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The Impact of Bilingualism on Children's Executive Function: A Critical Review of Evidences

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Abstract. This paper looks at what happens with kids' EF when they know two languages. Based on the three-factor model (inhibition, updating, and shifting), some research has shown that bilingual children could have some advantages when the task is hard, at the beginning of learning, and in a strong second language environment. But big and repeat studies make people wonder if this good thing is true everywhere, saying there are different ways of doing things, papers only showing nice results, and not matching real life well. Review shows that the bilingual advantage depends on context and is moderated by developmental stage, task type and environmental factors. Current studies are limited due to inconsistent definition of bilingualism, artificial tasks used and control of socio-economic and cultural factors. More future research will use long term and more natural methods, and classify bilingualism better so we can learn about how it changes children's EF. Bilingualism is not a universal benefit, but rather a potential resource, especially for early childhood education.

Keywords: Bilingualism, Executive function, Children, Early childhood education, Cognitive development

1. Introduction

With the rising trend of globalization and social diversification, it is becoming more common to be bilingual or multilingual. More and more kids use and get exposed to two or even three languages at home, school, and in their communities. This trend of dual-language exposure aligns with the global trend of linguistic diversity and affects educational practice and attitudes toward bilingual education as an important part of children's language socialization and cognitive development [1,2].

As more people became bilingual, researchers started looking into what being bilingual does to your brain. A lot of literature showed that there could be some benefits from having a bilingual experience, mainly concerning executive function such as inhibition control, cognitive flexibility, and working memory [3,4]. But some studies did not get the same result or said that the good things before might just come from how they did the study and picking what papers to read [5,6]. Therefore, the connection between bilingualism and executive function is quite contentious.

According to what I learned from other people's study about the connection between being able to speak two languages and having better control over your thinking processes, I wonder, does the real world show us that kids who know two languages do better with controlling their thoughts? Review

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also examined whether there was a possibility that the bilingual experience had some positive effects on children's executive function. It gives more evidence for our knowledge of how being bilingual affects your brain.

2. Literature review

2.1. Definitions and main parts of executive function

Executive function (EF) is described by Miyake et al's influential three-factor model, which consists of three related but distinct factors: inhibition (the capacity to inhibit the dominant or automatic response), updating (the capacity to monitor and modify temporarily stored information), and shifting (also known as cognitive flexibility; the capacity to shift from one task or rule to another). This model has proved most beneficial when studying kids aged 8-13 y/o according to Lehto et al. [7], and gives us a commonly acknowledged structure for looking into how experiences with two languages impact executive control.

2.2. Bilingual experience and executive function: theoretical framework and measurement model

In order to find out how having two languages impacts kids' ability to do things like paying attention, remembering, and switching between different activities, we use something called the Miyake et al. 3-factor model. This model works best for children aged 8-13 years old [7,8]. Based on this, in the following sections we will go over three lines of evidence: (1) Benefits of speaking two languages on inhibitory control tasks; (2) Age effects on task-switching, mostly studied via DCCS; (3) Load-dependent benefits from being bilingual measured through working memory tasks. Bilingual variables can be embedded into this well-known model so that we could know which EF pathways would be affected by the bilingual experience and also know when it would be most obvious [7,8].

2.3. Evidence for bilingualism advantage in executive function

2.3.1. Evidence for bilingual advantages

Bilingual experience improves different parts of executive function – stopping yourself from doing something, changing between tasks, remembering things – but this depends on when you learn another language and what kind of task it is. Morales, Calvo, and Bialystok carried out a thorough examination of working memory and inhibitory control in both bilingual and monolingual children by means of a high-conflict Simon task and a visuospatial span task. The study involved 5-year-old kids for the Simon task and 5-7 year-olds for the visuospatial task. From the results we can see that the bilingual children had much smaller interference effects than the monolinguals on the Simon task which shows that they have better at resolving conflicts cognitively and better inhibition control. In addition, in the visuospatial span task, bilingual children could remember and operate more spatial objects, and even more surprisingly, the bilingual advantage got stronger with the rise of task requirements. All these results together show a demand dependent pattern, which means that the cognitive benefits from being bilingual work best when there's lots of inhibition needed or when your working memory needs to do more [9].

Chamorro and Janke built upon the findings with an examination of how being exposed to a second language (L2) impacts monolingually raised children attending a bilingual education

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program. Inhibitory control was measured using go/no-go tasks. They discovered that those who were exposed to another language had more inhibition and less commission error. This paper mentions the effect of environment and experience on bilingual advantages. The results show that besides being bilingual, it's also the type and quality of your bilingual experience that can impact the development of executive function [10].

And these three lines of work are supplemented by behavior study. Blakey and Carroll adopted a meta-analytic synthesis method to examine task-switching in preschool kids mostly through DCCS task. From the results we can see that there is a bilingual advantage for task switching only until early childhood (3-6 years), after which it disappears. The strong temporal specificity of the bilingual advantage for task switching, i.e., preschoolers perform better on task-switching tasks, indicates that the higher neuroplasticity in early childhood may be required to observe switching benefits, according to the theory that experience-dependent cognitive improvements might be most apparent during sensitive developmental periods. Furthermore, it was also observed that the extent of the bilingual advantage would depend on individual differences among children with varying amounts of pre-switch working memory and attention control [11].

In sum, all three lines point towards a conditional bilingual advantage. First, gains on executive function tasks occur when there is high inhibitory or working memory demand. Secondly, it's advantageous at first because neuroplasticity is high. Finally, there is a moderation of the advantage in terms of cognitive functions based on the level of bilingualism and the context of learning (formal education and L2 exposure) [9-11].

2.3.2. Evidence against bilingual advantages in executive function

Small sample studies at first showed that bilingual kids had some benefits when it came to executive function, but as more research came out and people did reviews of all those studies, they started questioning whether there really were these benefits. Dick et al. carried out a big study using information from the ABCD (Adolescent Brain Cognitive Development) study which is national in the US; they looked at how well over 4,500 kids who spoke two languages and those who spoke just one did on lots of different tests that measure their ability to control their thoughts and actions.

In a recent study, the scores of the two groups were similar on the measures of inhibitory control, sustained attention, and task switching, which contradicts the previous claims of a bilingual advantage on executive function [3].

And also, there was recently another replication study which did not find any evidence for a bilingual advantage, suggesting that the small samples and kinds of tasks used in the original studies may have skewed the findings [12]. Similarly, some reviews found that if there was a bilingual advantage, it would be tiny and publication bias would be highly sensitive to it [13,14]. In other words, all this means that the so-called "bilingual advantage" is not universal and is rather weak; it is likely caused by different designs and participants in the studies.

3. Discussion

The research indicates that there is a conditional bilingual advantage on aspects of executive function such as inhibition during childhood. It is related to its development phase and also to the demands of the task. They are good at studying since they use suitable for their age tasks or children as subjects and thus obtain data regarding early development. In addition, Morales et al., and Chamorro & Janke show us just how much task load or L2 exposure affects our inhibitory control,

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proving that the Bilingual Advantage is conditional. And Blakey & Carroll's meta-analysis makes these conclusions stronger.

On the contrary, studies that question the benefits of being bilingual have much bigger samples – at the national level – and they find no big difference between bilingual and monolingual children when it comes to controlling impulses, remembering things, or switching between tasks. And also they deal with certain issues concerning the methods which include publication bias and inability to control for covariates.

4. Limitation

Although there are some studies supporting the idea that children who grow up bilingual would have better inhibitory control than those monolingual, it has its own limitation. First, Morales et al. and Chamorro & Janke used structured experimental tasks such as high-conflict Simon task and Go/No-Go task. Though key variables such as vocabulary ability were controlled for, the highly artificial nature of these tasks limits their ecological validity and generalizability, so we need to be cautious about interpreting the practical impact of bilingualism on children's inhibitory control, and it is difficult to generalize to other populations or educational settings [9,10].

Secondly, the conclusions made by Blakey & Carroll mainly rely on the quality of the original research study itself, which may have overlooked individual differences as well as educational background factors and this can affect the reliability and validity [11]. Generally speaking, they show that the bilingual advantage for inhibitory control during childhood is conditional; it is most prominent at the beginning of development and with high cognitive loads or language-conflict tasks, but the findings are heavily influenced by how the experimental task is designed and the quality of the underlying data, which reduces its ecological validity and generalizability [9-11].

But there are also studies that question the so-called "bilingual advantage" and these studies have limitations as well. Some did cross-sectional design, it doesn't tell us whether bilingual experience leads to changes in executive function; even if there are some differences on certain executive function tasks between bilinguals and monolinguals, we cannot conclude that these differences are due to being bilingual [3,12]. And then there's also quite a lot of variation in terms of how good at both languages they are, how often they use them, what kind of switching behavior they exhibit – all things that tend to get left out when people do these kinds of studies [10].

5. Implications

The fact that the bilingual advantage in executive function is conditional is important for both theory and application. In theory, it means that we shouldn't limit ourselves to a simple "advantage or no advantage" view, but instead consider that the effects of being bilingual are changing, depending on the situation, and affected by how someone develops, which languages they use, and their surroundings [9-11]. This makes it easier for us to see how different languages change the way we think [9,10].

From a practical standpoint, it means that being able to speak two languages may give children an advantage when it comes to developing their executive functions, but it's not something we can count on for sure, especially if they're still quite young [9,10]. Promoting lots of long-lasting bilingual exposure via education and policy – such as dual language programs, curriculum that includes switching languages, and culturally relevant teaching – may increase potential cognitive benefits [9,10]. Also, at the same time, we should also consider the differences among people in terms of their levels of proficiency in the foreign language, their family backgrounds and learning

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environments so as not to generalize too much and ensure that the intervention works just as well for all kinds of people [9,10].

6. Conclusion

The review of the evidence indicates that there is a conditional bilingual advantage in executive function during childhood, specifically for inhibitory control. Developmental stages, task demands, and environments all affect the bilingual benefit on executive functions during childhood. Bilingual kids can get pretty clear advantages when there's a lot of thinking going on or when mixing languages gets tricky, especially when they're young – that's when their brains are extra bendy and it might make switching between languages easier for them. At this point, experience-based enhancement of executive control is most apparent in inhibition and task-switching processes. But this advantage is not universal; it is highly dependent on how the experiment is conducted, who participates in it, what type of task is performed, and the cultural and educational backgrounds of the participants [9-11].

There are probably a few different ways this could happen. Bilingual kids who change between languages quite a bit may end up getting better at thinking flexibly and stopping themselves from using the wrong language since they need to keep one language out of their head and handle both at once. Also, it can improve working memory when monitoring and controlling two languages which will help with switching tasks and resolving conflicts. But all of these mental activities are rather dependent on the situation, so whether or not they occur depends on how much exposure to bilingualism there is, how alike the two languages are, and how difficult the task is [9,10].

And existing research also has some important restrictions. First of all, the task sensitivities are different; the most commonly used non-verbal interference tasks such as the Flanker task, Simon task, and Stroop task are uncorrelated with each other, which makes the comparison and generalization of the results difficult [9-11]. Second, it is often reduced to just one of two states (i.e., being a bilingual), without taking into account the differences in levels of proficiency, how often people use their languages, and whether or not they switch between languages [10]. And thirdly, there are a lot of studies using some kind of structure experimental task which controls some variable but quite different from real life situation, so they don't have ecological validly [9,10]. In addition, some research uses cross-sectional designs, which prevents us from making cause-and-effect statements about how bilingual experience affects executive function. Family environment, socioeconomic status, education methods etc. may also influence the manifestation of bilingual advantages, however, these aspects are not consistently regulated across current studies [5,6].

Given those limitations, maybe other people will do research on those things if they want to know more about how knowing two languages changes how well kids get smarter in their heads. First of all, long-term investigations should be carried out to follow the development process and clarify the cause-and-effect relationship between bilingual experience [9,10]. Second, evaluations of executive function need to become more diverse as well; it would be beneficial to include both naturalistic and classroom-based tasks in addition to interference control and working memory measures [11]. Third, we need to standardize the definition of bilingualism. This means defining how much of each language someone knows, how often they use it, and how intense their exposure is. This way, different studies can be compared [10]. Finally, we have to consider individual differences, families' backgrounds, cultures and education environments to see when being bilingual gives someone advantages on thinking skills [9,10]. Researchers can figure out whether there is a benefit from speaking two languages for children's executive functioning by doing good and sensitive work, finding out how big this benefit is, and figuring out why it happens [11].

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