



# Cognitive Development In A Bilingual Environment: To Explore The Effects Of L1And L2 Use On Early Cognitive Performance In Children

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## ARTICLE INFO

## ABSTRACT

Early childhood bilingual education is the foundation of basic education, is an important part of bilingual education, and is also an indispensable way to accelerate the training of bilingual talents. The country attaches great importance to preschool bilingual education and the rapid development of preschool bilingual education puts forward the need for scientific consideration of the physical and mental development of preschool bilingual children. Cognitive development is one of the important contents of children's physical and mental development, and is the basis of all other development. Children's cognitive development is different in different cultural and linguistic environments. Scientific examination of preschool children's bilingual level is an important indicator to test children's cognitive ability. Through the assessment of children in two kindergartens in SH City, this paper found that children in bilingual kindergartens scored higher in literacy test and number test than children in ordinary kindergartens, so children in a bilingual environment can better develop cognitive ability.

**Key words:** bilingual environment; L1; L2; Children; Cognitive ability

## 1 Introduction

Early childhood education is always at the forefront of national education, is an indispensable part of basic education, is the foundation of lifelong education and school education. In 2001, China issued the "Guidelines for Kindergarten Education (Trial)", positioning the comprehensive development of children in all teaching work, and positioning it in the whole teaching process. This clearly shows that the child's development problem is the most basic problem of the child. In 2012, the Guide to Learning and Development for Children aged 3-6 issued by the Ministry of Education clearly pointed out that it is necessary to pay attention to the integration of children's learning and development, pay attention to the mutual integration and integration of fields and goals, not only pay attention to one or more levels of development, but also pay attention to the development of children aged 3-6 in various fields such as health and science. So as to promote the comprehensive and complete development of children. Therefore, improving the quality of children is the main task and ultimate goal of today's education. In order to master the current special teaching situation and teaching quality in our country, we must take early childhood development as the main evaluation factor. Scholars in our country believe that in the early days of young children's growth, teaching should create appropriate environment and conditions for the growth and development of young children, provide appropriate guidance and assistance for young children, and promote the optimal development of young children. In the process of children's development, if we do not understand the levels and rules of children's development, it is easy to lead to deviations in children's development. This statement enlighten us that the ultimate goal of education is to promote the optimal development of children. Only by scientific consideration of the levels and laws of children's development can teachers carry out more targeted teaching, so as to make education better.

The bilingual teaching environment of children is very important, and the teaching application of L1 and L2 languages should pay attention to the language development of children, but also pay attention to the overall development of children. With the rapid development of preschool bilingual teaching in our country, on the basis of attaching importance to preschool education, higher requirements are put forward for the teaching

quality of preschool education. In a narrow range, the quality of teaching mainly refers to the quality of the people being cultivated. The evaluation of the education quality of children is mainly to determine the development of children. Through the evaluation of the development of children, we can grasp the current teaching situation and diagnose the current teaching situation.

## 2 Relevant review studies

### 2.1 Research on bilingual teaching

In English, it is called "Bilingual". From this point of view, as a nation, in two different cultural backgrounds, such as Singapore and Canada, there are differences in the purpose, role and environment of implementation, so in our bilingual environment, the pertinence of bilingual teaching is very important. When we say "bilingualism", we mean learning a second language based on our own language. Under the background of knowledge economy and global integration, especially after joining the World Trade Organization, our country urgently needs talents with international complex, and language has gradually become a way of life and development. Therefore, people are constantly increasing their investment in foreign languages in various aspects, and many children begin to learn a second language in preschool. The bilingual teaching of this paper is also with Chinese as mother tongue and English as foreign language. In a nutshell, in our country, "bilingualism" means teaching in both Chinese and English, not just the languages of ethnic minorities.

### 2.2 Children's cognitive ability

There are various opinions in the academic community regarding the definition of "cognition". As shown in Figure 1, foreign scholars view human cognitive ability as the ability to recognize, understand, analyze, and evaluate the external environment, one's own situation, and the relationship between the two (Zhang Long, 2020). Under the framework of cognitive performance theory, some scholars classify student learning performance into three aspects: "learning", "thinking", and "learning efficacy". Some people also classify human ability levels into four categories in their ability theory: intelligence, memory, problem-solving, and speech ability (Wang Ping 2020). Some people also believe that the improvement of cognitive ability can be achieved through education and training, such as reading and thinking training.

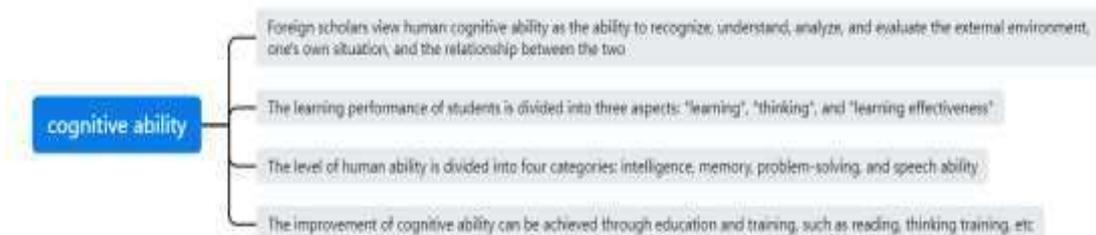


Figure 1 Definition of cognitive ability

### 2.3 The impact of bilingual teaching on children's cognitive learning ability

From the 1920s to the early 1960s, many scholars believed that being bilingual had a negative impact on a child's intellectual development (HANNAWAY, et al., 2019). For example, many scholars believe that children who speak two languages tend to be confused and sometimes slow in thinking. And many studies have shown that speaking two languages can negatively affect brain development.

However, previous studies did not analyze socioeconomic status, parental occupation, children's years of residence, and different cultural factors in the test, leading to poor interpretability of the findings of this study. As shown in Table 1, there are certain differences between French-English bilingual children and French-monolingual children in terms of age, gender and social and economic status. (D'SOUZA, et al., 2021). Foreign scholars have conducted research on this issue, and the research shows that bilingual children have obvious improvement in both language ability and overall intelligence.

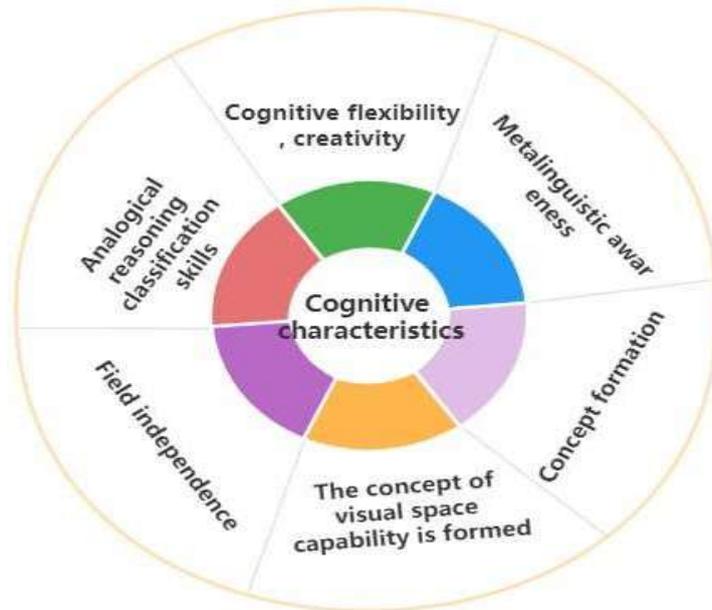
Table 1 Intelligence test scores

variable	researcher	Test score
age	Bilingual children	high
sex	Monolingual child	low
Socioeconomic status		

As shown in Figure 2, it is generally believed internationally that monolingual children are inferior to bilingual children in cognitive flexibility, creativity, metalinguistic awareness, concept formation, spatial imagination, classification and domain independence. Moreover, bilingual children are superior to monolingual children in cognitive flexibility, creativity, metalinguistic perception, concept formation, spatial imagination, analogical reasoning, classification and domain independence. (Zhang Xuemei. 2022). It has also

been compared between Afrikaans-English bilingual toddlers and paired monolingual toddlers with random characteristics in nominal-object relationships, showing that bilingual children have higher cognitive resilience compared to monolingual children. Through a comparative study on the creativity of children with two languages, it is concluded that children with two languages are superior to monolingual children in creativity, originality and precision (Liu He & Bao Bingbing.2019).

**Figure 2.** Cognitive ability characteristics of bilingual children



In addition, some scholars also used children with two language abilities as subjects, and found the differences between the two languages by comparing the two language abilities. On this basis, this study takes bilingual students as the research object. Our previous research shows that the use of L1 and L2 has a positive effect on their bilingualism. As for the effects of English second language learning on children's cognitive level, there are different research results at home and abroad. Therefore, this paper takes the use of L1 and L2 as examples to investigate the effects of bilingual learning on children's cognitive development.

### 3 Empirical studies on the use of L1 and L2

In this paper, a questionnaire survey is used to demonstrate the early cognitive ability of children. The main research is the impact of L1 and L2 use on children's cognitive ability in a bilingual environment.

#### 3.1 Sample determination

This paper selected two kindergartens in SH city, one of which was a bilingual kindergarten and the other was a general kindergarten, with a total sample size of 300 people. As shown in Table 2.

**Table 2** Distribution of samples

index	Bilingual kindergarten	General kindergarten
male	80	76
female	70	74
total	150	150

#### 3.2 Determination of variables

Since different scholars have defined it, in this paper, we will combine the research results of Chinese scholars and use CFPS literacy and math test scores to measure individual cognitive level. In the CFPS study, each participant conducted a self-answering questionnaire to collect data. The fundamentals of the CFPS literacy and Math test are performed on a cognitive test. In the reading and writing test, the subjects were asked to show 34 Chinese characters ranging from easy to difficult, and if they answered three wrong answers in a row, the test was stopped. The ranking order of the most difficult Chinese characters is the factor that affects their performance. In this math test, the subjects did 24 questions in order from easy to difficult, and when they made three mistakes in a row, the test was stopped. The order in which respondents were placed on the most difficult questions affected their scores.

Considering the current domestic and foreign research results on personal perception, it is divided into two parts: educational factors and personal factors, as shown in Table 3. Among them, parents' attention to their children's education is influenced by the level of education, while individuals are affected by their children's gender, age, household registration, economic status, etc. The educational level of the individual is the educational level of the parents at the time of study.

**Table 3.** Test variable table

	Variable name	Variable definition
Cognitive ability	Literacy test	Literacy score
	Math test	Math score
Educational variable	How much parents value education	Importance score
Individual variable	sex	bivariate
	age	(1 is male, 2 is female)
	Registered permanentresidence	Binary variables (1 is agricultural account, 2 is non-agricultural account)
	Educational background	Binary variables (1 is ruralhousehold registration, 2 is urban household registration)
	Household income	Binary variables (1 is belowundergraduate level, 2 is above undergraduate level)

**3.3 Test Model**

**3.3.1 OLS model**

This paper uses OLS regression to compare the effects of L1 and L2 on individual cognitivedevelopment.

$$Y_i = \alpha + \beta_1 + \sum Y_i X_i + \sum \gamma_i Z_i + \varepsilon \tag{1}$$

Yi scores on tests of cognitive ability, including literacy tests and math tests. xi is the education variable: the degree of emphasis on education. zi is a series of control variables, including individual variables and family variables. Individual variables: age, gender, household registration, education background; Family variables: parental education, family income, etc. ε is the perturbation term.

$$Y_i = \alpha + \beta_1 + \beta_2 + \beta_3 + \sum Y_i X_i + \sum \gamma_i Z_i + \varepsilon \tag{2}$$

**3.3.2 PSM Model**

For individuals, it is a matter of personal decision whether or not to conduct bilingual teaching. This project intends to use PSM method to evaluate individual learning behavior in young children's learning process and try to avoid endogenous problems caused by selection bias. In the empirical analysis, a new method, propensity score comparison, is used, that is, the explanatory variables are effectively controlled. Its mechanism is relatively direct: Firstly, the mean difference of each observation point of each explanatory variable is analyzed, and then the overall causal effect is obtained by summing.

The basic steps of the method are:

First, although the trend scores of the treatment and control groups were obtained by Logit regression, the PS values of the treatment and control groups were measured:

$$P(X_i) = P(D_i = 1 | X = X_i) \tag{3}$$

Among them, xi represents the variable that affects individuals' acceptance of bilingual education. In this paper, logit regression is used to calculate the scores of individuals' propensity to accept kindergarten education.

Second: to predict the average processing effect of individual bilingual education

$$ATT = E(testscore_1 - testscore_0 | D_i = 1, P(x)) \tag{4}$$

**3.4 Statistical analysis of children's cognitive ability**

**Table 4** Statistics of cognitive ability of children in general kindergartens

		Sample size	Mean value	Standard deviation	Minimum value	Maximum value
General kindergarten	Digital test	150	21.83	7.05	0	32
	Literacy test	150	11.21	4.33	0	32
	Degree of educational importance	150	1.16	2.0	0	1

**Table 5** Statistical analysis of cognitive ability of children in bilingual kindergartens

Bilingual kindergarten		Sample size	Mean value	Standard deviation	Minimum value	Maximum value
	Digital test	150	26.48	6.02	0	32
	Literacy test	150	14.50	5.59	0	32
	Degree of educational importance	150	1.35	1.0	0	2

As can be seen from Table 4 and Table 5, in the digital test, the average score of children in bilingual kindergartens is 26.48 points, and that of ordinary kindergartens is 21.83 points, and the average score of bilingual children is higher than that of ordinary children. In terms of literacy test, the average score of bilingual children was 14.50 points, and that of ordinary children was 11.21 points. The average score of bilingual children was higher than that of ordinary kindergartens. In terms of educational importance, parents of bilingual children deserve 1.35 points, and parents of ordinary kindergartens get 1.16 points. The average score of parents of bilingual children is higher than that of parents of ordinary children.

**3.5 OLS regression verification**

**Table 6** Regression verification of children in bilingual kindergartens and general kindergartens

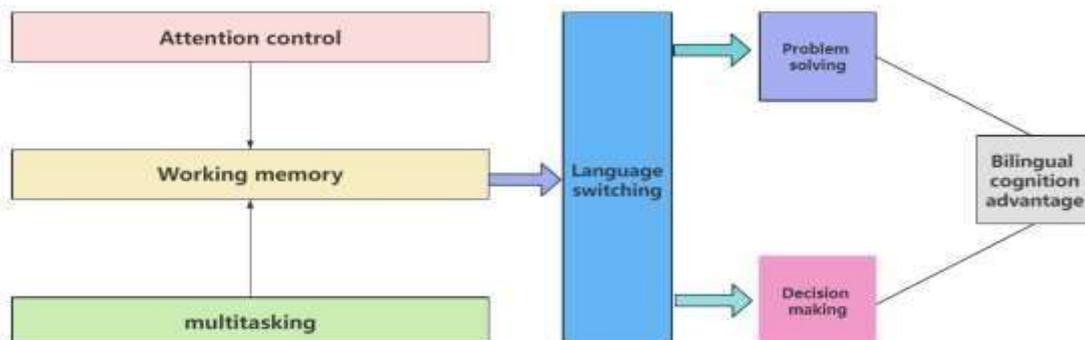
		OLS literacy test	OLS digital test
Educational environment	Bilingual environment		
	Ordinary environment	0.02**	0.03**
	Degree of educational importance	0.03	0.02
Registered permanent residence	towns		
	village	0.04*	0.01**

As can be seen from Table 6, the teaching environment of a school is positively correlated with students' academic performance. Among these research results, bilingual teaching situation has a greater impact on children's cognitive level. In addition, in kindergarten, L1 and L2 used together is better than L1 alone, and each module of children's personal cognitive development has different promoting effects on them, which has a greater promoting effect on word ability and a smaller help on mathematics. Chinese researchers have also shown that for the positive effect of children's learning, bilingual teaching situations can actively predict children's cognitive development, and have a more obvious promotion effect on word performance. It can also be seen from the table that other factors related to individuals' cognitive development also have a great influence on individuals' cognitive development. For example, parents' attention to education will increase, so that individuals' cognitive level can be better developed (Chen Yan & Feng Guoxin. 2021).

In conclusion, through OLS regression analysis, it can be seen that bilingual teaching environment can effectively improve students' cognitive level in the learning process. Kindergarten teaching can promote the development of individual cognition, which is manifested in vocabulary and arithmetic, while in primary school, the use of primary and secondary language has a lasting improvement in vocabulary and mathematics level, which is manifested as the "agglomeration effect"(JONES, et al., 2022).

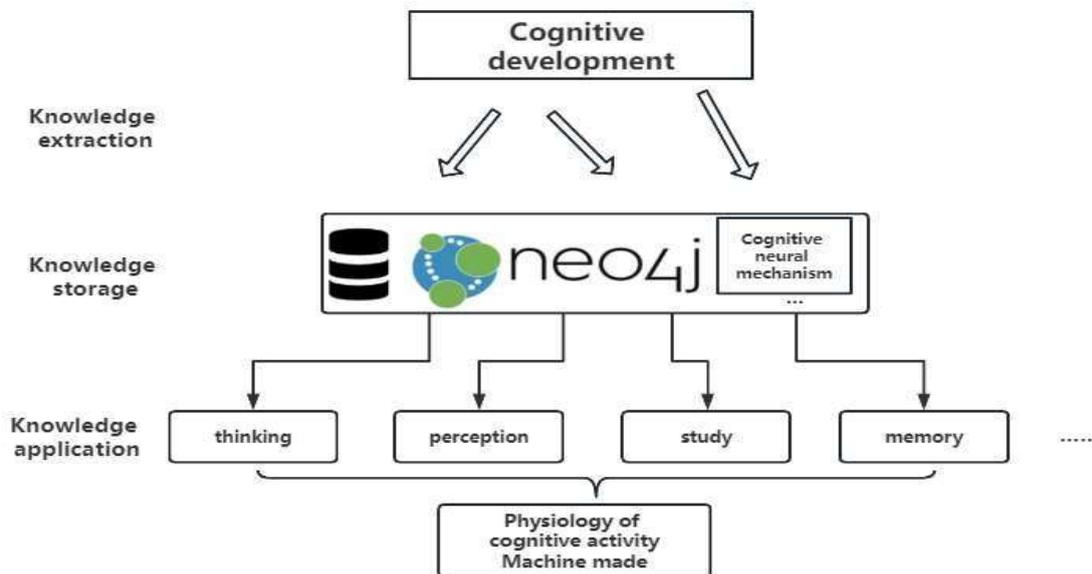
**4. Analysis of the advantages of bilingual cognition**

The cognitive advantage of bilingualism refers to the fact that people who know two languages have greater advantages in some specific cognitive functions and intelligence than people who do not use languages, as shown in Figure 3. These advantages are manifested in attention control, working memory, multitasking, language switching, problem solving, decision making, etc. (LEHER SINGH, et al., 2023.).



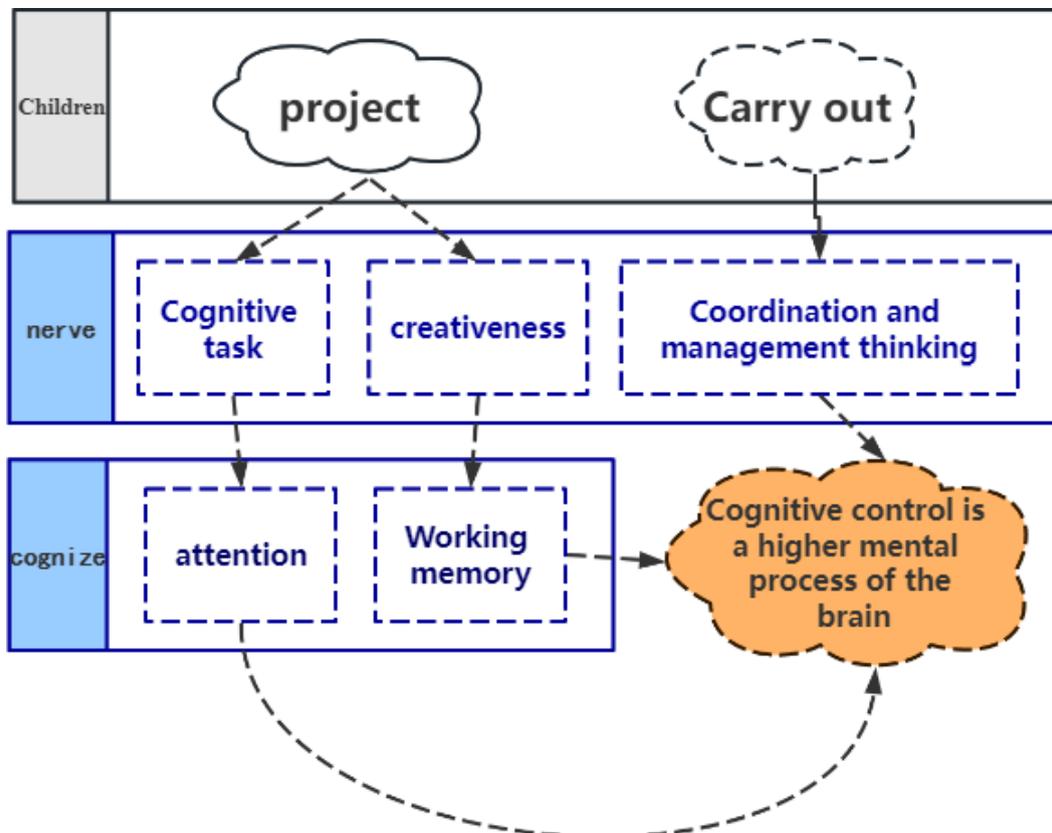
**Figure 3.** Cognitive advantages of bilingualism

Existing studies have shown that both bilingual experience and bilingual teaching can effectively improve students' cognitive ability. As shown in Figure 4, the cognitive neural mechanism of human brain is the biological process and organization that studies human perception, thinking, learning, memory and other complex thinking activities, which is also the physiological basis of cognitive activities of human brain. (Li Mingdi, 2022).



**Figure 4** Demonstration of cognitive neural mechanisms

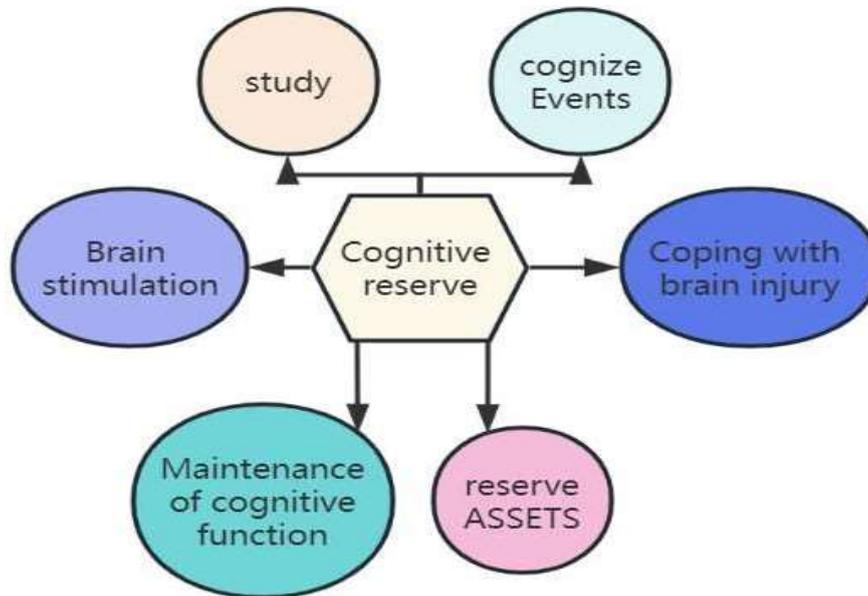
Cognitive regulation is a complex thinking activity, as shown in Figure 5. It involves a series of complex activities such as planning, implementing, regulating and monitoring thinking, attention, working memory, decision-making, problem processing, etc. (ELENI PERISTERI, et al., 2022.).



**Figure 5** Process of cognitive control

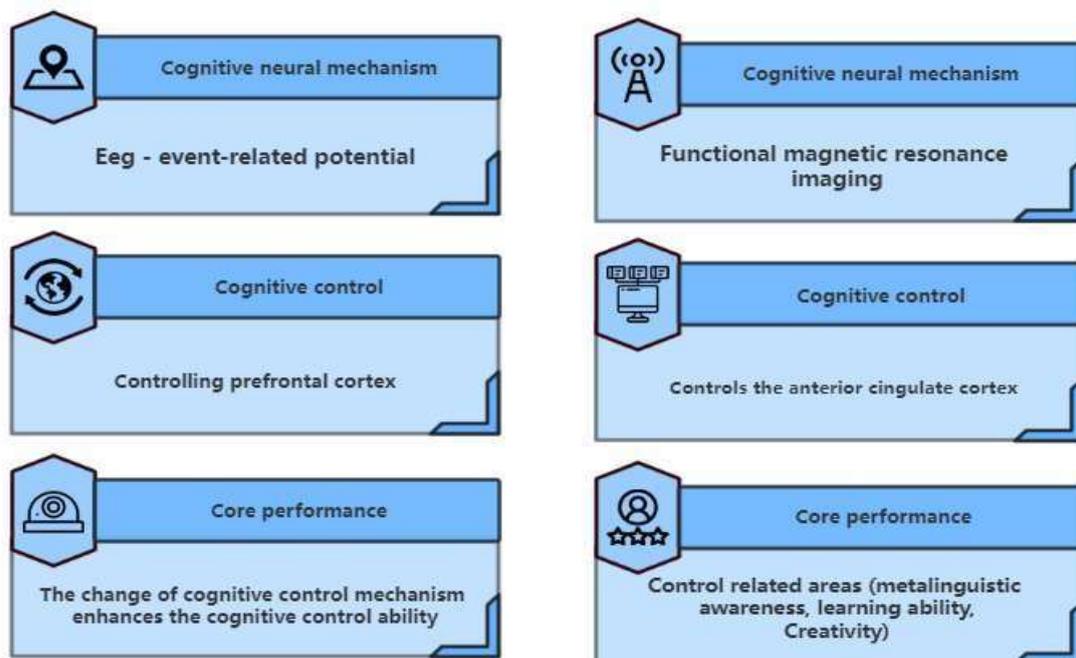
Cognitive reserve is a kind of ability to adapt to cognitive decline formed by a person's lifelong learning, cognitive activities and the comprehensive effect of various factors in the brain, that is, a reserve resource needed to maintain cognitive function, as shown in Figure 6. (IRANI,et al., 2023.) As the material basis of all

cognitive behaviors, it has its own occurrence and development laws, and is regulated and changed by external environmental factors, namely the plasticity of the brain (BELOGI,et al., 2022). Bilingual learning is an external condition with brain remodeling function, and its function is to improve bilingual users' cognitive function by changing their cognitive brain structure, so as to enhance their language understanding ability (ALTMAN, et al., 2022).



**Figure 6** Cognitive reserve patterns

At present, the research on how bilingual teaching affects the brain mostly uses EEG (ERP) and fMRI (MUSYOKA&MILLICENT M. 2023). Previous studies have shown that the electrical effects of bilinguals are significantly higher than those of monolinguals, and the activity in the brain is more intense (LINDA MULGREW, et al., 2022). This study will explain the physiological advantages of bilingualism. In the brain, however, cognitive regulation can be achieved by regulating brain activity in the brain, as shown in Figure 7. The influence of bilingual experience on cognitive development is mainly reflected in the following aspects: on the one hand, through the changes of cognitive regulation, such as inhibition, conversion, working memory, etc.; On the other hand, bilingual people are also better than monolinguals in terms of metalinguistic awareness, learning ability and creativity. In the process of brain aging, the efficient use of brain networks can enhance brain function and delay brain aging (JONES, et al., 2023).

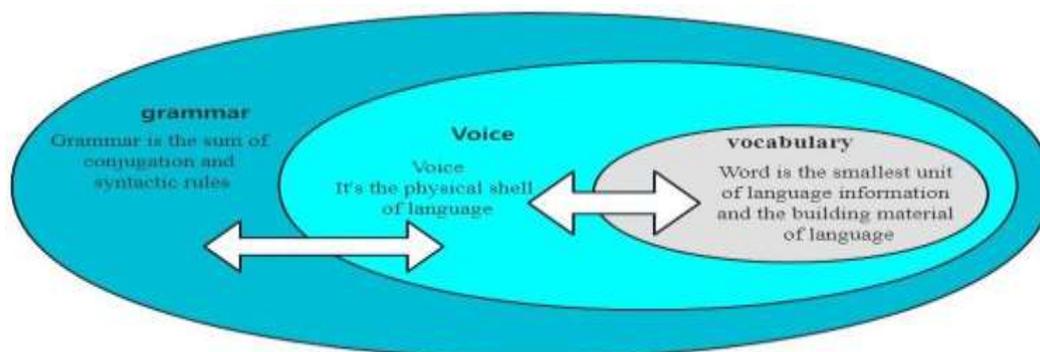


**Figure. 7** Research on the cognitive neural mechanism of bilingual learning

## 5. The influence of L1 and L2 bilingual teaching on children's cognitive ability

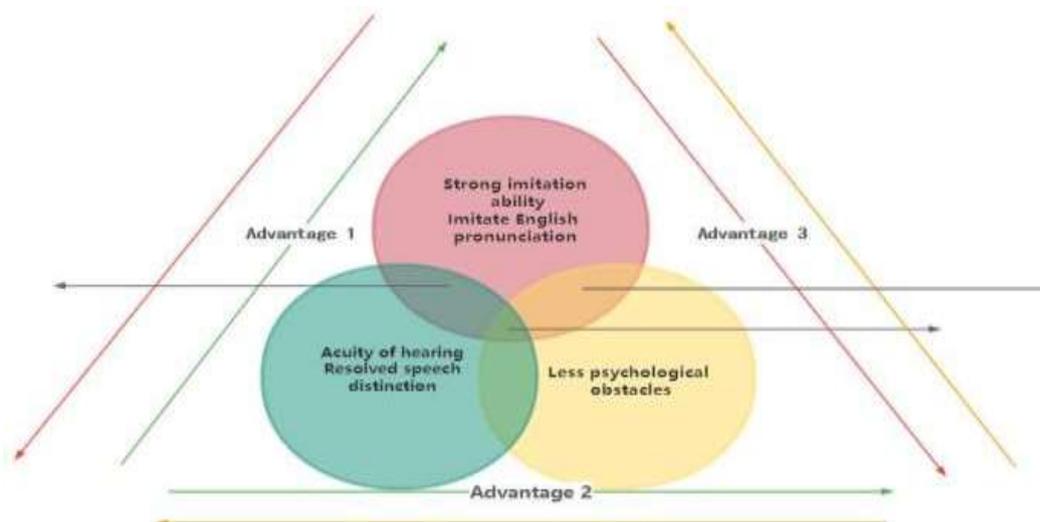
Because of the cognitive nature of children, they show great openness to new experiences. (SALAMEH-MATAR, et al., 2022) They are more inclined to think that under the new rules of the game, they can easily translate new things into their own thinking. This open mind is largely due to the elasticity of its nerves. In the process of growing up, children will gradually be influenced by acquired habits and existing knowledge experiences, and will rely more on specific motivation and systematic learning. It can be seen that children are more interested in learning L2 and are more likely to do so. In addition, due to their own cognitive development is not perfect, children's L2 acquisition process, their psychological pressure is relatively light. Therefore, if parents and preschool educators can give children phonetic, vocabulary and grammar incentives in time according to the development process of children's language cognition level, they can cultivate better speech skills in this sensitive period.

The benefits of having two languages are clear for children at this time. First, since there are many similarities between two different languages, simultaneous learning of L1 and L2 can help each other. Every language is inseparable from the three major factors of phonetics, vocabulary and grammar, as shown in Figure 8. (DA SILVA JUNIOR, et al., 2019). Speech is the external form of speech, it is the material shell of speech. Only with voice can people better understand and use it, better as a means of communication. Mastering pronunciation is essential for verbal communication. Grammar is the most basic unit of speech and the material basis of speech. Words must follow certain grammatical rules if they want to convey their meaning.



**Figure 8** Three elements of language

Bilingual teaching strengthens pronunciation, vocabulary and grammar, thus speeding up children's mastery of the language (Zhang Shu.2019). Secondly, bilingual teaching opens up a new learning space for children and expands their ways of expression. Mastering the pragmatic rules and culture of bilingualism creates a wide range of application space for it, and also lays a foundation for its rationality. Children's mastery of a second language is also of great benefit. As shown in Figure 9: One is good at imitation, can simulate English pronunciation, and can communicate in basic English under the guidance of teachers; Second, sensitive listening, can distinguish different pronunciation, is conducive to the mastery of English; Third, the psychological barrier to English is small, and the acceptance and mastery of the language is very convenient. This is beneficial to children's early language learning and good phonetic habits, and it is also beneficial to future English learning (NASIR,et al., 2021).



**Figure 9** Children's learning advantages

## 6. Analysis of the causes of the influence of bilingual teaching on children's cognitive ability

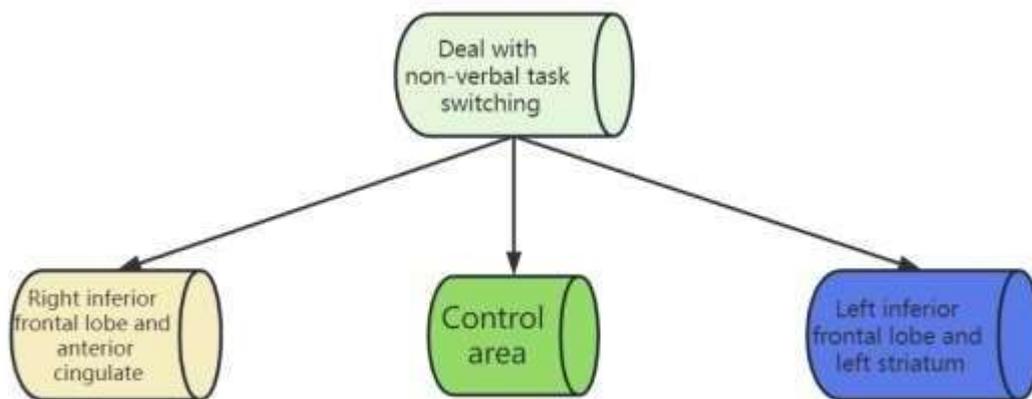
### 6.1 Bilingual thinking experience promotes the development of inhibitory control

Why bilingual education can improve people's cognitive ability? Some scholars have proposed that bilingual education in the first and second grades can help students improve the ability of central execution, thereby improving students' specific cognitive abilities (REUBEN, et al., 2019). Central executive is the center where the human brain processes different types of information, and its superior central function enables bilinguals to better complete various specific cognitive activities (PAPACHRISTOU E&FLOURI E. 2020).

Research has shown that there is a "speech suppression" in the use of two languages, and this "suppression" is an important factor causing this "central" effect. One of the first researchers to study the use of bilingualism pointed out that bilingual people had to switch off one language before they could feel comfortable using the other. However, previous studies have found that there are two different speech activities in the brain of bilingual children, and they always maintain synchronous activity between them, which can not be "switched off". Because bilinguals have two different kinds of doublethink, it is necessary to regulate their inhibitory regulation of other languages through central control when performing certain language behaviors. Because bilingual learners tend to get more information in the learning process, bilingual learners tend to suppress their native language to achieve better communication results.

Conversely, if people who are bilingual are speaking their own language, their language becomes less positive, so people who speak two languages are slightly affected. People who speak two languages exercise control over speech, which requires further training in repressive control. In some studies of the brain, it has been found that there is a different phonetic transformation phenomenon between two different types of language, and this phenomenon has a close relationship with central execution. For example, in an ERP experiment, we observed that subjects in both languages had a "Go/No-Go" -like pause in the forehead area. The design of the experiment used two words or images, with subjects responding to one stimulus and not to the other) to suppress their actions and initiate them in a similar way during the two language transitions. Another study found that in the process of processing non-verbal behaviors, the main brain regions activated by a single speaker are the right frontal lobe and the anterior cingulate area, which are thought to be important brain regions related to language.

From the perspective of the brain, this paper reveals the contradictions of other non-verbal information in the process of bilingual acquisition, as shown in Figure 10. The above findings provide a theoretical basis for the superior central executive function of bilingual learners. However, the negative training of bilinguals can well interpret the inhibitory effect of bilinguals on the center, but cannot understand the multi-center processing of bilinguals (For example: simultaneous processing of multiple tasks, changes in multiple tasks, retention and processing of information in long-term memory, etc.).



**Figure 10** Neural control of language conversion

### 6.2 Bilingual learning experience promotes changes in brain functional activity patterns

In fact, the central completion ability of bilinguals is better than that of the general population, which is likely due to the deeper changes in brain activity patterns caused by bilingual repressing learning. In the study of the meta-analysis, we noted that as bilingualism improved, so did the linguistic expression areas of bilinguals: those who began learning a foreign language before the age of 6 had a bidirectional tendency to express in the brain. Those who acquired second language after the age of 6 showed left brain dominance. Therefore, bilingual people are more likely than monolingual people to activate both brain hemispheres at the same time, strengthening the communication between the two hemispheres.

It's important to note that the trend toward increased communication between the two hemispheres of the brain may not be limited to people who are proficient in two languages. At present, the international L1-L2 bilingual language judgment research shows that in the bilingual environment, regardless of whether the balance (two languages are the same fluency) and unbalanced (two languages have different fluency), the processing ability is better than the two languages. More critical is the brain characteristics of bilingual children's working memory, that is, there is a phenomenon of cooperative processing between the two hemispheres in the brain. We hypothesize that the bilingualism experience enhances communication between the two brains, thus improving working memory (central executive) processing, and thus allowing bilinguals to have more agile and rapid processing patterns that play a role in a variety of cognitive activities.

## 7 Conclusions

To sum up, children in a bilingual environment have a more significant cognitive level, and if children are given bilingual education as early as possible, the use of L1 and L2 can well improve the neural control of children's language, and in a bilingual environment, children's thinking will also be stimulated, thus promoting the development of the inhibitory ability of thinking experience and the change of brain functional activities.

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