The relation between executive function and emotion regulation in 3-6-year-old children: the mediating role of language ability

Abstract: The aim of this study was to determine the relationship between executive function, emotion regulation and language ability in children aged 3-6 years. A total of 180 children from 10 kindergartens were selected as the research subjects. The results showed that executive function and language ability had a positive predictive effect on children's emotion regulation, and language ability played a complete mediating role in the relationship between executive function and emotion regulation. Studies have shown that preschool educators should pay attention to the development of children's language ability, so as to promote the development of children's executive function and emotional regulation ability.

Keywords: executive function; emotion regulation; language skills

1. Introduction

Emotions develop rapidly in early life, and are psychological tools for early children to adapt to survival, for example, adults can transmit emotional information through the caresses of babies to meet children's needs for safety. At the same time, emotion is also the source of children's ability to cope with social life situations, and it is the psychological stimulation that organizes children's cognitive activities, and plays a role in promoting or interfering with children's cognitive activities[48-50]. Young children's social experiences in preschool allow them to internalize rules and thus build an understanding of their own emotional experiences(Gross, J. J. 2008).As a result of the development of emotional understanding, in the preschool years, they become more autonomous in emotional regulation, being able to gradually acquire a new set of skills, such as theory of mind and the ability to inhibit dominant responses, allowing them to spontaneously try to regulate their emotions and manage their emotions without adult support(Sala M N et al., 2014).3-6 years old children begin to transition from relying on external emotional regulation to internal self-regulation, which is an important period for the development of children's emotional regulation skills, so it is very important to cultivate emotional regulation ability in the preschool stage, and studies have shown that emotional regulation is the basis for children's mental health and future school adaptation(Alamos P et al., 2022),Therefore, the

development of children's ability to adapt to the primary school environment and emotional regulation plays a key role in the transition between early childhood and primary school (Blair C, 2002 ; Harrington E M aet al., 2020).

The study of cognitive development not only helps human beings to understand themselves, but also greatly contributes to the practical activities of talent training. Executive function plays a very important role in early childhood development, including attention, cognitive flexibility and memory development, and it has also been shown that executive function can support the development of early childhood emotion regulation skills, which is based on inhibitory control(Alamos P et al., 2022).Language ability, on the other hand, consists of expressive language and comprehension language. Executive function and language skills develop rapidly at the same time in early childhood(Gooch D et al., 2016).Vygotsky believed that language is an important tool for thinking activities, and language plays a central role in goal-oriented, complex, and flexible cognitive activities, and is an important tool for acquiring higher cognitive functions. Therefore, language is another basic cognitive ability for children to regulate behavior and emotions, and with the development of children's early language skills, children can use language to manage their own behavior, and express their thoughts, needs and feelings through language(Yang Xiaohui, 2017), and then promote the development of executive function. Vygotsky's conceptualization of self-talk is central to this claim. That is, as young children mature in the first years of life, they begin to manage their behavior using private words from infancy and early childhood (e.g., telling toddlers to "wait" or "shake hands" near a busy street) that caregivers externally regulate their behavior, and young children eventually internalize this language to plan and direct their actions(Kray, J. et al., 2004).

2. Literature review

2.1 Emotional regulation

Gross (2001) believes that emotion refers to the process of an individual's influence on the occurrence, experience and expression of emotion, and he regards emotion regulation as a dynamic process, involving a series of changes in the latency period, occurrence time, duration, behavioral expression, psychological experience, and physiological response of emotion. (Gross, J. J. ., 2015),There are five main aspects of emotion regulation in the process of emotion generation: selection of

situations, modification of situations, attention allocation, cognitive changes, and response adjustments (Zhenhong, W. , & Dejun, G. ., 2003).The factors influencing the development of children's emotion regulation ability include internal factors, temperament, physiological maturity, etc., as well as external factors, including social environment, interaction between individuals and caregivers, and parent-child attachment relationship(Lu Fang, 2004; Zimmer-Gembec et al,. 2015).The development of emotion regulation has the characteristics of age, and as they grow older, children are more willing to choose positive regulation methods to regulate their emotions. On the issue of gender, there is still no consensus among scholars, and some studies believe that because sociocultural rules have different effects on the emotional regulation ability of individuals of different genders, for example, boys are more likely to use emotional venting strategies, while female students are better at using problem-solving strategies(Lu Fang, 2004). Some scholars have also found that there are different gender differences in the subcomponents of emotion regulation. Sala (2014) found significant gender differences in behavioral support and cognitive reassessment(Sala et al,. 2014). In her study, Lu Li used an independent sample T-test and found that girls used cognitive reconstruction strategies significantly higher than boys, and boys used positive moderation strategies significantly more than girls, while there was no gender difference in other components(Lv Li, 2017). Family environment factors among external factors can also have a profound impact on the development of children's emotional regulation(Morris et al,. 2007),There was a significant positive correlation between parental democratic parenting style and the development of positive emotion regulation strategies(Yang Fang Jiao, 2018), Punitive or aggressive caregiver responses to children's negative emotions can lead to the development of negative emotion regulation strategies, as well as more internalizing (e.g., anxiety, depression) and externalizing behaviors(Eisenberg, N et al., 2010).

2.2 Execution Functions

Executive function is a kind of high-level cognitive structure, which refers to the mental process of the organism to consciously control thoughts and actions, which begins to develop at the end of the first year of life at the earliest, and important developmental changes appear at the age of 2-5 years, which is inseparable from the development of children's psychology, language, memory and other abilities. Its functions include attention, cognitive flexibility and memory development(Miyake A,

2012), Working memory is primarily responsible for temporarily storing and processing information until the program begins to execute. Inhibitory control includes two aspects: interference control/attentional control and self-control, and cognitive flexibility, also known as attentional switching, refers to the ability to repeatedly switch between different tasks, operations, or mental norms, and is an endogenous attentional control mechanism(Costa A, 2008). Its influencing factors can be roughly divided into internal factors and external factors(Li Hong et al,. 2004). There were significant differences in age-demographic variables, with older age being associated with better executive function(Han Kai Li, 2019). Brocki (2004) found that gender differences were only manifested in the speed and arousal dimensions of executive function, and girls performed less in this dimension than boys(Brocki K C, 2004). External factors include parenting style, parent-child relationship, family environment, family noise, etc(Zeng Cong Zhou, 2014). In her study, Kelly Han found that there was a correlation between parent-child relationship and executive function, and that conflictual parent-child relationship and executive function were significantly negatively correlated, and the greater the parent-child conflict, the worse the performance of executive function. MeCloskey et al. divided the approaches and methods of executive function measurements into four categories: indirect informal measurements, indirect formal measurements, direct informal measurements, and direct formal measurements, according to whether the performance of the test subjects was directly measured, and whether the measurement results were interpreted according to the norm according to standard measurement procedures(Zeng Cong Zhou, 2014).Indirect informal measures include interviews, in which children's parents or teachers are interviewed; Archival review and interpretation of the process sampling of teachers, parents, and children's self-reports. Indirect formal measures include parent behaviour ratings, teacher behaviour ratings, and child self-reports. Direct formal measurements include Wisconsin Card Sorting Mission, Stroop Variant Mission, Tower of London Mission, and other missions. Direct informal measurement methods include interviews with children, or systematic or non-systematic observation of children's behavior, and process sampling to explain the process of standard tests.

2.3 Language Proficiency

Language ability is an individual's mastery of vocabulary, sentence expression, and writing ability. Children's language ability development actually refers to

children's language development, generally refers to the occurrence and development of language perception, comprehension and expression ability, therefore, for early children, vocabulary level reflects children's language ability(Chen Jin, 2020). The learning of vocabulary includes expressive vocabulary and receptive vocabulary, and receptive vocabulary ability is an indicator of language comprehension, reflecting the degree of language proficiency of children. Expressive vocabulary ability, as an indicator of language output, reflects the degree of connection between the conceptual level and the lexical level. According to the order of development of language comprehension and expression, the acquisition of receptive vocabulary is the basis for the development of expressive vocabulary. However, expressive vocabulary can also facilitate the further development of receptive vocabulary. Vocabulary, as the basic unit of language, is closely related to the development of an individual's later reading comprehension ability(Hammer C S et al,. 2007),Therefore, many studies have used children's vocabulary as an important indicator of comprehension ability and language fluency(Schwartz M, 2014).As young children mature in the first few years of life, they begin to manage their behaviour using private words from infancy and early childhood caregivers that externally regulate their behaviour, and young children eventually internalize this language to plan and guide their actions(Kray J, 2004).

3. Research Status

Executive function and emotion regulation are both important contents of children's self-regulation development. The development of executive function enables young children to inhibit behavior, regulate attention, and work memory to retain information(Blankson A N, 2017). Li Wenxiu (2010) used six commonly used children's executive function tasks, such as inverted numbers, words, Stroop, and card classification, to measure the development of executive function in children aged 3-6 years(Li Xiu Wen, 2010). Zhao Yunli (2014) also found that there was a significant correlation between inhibitory control and emotion regulation in 4-year-old children by using a combination of situational observation and parental reporting. Li Quan found that there were differences between executive function and emotional development in children of different ages, and there was a significant positive correlation between executive function and emotional competency in 4 and 4.5-year-old children, but this correlation did not exist in 5-year-old children(Zhao YunLi,2013).From the perspective of cognitive control and emotion regulation, Liu

Yuxia explored the relationship between executive function and negative emotion, and found that children's executive function was regulated by negative emotion(Liu Yu Xia et al,. 2011). Shan Meichen explored the two-way relationship between executive function and emotion regulation in preschool children through cross-lag design, and found that cold and hot executive function and emotion regulation in executive function had predictive effects, while cognitive flexibility and working memory did not find a predictive relationship with emotion regulation(Shan Chen Mei, Zhou Nan, 2021). Meng Xiangrui (2020) explored the type tendency of children's emotion regulation strategies through potential analysis, and then used one-way ANOVA to explore the relationship between children's emotion regulation strategy type tendency and executive function, and found that there were significant differences in the four dimensions of executive function (inhibition of self-regulation, cognitive flexibility, metacognitive index, and total executive function) among passive, growthal, ambivalent and active children(Meng Xiangru et al,. 2020). Zhang Qinqin (2015) found that the inhibitory control ability of middle class children was significantly positively correlated with self-comfort in emotion regulation, and negatively correlated with venting, but there was no significant relationship between inhibitory control ability and emotion regulation ability of kindergarten children(Zhang Qinqin, 2015).Zhu Xiaolin (2023) found that children's emotion regulation ability can play a mediating role between children's executive function and externalizing problems, and children's inhibitory control ability can reduce externalizing problem behaviors through emotion regulation(Zhu Xiaolin, 2023).Therefore, executive function and emotion regulation are inextricably linked.

Previous studies have shown that there is a bidirectional relationship between children's executive function and speech skills, that is, language can predict the development of children's executive function(Martins E C et al,. 2016; Kuhn L J et al,. 2014),the maturation of executive function also promotes the development of young children's language(Fei Guanghong, Li Yisha, 2019). Through longitudinal studies, it was found that the development of early language in early childhood is a cognitive mechanism that affects the development of children's executive function, which plays an important role in promoting children's overall executive function, and cultivating children's early word acquisition and syntactic knowledge is helpful to alleviate and alleviate the development of children's early executive function(Bruce M et al,. 2023; Gooch D et al,. 2016). Cross-sectional studies have also generally found a correlation

between executive function and language ability in preschool children(Müller U, 2009). In contrast to fluent bilingual children, who manage multilingual tasks, two languages are activated simultaneously during speech generation, and bilingual individuals need to suppress one language when using the other(Liu Yujuan, 2019). In this way, bilingual children need to constantly use inhibitory control to provide more opportunities for the development of executive function, so that their executive function develops faster. Bilingual children from higher or lower socioeconomic status have better executive function development. Young children's language skills can be divided into vocabulary skills, syntactic skills, and early literacy skills. Vocabulary ability refers to children's ability to understand and use vocabulary, which is usually the most commonly used indicator to measure children's language ability, and understanding and using vocabulary requires the participation of multiple information processing processes, such as attention, reasoning, integration, and working memory, which are all core to cognitive function, so the level of executive function in preschool children is positively correlated with vocabulary ability(Fatzer S T, Roebers C M. , 2012). The acquisition of grammar is related to the ability to inhibit control, one of the core components of executive function, and the development of grammar ability in children who are more efficient at processing information is faster, suggesting that there is a correlation between early executive function and the development of grammatical ability. Welsh et al. found that indicators of executive function predicted the growth of early literacy skills during kindergarten. In addition, the growth of young children's executive function makes a unique contribution to the development of reading ability during kindergarten. It is believed that internal language helps to keep working memory content at the optimal activation stage to prevent interference from other potentially relevant information. And with the improvement of language ability, the age difference in executive function will be smaller(Kray J et al,. 2004).

Language is an effective cognitive skill that promotes emotion regulation, and studies have shown that language ability in preschool children is associated with the development of emotion regulation ability, and with the development of early childhood language skills, they enable children to use language to manage their behavior and express their thoughts, needs, and feelings. Both expressive and receptive language promote children's self-regulation in early learning, expressive language skills allow children to express emotions verbally rather than behaviorally,

and receptive language allows them to understand the rules and expectations of the classroom, as well as to understand the thoughts and needs expressed by their peers. And in the low-income sample, children with stronger language skills before the age of 4 showed better ability to regulate emotions than other children. Emotional ability is a comprehensive ability of individuals to master emotional knowledge, identify and understand their own and others' emotions, and regulate and express their own emotions, including four sub-abilities, namely emotional recognition, emotional understanding, emotional expression and emotional regulation. Fang Xin (2023) found that the emotion regulation ability of 3-5-year-old children is closely related to the development of speech ability, and the general speech ability of children in the middle and late stages (4-7 years old) is more predictive of emotional competency, including emotion regulation(Fang Xin, 2023). Zhao Dongqi found a correlation between emotional vocabulary and emotion regulation in a study of kindergarten children(Zhao Dong qi, 2022). Therefore, good early language skills, especially vocabulary and narrative skills, are essential for self-regulation and emotional comprehension.

Based on this, both executive function and language ability contribute to the development of children's emotion regulation ability. However, the effects of these two independent skills on emotion regulation are not coordinated. Shannon (2019) found that language ability is both a promoter and a protective factor for emotional regulation ability, and children with weak executive function development can still promote the development of emotional ability with the help of high-level language ability, and language ability has a certain compensatory effect on children with low executive function, which can promote the development of emotional regulation ability(Reilly S E, Downer J T., 2019). A study by Gooch et al. (2016) found that in a sample of 5- and 6-year-old children with dyslexia, executive function significantly promoted emotion regulation when executive function and language at age 4 were included in a model predicting emotion regulation at age 5 and 6, while language ability did not(Gooch D, 2016).Shannon believes that this may be due to the fact that young children need a certain level of executive function and language skills to effectively integrate these abilities to further regulate emotions(Reilly S E, Downer J T. , 2019).Therefore, the current research on how executive function and language skills promote the development of preschool children's emotional regulation ability is still unclear, and the relationship between the three is relatively lacking. Therefore, by

exploring the internal developmental relationship between the three, parents and preschool educators can better understand the influence of language ability on executive function and emotion regulation from the perspective of psychology, and on the one hand, provide theoretical support for promoting the development of preschool children's language ability, executive function and emotion regulation ability, and on the other hand, enable early childhood educators to understand the interaction between the three, so as to carry out related activities in teaching and play.

In summary, this research project aims to explore the general characteristics and relationship between language ability, executive function and emotion regulation in children aged 3-6 years, and explore the mediating role of language ability in the relationship between executive function and emotion regulation in young children. Based on existing research, the following hypotheses are proposed. First, there were significant age differences in language ability, executive function and emotion regulation in 3-6 year old children, but there was no significant gender difference; secondly, there was a significant correlation between language ability, executive function and emotion regulation in 3-6 year old children; thirdly, executive function could directly predict the development of emotion regulation, and it could also indirectly predict emotion regulation through the mediating role of language ability.

4. Method

4.1 Participants

Adopting the method of random stratification sampling, 10 public kindergartens were selected in X City, Guangxi, each kindergarten was stratified based on age, and 1 class of primary, middle and large classes was selected, 6-8 children were selected from each class, 60 people of all ages, and a total of 180 children were selected. Among them, 90 are boys and 90 are girls.

4.2 Tools

In this study, measurement and questionnaire methods were used to measure children's language ability, executive function and emotion regulation.

4.2.1 Peabody Picture Vocabulary Test

The Peabody Picture Vocabulary Test (PPVT) (Dunn L M, 1965) was used to examine children's receptive speech ability. A revised version by Lu Li and Liu

Hongxiang (2005) was used in this study（Lu. &Liu,2005）.Chen et al. have used this version several times in Chinese samples with good reliability and validity(] Chen S et al,. 2018).The test was conducted one-on-one, with four pictures presented and words that could be used to represent the picture. Based on the words they hear, the children choose the picture that corresponds to the word from four options. 1 point for correct answers and 0 points for incorrect answers. If you have 8 questions in a row and make 6 mistakes, you will stop the test. There is no time limit and the participant is allowed to guess the answer, and the total score of the participant is the raw score, and the higher the score, the higher the level of verbal comprehension.

4.2.2 Expressive Vocabulary Test

The Expressive Vocabulary Test (EVT) developed by Williams (Williams & Williams, 2007) was used to examine children's expressive language ability(Williams K T, 2007).Li Chuanjiang (2017) translated and revised EVT-IIEVT-II（Williams & Williams, 2007）,The correlation coefficient between the revised Chinese version of EVT and PPVT was 0.7, and the correlation coefficient between the revised Chinese version and the joint Raven test was 0.5. As in PPVT, the test taker and the child sit face to face, and the test taker shows the children the color pictures in the order of the picture card manual and asks the question "What is this?". Children respond based on pictures. The EVT task has 7 questions in a row, and if you get 5 questions wrong, you will stop the test, and one point will be given for each question. There is no time limit for the assessment, and the higher the score, the higher the level of verbal comprehension.

The correlation coefficient between the revised Chinese version of EVT and PPVT was 0.7, and the correlation coefficient between the revised Chinese version and the joint Raven test was 0.5.

4.2.3 Behavior Rating Inventory of Executive Function For Preschool

In order to measure the development of executive function in young children, Gioya et al. compiled a standardized, reliable and well-structured Behavey Olatin English Torry Ben Ekutif Finkcution on the basis of the original table Behavi Olatin English Torry Ben Ekutif Finktien Fuprescul (Brive Pur), It can provide important information for assessing a child's executive function(Lu Tengfei et al,. 2017).Through the analysis of the data of nearly 3,000 3-6-year-old children, the study shows that the Chinese 3-6-year-old children have shown good performance and good level of construct validity, which can be used in early childhood

development and research to assess the executive function of preschool children in China(Zeng Yunru, 2020). The scale includes 5 factor dimensions, 3 index dimensions and total executive function. The factor dimensions were inhibitory factors, conversion factors, emotion control factors, working memory factors and planning organization factors, and the exponential dimensions were inhibitory self-regulation index, flexibility index and metacognitive index, respectively. In the BRIEF-P revision, a higher total score indicates that children have fewer problematic behaviors in daily life and a higher level of executive function development.

In this study, it was found that the Clenbach Alpha coefficient of the total scale was 0.964, and the correlation index between each factor scale and the total scale was above 0.831, and the content validity was good, and the correlation coefficient between the subscales ranged from 0.535 to 0.806, and the construct validity also reached a good level.

4.2.4 Questionnaire on Children's Emotion Regulation Strategies

In order to test children's emotion regulation ability, this study used the "Questionnaire on Children's Emotion Regulation Strategies" revised and adapted by Lu Ling (2011) in the study, which was further revised on the basis of the "Preschool Children's Emotion Strategies Questionnaire" compiled by Lu Fang (2004), which was divided into 8 dimensions and 49 questions, and each dimension was cognitive reconstruction, problem solving, seeking support, alternative activities, self-comfort, passive coping, emotional venting and aggressive behavior. The scoring is based on a five-level grading system, with 5 points for "always like this". 4 points for "often", 3 points for "sometimes", 2 points for "occasionally", and 1 point for "never". The higher the total score of emotion regulation, the lower the development of children's emotion regulation ability, and the lower the emotion regulation ability, the higher the development of children's emotion regulation ability.

In this study, the Clenbach Alpha coefficient of the total scale was 0.7699, with good internal consistency, and the reliability of the whole questionnaire was high, and the correlation index between each factor scale and the total scale was calculated to be between 0.699-0.923, and the content validity was good, and the correlation coefficient between the sub-scales ranged from 0.567 to 0.811, and the structural validity also reached a good level.

5. Result and Discussion

5.1 Common method deviation test

In order to reduce the bias caused by the rater's measurement question and measurement environment, the Harman one-way test was used to test the common method deviation of the data to ensure that the common method deviation was within a reasonable range. The researchers set the common factor number to 1, and analyzed all the items of the children's executive function questionnaire and emotion regulation questionnaire. After the analysis of this study, the variance explanation rate of the first common factor of the Early Childhood Executive Function Questionnaire was 17.977, and the variance interpretation rate of the first common factor of the Early Childhood Emotion Regulation Questionnaire was 32.684, both of which did not exceed 40%, indicating that this study controlled the common method bias and could carry out the next step of analysis.

5.2 Describe Statistics

In order to understand whether there were differences in children's language ability, executive function and emotion regulation in gender and grade, independent sample T-test and analysis of variance were conducted with gender and grade as independent variables, and language ability, executive function and emotion regulation as dependent variables. The results (Table 1) showed that there were no significant differences between the sexes in terms of the total scores of language ability, executive function, and emotion regulation. There were significant differences in the sub-components of emotion regulation, cognitive reconstruction and self-soothing between genders, and the cognitive reconstruction and self-soothing abilities of boys were higher than those of girls.

Table 1 Descriptive statistics and comparisons of the study variables for boys and girls.

project	Man		woman		F	P
	M	SD	M	SD		
EVT	55.22	27.426	54.33	26.134	52.304	0.945
PPVT	60.33	21.932	57.56	16.993	141.608	0.768
Language skills	115.56	47.794	111.89	42.651	146.069	0.866
Inhibition control	25.33	5.874	25.89	4.256	19.151	0.821
Conversion	16.22	4.577	16.44	4.096	23.67	0.915

Emotional control	16	4.664	15.33	3.571	7.218	0.738
Working memory	26.33	6.124	24	3.708	5.423	0.343
Plan/Organize	15.56	3.504	14	2.693	1.56	0.307
Executive Functioning	100.33	22.023	95.67	14.265	19.597	0.601
Cognitive Reconstruction	19.44	4.126	15.44	2.789	0.963	0.028*
Problem Solving	17.67	4.213	18.56	4.902	7.144	0.685
Seek support	16.11	4.045	15.89	3.296	5.58	0.9
Alternative activities	25	4.69	23.11	2.713	1.22	0.311
Self-soothing	8.67	1.732	7.11	1.269	2.547	0.045*
Coping passively	12	3.536	9.56	3.087	6.265	0.138
Emotional venting	10.44	4.613	9.89	2.522	2.307	0.755
Aggressive behavior	5	1.118	6.22	2.048	2.467	0.136
Emotion Regulation	114.89	13.679	106	15.827	26.568	0.221

Note: *:P<.05

There were significant differences in the development of language skills between 3 and 6 year olds. There were significant differences in overall executive function, as well as sub-functions such as inhibitory control, switching, and emotion control. There were significant differences in the subcomponents of overall emotion regulation and problem solving. After post-event comparison, it was found that there were significant differences in overall executive function, inhibitory control, overall emotion regulation and problem solving between the small, middle and large classes (P<.05), and the inhibitory control ability of the large class was significantly higher than that of the children in the small class and the middle class (as shown in Table 2). At the same time, the LSD test showed that there was no significant difference in executive function and emotion regulation between the primary and middle classes, but there were significant differences with the large classes, and the scores of executive function and emotion regulation in the large classes were significantly higher than those in the middle and primary classes.

Table2 Descriptive statistics and comparisons of the study variables for grade

project	Small		Middle		Large			
	M	SD	M	SD	M	SD	F	P
EVT	29.5	3.209	48.5	6.892	86.33	15.175	52.304	<.001
PPVT	38.83	4.834	55.33	3.983	82.67	4.803	141.608	<.001
Language skills	68.33	4.59	103.83	9.218	169	14.67	146.069	<.001
Inhibition control	28	3.162	29	2.53	19.83	2.714	19.151	<.001

Conversion	20.33	2.338	17	2.366	11.67	1.862	23.67	<.001
Emotional control	18.17	3.601	17	3.742	11.83	1.169	7.218	0.006
Working memory	27.5	5.788	27.33	3.077	20.67	2.733	5.423	0.017
Plan/Organize	15.83	3.971	15.5	2.665	13	2.191	1.56	0.242
Executive Functioning	111.17	12.254	105.83	8.448	77	9.423	19.597	<.001
Cognitive Reconstruction	19.17	5.269	17.17	2.927	16	3.406	0.963	0.404
Problem Solving	20.33	4.761	20.17	2.994	13.83	1.722	7.144	0.007
Seek support	16.5	3.271	18.5	2.665	13	2.683	5.58	0.015
Alternative activities	24.5	3.886	25.5	4.764	22.17	2.317	1.22	0.323
Self-soothing	8.83	1.602	8	1.549	6.83	1.472	2.547	0.112
Coping passively	13	2.966	11.67	3.386	7.67	1.366	6.265	0.011
Emotional venting	10	2.966	12.33	4.761	8.17	1.602	2.307	0.134
Aggressive behavior	5.83	1.602	6.5	2.074	4.5	0.837	2.467	0.119
Emotion Regulation	119.33	5.715	119.83	8.841	92.17	7.679	26.568	<.001

Note: *:P<.05

5.3 Correlation Analysis

The mean, standard deviation, and correlation matrix for each variable are shown in Table 3. The researchers analyzed the five factors of receptive language vocabulary ability (Y1), expressive language vocabulary ability (Y2) and executive function (Z), five factors of inhibitory control (Z1), conversion (Z2), emotional control (Z3), working memory (Z4), planning/organization (Z5) and emotion regulation (Q). The results showed that there was a significant positive correlation between language ability and executive function and emotion regulation (P<0.05), in which there was no longer a correlation between planning/organization and emotion regulation in executive function (P>0.05), and the other four factors were significantly positively correlated with emotion regulation (P<0.05).

Table 3 Correlation matrix for each variable

	Y1	Y2	Y	Z1	Z2	Z3	Z4	Z5	Z	Q
Y1	1									
Y2	.902**	1								
Y	.982**	.967**	1							
Z1	-.711**	-.779**	-.758**	1						
Z2	-.849**	-.885**	-.885**	.751**	1					
Z3	-.590**	-.731**	-.666**	.834**	.718**	1				
Z4	-.468*	-.601**	-.538*	.696**	.469*	.567*	1			
Z5	-0.286	-0.404	-0.345	.476*	0.38	0.397	.811**	1		
Z	-.732**	-.848**	-.800**	.923**	.823**	.847**	.828**	.699**	1	

Q	-.783**	-.752**	-.789**	.691**	.772**	.587*	.659**	.560*	.796**	1

Note：**p< 0.01,*p <0.05.

5.3 Mediator Effect Test

In order to further explore the relationship between variables and verify whether language ability plays a mediating role in the relationship between executive function and emotion regulation, the Process plug-in analysis was used, with emotion regulation as the dependent variable, executive function independent variable, and language ability as the mediating variable. The sample size was set to 5000, with a 95% confidence interval for the estimated mediating effect. After the mediation test, it was found that the confidence interval of the indirect effect did not pass 0, indicating that language ability has a mediating effect in the relationship between executive function and emotion regulation. The confidence interval for the direct effect was 0, indicating that language ability constituted a complete mediator in the effect of executive function on emotion regulation (as shown in Table 2).

Table 4 Fitting results of the mediation model

	Effect	se	t	p	LLCI	ULCI
Total effect	0.6604	0.1255	5.2636	0.0001	0.3944	0.9263
Direct effects	0.38	0.1963	1.9358	0.072	-0.0385	0.7985
Indirect effects	0.2803	0.1688	/	/	0.0067	0.6567

6. Discussion and Conclusion

The first objective of this study was to investigate the general characteristics of language ability, executive function and emotion regulation in children aged 3-6 years. The second objective is to explore the relationship between language ability, executive function and emotional regulation in children aged 3-6 years. The third goal is to identify the mediating role of language ability in the relationship between executive function and emotion regulation in young children.

The results related to the first goal showed that the development of language ability, executive function and emotion regulation in kindergarten was significantly higher than that in kindergarten and kindergarten, and there was little difference in emotion regulation between kindergarten and kindergarten. There were no significant differences in language ability, executive function and emotion regulation among 3-6 year old children, but there were significant differences in the subcomponents of

emotion regulation, cognitive reconstruction and self-comfort, and the cognitive reconstruction and self-comfort ability of boys were higher than those of girls. There were significant differences in the development of language ability among children aged 3-6 years, and there were significant differences in overall executive function, inhibitory control, switching, emotional control and other sub-functions, while there were no significant differences in other components in grades. There were significant differences in the subcomponents of overall emotion regulation and problem solving, and significant differences in other components. The results of the study related to the second objective showed that the correlation coefficient between language ability, executive function and emotion regulation in young children was significant, which was consistent with the results of previous studies. The results of the study related to the third objective suggest that language ability constitutes a complete mediating role in the effect of executive function on emotion regulation. In previous studies, Li Xiuwen (2010) found that the influence of language ability on emotion regulation is mainly achieved through executive function. A study by Gooch et al. (2016) found that when executive function and 4-year-old language were included in a model predicting behavior regulation at 5 and 6 years old, executive function promoted emotion regulation, while language ability did not.

Disclaimer (Artificial intelligence)

Option 1:

Authorhereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

Consent

As per international standards, parental written consent has been collected and preserved by the author(s).

Ethical Approval:

As per international standards or university standards written ethical approval has been collected and preserved by the author(s).

References

1. Sala, M. N., Pons, F., & Molina, P. (2014). Emotion regulation strategies in preschool children. *British Journal of Developmental Psychology, 32*(4), 440-453.
2. Gross, J. J. (2008). Emotion regulation. *Handbook of emotions, 3*(3), 497-513.
3. Alamos, P., Williford, A. P., Downer, J. T., & Turnbull, K. L. (2022). How does inhibitory control predict emotion regulation in preschool? The role of individual children ' s interactions with teachers and peers. *Developmental psychology, 58*(11), 2049.
4. Blair, C. (2002). School readiness: Integrating cognition and emotion in a neurobiological conceptualization of children's functioning at school entry. *American psychologist, 57*(2), 111.
5. Harrington, E. M., Trevino, S. D., Lopez, S., & Giuliani, N. R. (2020). Emotion regulation in early childhood: Implications for socioemotional and academic components of school readiness. *Emotion, 20*(1), 48.
6. Gooch, D., Thompson, P., Nash, H. M., Snowling, M. J., & Hulme, C. (2016). The development of executive function and language skills in the early school years. *Journal of Child Psychology and Psychiatry, 57*(2), 180-187.
7. Yang Xiaohui.(2004)Development and promotion of children's executive function[M].Shaanxi:Shaanxi Normal University Press,.157.
8. Kray, J. , Eber, J. , & Lindenberger, U. . (2004). Age differences in executive functioning across the lifespan: the role of verbalization in task preparation. *Acta Psychologica, 115*(2-3), 143-165.
9. Gross, J. J. . (2015). Emotion regulation: current status and future prospects. *Psychological Inquiry, 26*(1), 1-26.
10. Zhenhong, W. , & Dejun, G. . (2003). Review of gross's research on emotion regulation process and strategy. *Advances in Psychological Science, 11*(06), 629-634.
11. Lu Fang.(2004). Development of emotion regulation strategies in preschool children and related research[D].East China Normal University.
12. Zimmer-Gembeck, M. J. , Webb, H. J. , Pepping, C. A. , Swan, K. , & Dunbar, M. . (2015). Review: is parent-child attachment a correlate of childrens emotion regulation and coping?. *International Journal of Behavioral Development, 41*(1).
13. Sala, M. N., Pons, F., & Molina, P. (2014). Emotion regulation strategies in preschool children. *British Journal of Developmental Psychology, 32*(4), 440-453.
14. Lv Li. (2017). Investigation and analysis of the current situation of children's emotion

regulation strategies: A case study of a kindergarten in a district of Guangzhou[J].*Journal of Jingchu Institute of Technology, 32*(01):47-51+79.

15. Morris, A. S., Silk, J. S., Steinberg, L., Myers, S. S., & Robinson, L. R. (2007). The role of the family context in the development of emotion regulation. *Social development, 16*(2), 361-388.
16. Eisenberg, N., Spinrad, T. L., & Eggum, N. D. (2010). Emotion-related self-regulation and its relation to children's maladjustment. *Annual review of clinical psychology, 6*, 495-525.
17. Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current directions in psychological science, 21*(1), 8-14.
18. Costa, A., Hernández, M., & Sebastián-Gallés, N. (2008). Bilingualism aids conflict resolution: Evidence from the ANT task. *Cognition, 106*(1), 59-86.
19. Li Hong,Wang Nai Ge.(2004). On the study of executive function and its development.*Psychological Science*, (02):426-430.
20. Han Kai Li.(2019). Effect of parent-child relationship on executive function in 3-6-year-old children: the moderating effect of temperament. Shanghai Normal University.
21. Brocki, K. C., & Bohlin, G. (2004). Executive functions in children aged 6 to 13: A dimensional and developmental study. *Developmental neuropsychology, 26*(2), 571-593.
22. Chen Jin.(2020). *Research on the relationship between language and executive function development of Uyghur-Chinese bilingual preschool children*. East China Normal University,
23. Hammer, C. S., Lawrence, F. R., & Miccio, A. W. (2007). Bilingual children's language abilities and early reading outcomes in Head Start and kindergarten.
24. Schwartz, M. (2014). The impact of the first language first model on vocabulary development among preschool bilingual children. *Reading and writing, 27*(4), 709-732.
25. Kray, J., Eber, J., & Lindenberger, U. (2004). Age differences in executive functioning across the lifespan: The role of verbalization in task preparation. *Acta Psychologica, 115*(2-3), 143-165.
26. Blankson, A. N., Weaver, J. M., Leerkes, E. M., O ' Brien, M., Calkins, S. D., & Marcovitch, S. (2017). Cognitive and emotional processes as predictors of a successful transition into school. *Early education and development, 28*(1), 1-20.
27. Li Xiu Wen.(2010). *Relationship between executive function and emotion regulation in*

preschool children aged 3-6 years. East China Normal University,

28. Zhao YunLi.(2013). *Parents' meta-emotional concept, inhibition control and emotion regulation of 4-year-old children*.Liaoning Normal University.
29. Liu Yu Xia, Jin Xin Yi, Cai Yu Rong, He Jie.(2011). Relationship between persistence and executive function and negative emotions in young children. *Journal of Applied Psychology, 17*(02):185-192.)
30. Shan Chen Mei, Zhou Nan.(,2021). Cross-lagging study on the relationship between executive function and emotion regulation in preschool children[A]Abstract collection of the 23rd National Conference on Psychology. Chinese Psychological Society,Chinese Psychological Society:2.
31. Meng Xiangrui, Liu Wen, Che Hanbo, Liu Fang, Hu Wenwen.(2020). Relationship between the type of emotion regulation strategy type and executive function in 3~5-year-old children. *Preschool Education Research*,(07):14-23.)
32. Zhang Qinqin.(2015). Research on the relationship between inhibitory control, emotion regulation strategies and peer acceptance in 4~6-year-old children. *Early Childhood Education*,(Z3):55-59.)
33. Zhu Xiaolin.(2023). Relationship between executive function and externalizing and internalizing problem behaviors in 4-6-year-old children. Southwest University.
34. Martins, E. C., Osório, A., Veríssimo, M., & Martins, C. (2016). Emotion understanding in preschool children: The role of executive functions. *International Journal of Behavioral Development, 40*(1), 1-10.
35. Kuhn, L. J., Willoughby, M. T., Wilbourn, M. P., Vernon‐Feagans, L., Blair, C. B., & Family Life Project Key Investigators. (2014). Early communicative gestures prospectively predict language development and executive function in early childhood. Child development, 85(5), 1898-1914.
36. Fei Guanghong, Li Yisha.(2019). Internal factors influencing children's executive function:Research progress at home and abroad in the past decade. *Preschool Education*, (03):7-9.)
37. Bruce, M., Ermanni, B., & Bell, M. A. (2023). The longitudinal contributions of child language, negative emotionality, and maternal positive affect on toddler executive functioning development. *Infant Behavior and Development, 72*, 101847.
38. Müller, U., Jacques, S., Brocki, K., & Zelazo, P. D. (2009). The executive functions of language in preschool children.
39. Fatzer, S. T., & Roebers, C. M. (2012). Language and executive functions: The effect of

articulatory suppression on executive functioning in children. *Journal of Cognition and Development, 13*(4), 454-472.

40. Fang Xin.(2023). *Developmental characteristics of children's emotional competency and its relationship with speech ability*. Southwest University,
41. Zhao Dong qi.(2022). *The relationship between emotional vocabulary and emotion regulation ability of kindergarten children: the mediating role of teachers' emotional vocabulary*.Southwest University.
42. Reilly, S. E., & Downer, J. T. (2019). Roles of executive functioning and language in developing low-income preschoolers' behavior and emotion regulation. Early childhood research quarterly, 49, 229-240.
43. Dunn, L. M., & Dunn, L. M. (1965). Peabody picture vocabulary test--.
44. Chen, S., Lawrence, J. F., Zhou, J., Min, L., & Snow, C. E. (2018). The efficacy of a school-based book-reading intervention on vocabulary development of young Uyghur children: A randomized controlled trial. *Early Childhood Research Quarterly, 44*, 206-219.
45. Williams, K. T. (1997). Expressive vocabulary test second edition (EVT™ 2). J. Am. Acad. *Child Adolesc. Psychiatry, 42*, 864-872.
46. Lu Tengfei, Shuai Lan, Zhang Jinsong, et al.(2017). Validity and reliability of the parent version of the Chinese version of the Executive Function Behavior Assessment Questionnaire for Preschool Children (BRIEF-P).*Chinese Journal of Mental Health*,*31*(02):138-143.)
47. Zeng Yunru.(2020). *Investigation on the current situation of executive function development in children aged 3-6 years*. Sichuan Normal University,

48. Forte S, Salamah MA. Importance of Home in the Literacy Process of Child. Asian J. Educ. Soc. Stud. [Internet]. 2022 Nov. 25 [cited 2024 Jun. 4];36(1):1-9. Available from: https://journalajess.com/index.php/AJESS/article/view/766

49. Language and Reading Research Consortium. The dimensionality of language ability in young children. Child Development. 2015 Nov;86(6):1948-65.

50. Charman T. Matching preschool children with autism spectrum disorders and comparison children for language ability: Methodological challenges. Journal

of autism and developmental disorders. 2004 Feb;34:59-64.