications

As discussed in 3.1, many research papers have demonstrated profound evidence suggesting bilingualism's advantages that extend beyond language processing. These papers suggest that bilingual advantages primarily comprise a better performance on cognitive tasks (specifically, in testing abilities in executive function, attentional control, and cognitive flexibility) [1, 3, 6], as well as a potential delay of the onset of aging-related cognitive decline [2,10], shedding light on both education and medical areas. Despite these promising findings, appropriate bilingual education remains underemphasized in many parts of the world. Many bilingual education programs have limited funds allocated by the educational systems, leading to larger class sizes and fewer specialized resources; furthermore, in some countries, teachers in bilingual programs have not received proper training in bilingual instruction techniques, leading to less impactful bilingual education in students. In this section, the authors will re-emphasize the importance of bilingual education and balanced language usage and provide recommendations for the implementation of bilingual education. Bilingual education could be a potent tool to enhance cognitive development in children and reduce aging-related cognitive decline.

3.2.1. The Role of Bilingualism in Cognitive Development and Education

As discussed before, bilingual education not only confers traditional advantages, such as increasing cultural awareness and improving communication skills, but it also suggests a simultaneous advantage in cognitive ability. Bilinguals have exhibited superior cognitive skills, including attentional control, alerting, task switching, and novel word learning. However, it should be noted that having the right bilingual education is indispensable. Consistent and balanced use of both languages is essential to maximizing the cognitive benefits of bilingualism. One of the key insights from recent studies is that the advantages associated with bilingualism are closely tied to the degree of proficiency and frequency of use of both languages [12]. Simply having a second language class may not be sufficient to reap the cognitive benefits. Instead, actively engaging with both languages in everyday life ensures the cognitive mechanisms associated with bilingual advantage. In the context of bilingual education, this underscores the importance of moving beyond traditional second-language instruction that is often confined to the classroom. Instead, schools and educational institutions should actively promote opportunities for students to immerse themselves in both languages, whether through cultural exchanges, extracurricular activities, or family engagement. Cultivating balanced language usage is not only vital for fostering a deeper appreciation of linguistic and cultural diversity, but it also enhances their cognitive development.

3.2.2. Bilingualism and its Potential Impact on Neurodegenerative Diseases

Neurodegenerative diseases, characterized by the gradual and irreversible degeneration of neurons, are among the most pressing health challenges faced by our aging global population. The most prominent neurodegenerative diseases, Alzheimer's disease, and Parkinson's disease, affect memory and cognitive functions and could lead to difficulty of movement. In recent years, researchers have developed ways to delay neurodegenerative diseases in adults, mostly through medicine. Intriguingly, emerging research has suggested that bilingualism may have a protective effect against neurodegenerative diseases and potentially slow down the decline of working memory. For example, Bialystok et al. and Costa et al. [2, 5] claimed that bilingual individuals often exhibit enhanced working memory compared to their monolingual counterparts, suggesting that bilingualism might

serve as a protective factor against cognitive decline and the onset of neurodegenerative diseases. Building on this viewpoint, research by Bialystok, Craik, and Freedman [13] revealed that bilingual individuals were diagnosed with Alzheimer's disease on average 4.5 years later than monolinguals. Importantly, balanced usage of both languages also appears to be a key factor in maximizing these benefits, as more proficient bilinguals show greater cognitive advantages and delayed onset of neurodegenerative diseases [3,14]. This body of evidence supports the notion that bilingualism, particularly when languages are used proficiently and regularly, may help in delaying or slowing down neurodegenerative diseases that affect working memory and other cognitive functions.

To translate this promising research into practical applications, it is crucial to promote bilingualism among older adults. Initiatives that encourage language learning among the elderly population may include community-based language classes, interactive language learning apps tailored to different age groups, and cultural exchange programs that encourage proficient language use. Additionally, policymakers should consider incorporating bilingualism promotion into public health campaigns and senior centers, recognizing it as a potential strategy to mitigate the burden of neurodegenerative diseases.

4. Research Gaps & Future Directions

4.1. Consistency in Experimental Design

4.1.1. Varying Cognitive Tasks

In the realm of bilingualism research, there's a vast array of cognitive experiments being used. Bialystok [1] initiated this trend with attentional control tasks, aiming to discern how bilingual children think. Through tests such as the moving word task and the dimensional change card sort task, it became clear that bilingual children might think in unique ways.

The spectrum of experiments grew wider as research progressed. Costa et al. [5] ventured into new territory with the Attentional Network Task (ANT), delving deeper into the untapped area of alerting and decision-making processes. His experiments are indeed effective; however, the use of different tasks brings about a challenge, as each one could potentially analyze a distinct facet of cognition. Kaushanskaya [6] stands out in this regard by focusing on how individuals acquire new words—a somewhat different angle from previous works. There's also mention of tasks like the Simon task, highlighted by Green, which focuses on spatial responses, and the Stroop task, which delves into interference handling. With such a variety of tasks at hand, comparing outcomes across different studies becomes inherently complex.

One potential solution could be a meta-analysis of different tasks. By amalgamating findings from numerous studies, we might discern which tasks truly shed light on the cognitive advantages of bilingualism. Additionally, there should be a commission of a study where it is designed to evaluate the efficacy of each of these cognitive tasks in relation to bilingualism. Such a study should aim to identify which experiments are more indicative of bilingualism's unique cognitive influences. By identifying the best experiments for the effects of bilingualism in cognitive influences, the academic community can then produce a more standardized approach to studying bilingual cognition.

4.1.2. Reporting Standards

The importance of consistency in research isn't limited to the design of experiments; it extends to the way findings are reported. Not only is it crucial to standardize experiments, but it's equally vital to establish a uniform reporting system. However, a few current reporting standards have clearly not reached a consensus. For instance, Abutelebi et al. and Kousaie et al. both provide valuable insights into bilingual cognition through flanker tasks, but there are noticeable differences in the way they

present their findings. Abutelebi et al. examined bilinguals and monolinguals separately, demonstrating that bilinguals had a flanker effect reduction that was significant while monolinguals had a reduction that was insignificant; Kousaie et al., however, directly tested if the bilingual flanker effect reduction was significantly greater than the monolingual flanker effect reduction. These disparities can lead to different conclusions, with Abutelebi et al. showing a bilingual advantage and Kousaie et al., showing an insignificant result, and they can also make it challenging for scholars to compare results and draw overarching conclusions.

Another inconsistent standard lies within the definition of bilingualism itself. Paap, Johnson, and Sawi [11] brought attention to this issue, discussing the myriad ways bilingualism is conceptualized and reported in the literature. Without a uniform reporting standard, the term "bilingual" might refer to someone who speaks two languages at home, someone who has studied a second language for a few years, or even someone who is fluent in two languages but uses them in entirely different contexts.

For the field to move forward cohesively and for its findings to resonate more robustly, adopting a uniform reporting standard becomes imperative. Researchers should develop a reporting system where the word "bilingual" is not ambiguously used and findings are analyzed and standardized so that other researchers can extract information quickly.

4.2. Sample Selection

4.2.1. Bilingualism Across Different Language Groups

In the growing field of bilingualism research, there exists a notable gap when it comes to exploring bilingualism across various language combinations. While esteemed researchers like Bialystok have laid crucial groundwork in understanding the cognitive benefits generally attributed to bilingualism, these studies often lack a nuanced approach when it comes to the specific languages spoken by bilingual individuals. This omission is far from trivial; when researchers like Bialystok, Craik, and Luk discuss cognitive advantages like better attentional control or delayed onset of dementia, they usually generalize across all bilinguals. However, these cognitive benefits are not universally accepted, as evidenced by opposing views from scholars like De Bruin and Paap. One major critique is that existing studies often lump together various bilingual experiences without considering the potential nuances of different language pairs. For instance, there could be a world of difference in cognitive advantages between someone bilingual in closely related languages such as Spanish and Portuguese versus someone fluent in disparate languages like Mandarin and English. Languages from different families may require the brain to adapt to diverse linguistic structures, thereby potentially affecting cognitive advantages in unique ways. Costa's research provides an initial foray into this kind of specificity, suggesting that the language combinations, indeed, could be a significant variable.

Therefore, the next wave of research in this field should aim for more particularity, specifically addressing bilingualism across different language groups. One constructive way forward would be a rigorous meta-analysis of existing studies complemented by newly commissioned experimental research. These should focus on whether the language pairs in bilingual individuals substantially affect cognitive advantages such as problem-solving, memory retention, and multitasking capabilities. Implementing these targeted approaches could offer a more detailed picture and perhaps settle ongoing debates within the academic community.

While existing research offers valuable broad strokes insights into the cognitive benefits of bilingualism, it doesn't yet provide a full canvas. An examination of the effects across different language combinations would add much-needed detail to this picture. By focusing on this aspect, future research could offer a more comprehensive, nuanced understanding of the cognitive advantages that bilingualism may afford, thereby enhancing the overall quality and applicability of bilingualism research.

4.2.2. Age and Proficiency Variability

In the field of bilingual research, we often see studies that focus on people who are the same age or have the same skill level in both languages. However, there are not many studies focusing on how age and proficiency can play a role in cognitive advantages. Age is an important element when looking at the benefits of being bilingual. For example, research by Bialystok and her team in 2007 [13] showed that older bilingual people may exhibit more profound cognitive advantages and are less likely to show early signs of dementia. Another study by Kousaie and Phillips in 2017 [10] looked at how well older bilinguals could control their attention compared to younger ones. For instance, Morales and his team in 2013 [4] only looked at children without considering other age groups. Missing out on a range of ages and skills means we don't get the full picture of how bilingualism affects people's thinking. These findings make us question if results from studies focused on just one age group can be applied more widely.

Also, language proficiency shall be taken into account in future studies. Skill level in each language could affect the extent of bilingual cognitive advantages. Luk and Bialystok in 2013 [12] showed that how well you know each language can affect your thinking skills. Most existing studies don't consider this aspect, making their results less useful for a broader range of people. Based on these gaps, it's clear that we need to include a more diverse range of ages and skill levels in future research.

4.2.3. Socioeconomic and Educational Factors

Within the realm of bilingual research, studies often zero in on specific groups—perhaps those of a certain age or language proficiency. But what about other factors like a person's socioeconomic background or level of education? Surprisingly, there's not much out there that tackles these aspects.

Socioeconomic factors, including income and occupation, could potentially shape the cognitive advantages of bilingualism. Yet, the evidence is sparse. For example, De Bruin et al. in 2015 [8] raised concerns about how socioeconomic factors were often overlooked. They argued that ignoring these factors could skew the results and make them less applicable to a broader population. Similarly, education is another aspect that needs attention. A study by Prior and Gollan in 2011 [3] dealt with how educational experiences can impact language-switching skills, suggesting that educational background might influence cognitive benefits. However, like with socioeconomic status, most studies don't examine this closely enough.

Given these gaps, it's clear that future research should look at a broader set of variables, including socioeconomic status and education. Paap et al. in 2015 [11] even went so far as to question the very existence of cognitive advantages in bilingualism, partly because of the lack of diversity in studied groups. Clearly, without accounting for these factors, we miss out on understanding how bilingualism truly affects cognition in different social strata.

4.2.4. Holistic Approach: Integrating Multiple Factors within a Bilingual Population

The prior sections have identified notable gaps in our current understanding of bilingual cognitive advantages. These gaps chiefly concern the limited diversity in the demographic variables examined in most studies, such as age, language proficiency, socioeconomic status, and educational background. To better address these limitations, a comprehensive research methodology designed to deliver a more nuanced and universally applicable understanding of bilingual cognitive benefits shall be implemented.

While existing research has contributed significantly to our understanding of bilingualism and cognition, there are persistent shortcomings in how these studies are designed. Morales et al. and Luk and Bialystok [4, 12] have generated valuable insights into the cognitive benefits of bilingualism

among certain age groups and proficiency levels. However, these studies are not universally applicable due to their limited demographic scope. Furthermore, De Bruin et al. [8] and similar studies have often omitted socioeconomic and educational backgrounds from their analyses, thereby limiting the generalizability of their findings.

The limitations of prior studies necessitate a new research design that incorporates a broader set of variables. In line with this need, a longitudinal study, borrowing from the methodology of Bialystok et al. [13], could be employed to track cognitive changes across a wide age range. Additionally, the issue of language proficiency should be addressed through standardized testing, a method championed by Luk and Bialystok [12]. Socioeconomic and educational status must also be considered in the study, thereby resolving the gaps pointed out by De Bruin et al. [8]. To successfully implement this research design, careful planning, and execution are crucial. The sample should be both random and diverse, taking cues from the diverse sampling strategy outlined by Prior and Gollan [3]. Cognitive tests should be chosen based on their recognized reliability, as shown by the work of Costa et al. [5]. Advanced statistical models capable of handling multiple variables should be employed in the data analysis stage to disentangle the different factors contributing to cognitive advantages in bilingualism.

One possible criticism of such a broad study is its potential complexity. Critics may argue that incorporating multiple variables might dilute the focus of the research. However, Paap et al. [13] effectively counter this argument, positing that a comprehensive approach is necessary for a complete understanding of the cognitive advantages or limitations associated with bilingualism. After all, by adopting this comprehensive, multi-variable approach, the research community will be better positioned to address the questions and challenges identified in previous sections. The methodology outlined here is not just comprehensive but also responsive to the nuanced factors that influence bilingual cognitive advantages. It offers the promise of contributing substantially to the academic discourse, aligning with the multi-variable approach advocated by Paap et al. [11].

5. Conclusion

In synthesizing the existing body of literature on the cognitive effects of bilingualism, it is evident that while substantial progress has been made, considerable gaps remain. Researchers have employed a range of methodologies and experimental designs to explore various facets of bilingual cognition. However, the lack of standardization in these approaches makes it challenging to draw robust conclusions that are broadly applicable.

Additionally, many studies yield findings that only apply to specific demographic groups. There is a pressing need for more comprehensive research that incorporates a wider range of variables, including age, language proficiency, socioeconomic status, and educational background.

One may argue that the inclusion of multiple variables could introduce a level of complexity that complicates data interpretation. However, it is precisely this multifaceted approach that is needed to yield a nuanced understanding of the cognitive advantages—or perhaps limitations—associated with bilingualism. Longitudinal studies incorporating diverse and random sampling strategies may serve as a particularly effective means to address these gaps.

Furthermore, it is imperative to address the issue of publication bias within this field of study. As the academic community continues to examine the cognitive effects of bilingualism, it is crucial to recognize and publish studies that do not necessarily align with the prevailing narrative of cognitive advantage. This will serve to provide a more balanced, accurate representation of the current state of knowledge, thus enabling more reliable applications and policy formulations.

Authors' Contributions

Ruiqi Liu and Wendi Li, as the first co-authors, contributed equally and most substantially to this literature review. Both were intricately involved in every stage of the literature review process, which included identifying relevant academic papers, brainstorming key themes, and recognizing research gaps in the existing literature. They were primarily responsible for the article's critical analysis, synthesis, and coherent presentation of findings. Additionally, they worked collaboratively in drafting and revising the article to ensure intellectual rigor and content accuracy. Each reviewed and approved the final version of the manuscript to be published.

The third author provided valuable assistance in the initial stages of the research by engaging in the discussion of setting the theme of the review. While their early contributions laid a foundational framework, the majority of the review, including revisions and the majority of the first draft, was conducted by the first co-authors, Ruiqi Liu and Wendi Li. As such, the final review reflects primarily the intellectual efforts and direction of the first co-authors.

References

- [1] Bialystok, E., 1999. *Cognitive Complexity and Attentional Control in the Bilingual Mind*. *Child Development* 70, 636–644. <https://doi.org/10.1111/1467-8624.00046>
- [2] Bialystok, E., Craik, F.I.M., Klein, R., Viswanathan, M., 2004. *Bilingualism, Aging, and Cognitive Control: Evidence From the Simon Task*. *Psychology and Aging* 19, 290–303. <https://doi.org/10.1037/0882-7974.19.2.290>
- [3] Prior, A., Gollan, T.H., 2011. *Good Language-Switchers are Good Task-Switchers: Evidence from Spanish–English and Mandarin–English Bilinguals*. *J Int Neuropsychol Soc* 17, 682–691. <https://doi.org/10.1017/S1355617711000580>
- [4] Morales, J., Calvo, A., Bialystok, E., 2013. *Working memory development in monolingual and bilingual children*. *Journal of Experimental Child Psychology* 114, 187–202. <https://doi.org/10.1016/j.jecp.2012.09.002>
- [5] Costa, A., Hernández, M., Sebastián-Gallés, N., 2008. *Bilingualism aids conflict resolution: Evidence from the ANT task*. *Cognition* 106, 59–86. <https://doi.org/10.1016/j.cognition.2006.12.013>
- [6] Kaushanskaya, M., Marian, V., 2009. *The bilingual advantage in novel word learning*. *Psychonomic Bulletin & Review* 16, 705–710. <https://doi.org/10.3758/PBR.16.4.705>
- [7] Duñabeitia, J.A., Carreiras, M., 2015. *The bilingual advantage: Acta est fabula?* *Cortex* 73, 371–372. <https://doi.org/10.1016/j.cortex.2015.06.009>
- [8] De Bruin, A., Treccani, B., Della Sala, S., 2015. *Cognitive Advantage in Bilingualism: An Example of Publication Bias?* *Psychol Sci* 26, 99–107. <https://doi.org/10.1177/0956797614557866>
- [9] Kousaie, S., Phillips, N.A., 2012. *Conflict monitoring and resolution: Are two languages better than one? Evidence from reaction time and event-related brain potentials*. *Brain Research* 1446, 71–90. <https://doi.org/10.1016/j.brainres.2012.01.052>
- [10] Kousaie, S., Phillips, N.A., 2017. *A behavioral and electrophysiological investigation of the effect of bilingualism on aging and cognitive control*. *Neuropsychologia* 94, 23–35. <https://doi.org/10.1016/j.neuropsychologia.2016.11.013>
- [11] Paap, K.R., Johnson, H.A., Sawi, O., 2015. *Bilingual advantages in executive functioning either do not exist or are restricted to very specific and undetermined circumstances*. *Cortex* 69, 265–278. <https://doi.org/10.1016/j.cortex.2015.04.014>
- [12] Luk, G., Bialystok, E., 2013. *Bilingualism is not a categorical variable: Interaction between language proficiency and usage*. *Journal of Cognitive Psychology* 25, 605–621. <https://doi.org/10.1080/20445911.2013.795574>
- [13] Bialystok, E., Craik, F.I.M., Freedman, M., 2007. *Bilingualism as a protection against the onset of symptoms of dementia*. *Neuropsychologia* 45, 459–464. <https://doi.org/10.1016/j.neuropsychologia.2006.10.009>
- [14] Bialystok, E., Craik, F.I.M., Luk, G., 2012. *Bilingualism: consequences for mind and brain*. *Trends in Cognitive Sciences* 16, 240–250. <https://doi.org/10.1016/j.tics.2012.03.001>