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Developmental Trends of Executive Function in Chinese Preschool Children

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Abstract

Executive functions have the irreplaceable function of ensuring survival and promoting growth for children development, especially in the early childhood. This study investigates the developmental trends of executive function in Chinese preschool children, specifically focusing on inhibitory control, cognitive flexibility, and working memory. This study employed a quantitative and cross-sectional design involving 222 preschool children aged 3 to 5 from four kindergartens of Shaanxi province. SPSS was used to identify the age and gender differences. The Peabody Executive Function Assessments, comprising three subtests, were employed to measure executive function skills. The results reveal significant developmental progress in executive function during preschool, with ages 4 to 5 exhibiting particularly rapid improvement. The findings also showed that there is significant age differences in all variables while significant gender differences in inhibitory control but not in cognitive flexibility, working memory. These findings offer valuable insights into the cognitive development of Chinese preschoolers and highlight the importance of early intervention programs to foster executive function skills for better academic achievement and cognitive functioning.

Keywords: Executive Function, Age, Gender, Preschool Children, China

Introduction

Executive function (EF) is a crucial cognitive domain that plays a fundamental role in guiding and regulating higher-order cognitive processes and explicit behaviors. It encompasses a range of essential abilities such as attentional control, working memory, inhibitory control, cognitive flexibility, and goal-directed behavior. Research on executive function has gained significant attention in various disciplines, including psychology, neuroscience, and education, due to its profound implications for academic achievement, cognitive development, and overall well-being.

Despite its importance, the understanding of executive function and its developmental trajectory remains a subject of ongoing investigation, particularly in diverse cultural contexts. China, as a culturally rich and dynamic nation, presents a unique opportunity to explore the developmental trends of executive function in early childhood, a critical period of cognitive growth and skill acquisition.

This study aims to examine the developmental trends of executive function in Chinese preschool children aged 3 to 5 years in Shaanxi Province, China. Adopting a comprehensive assessment approach, the study utilizes the Peabody Executive Function Assessments, a well-established and reliable tool specifically designed for preschool children, to measure inhibitory control, cognitive flexibility, and working memory.

The multifaceted nature of executive function requires a comprehensive assessment approach to capture its various components accurately. Thus, the Peabody Executive Function Assessments, with its three subtests - Head Toes Knees Shoulders, Dimensional Change Card Sort, and Corsi Blocks - provides a holistic evaluation of executive function in young children. These subtests enable the assessment of inhibitory control, cognitive flexibility, and working memory, which are considered fundamental building blocks for cognitive development and academic success.

By investigating the developmental features and norm scores of executive function in this specific population, the study contributes to the existing literature on executive function in preschool children. The findings will shed light on the cognitive milestones and developmental trajectories of executive function during early childhood in the Chinese cultural context. Additionally, understanding the developmental trends of executive function in Chinese preschoolers can inform educators, parents, and policymakers about the cognitive abilities and challenges faced by children in this age group.

Furthermore, this study's implications extend beyond the academic realm, as executive function plays a pivotal role in a child's social and emotional development. The ability to regulate attention, manage impulses, and shift cognitive strategies contributes to a child's overall adaptive behavior and self-regulation skills, essential for successful social interactions and emotional well-being.

The findings from this study may pave the way for the design and implementation of targeted interventions and educational strategies that foster the development of executive function in Chinese preschool children. Early identification and intervention of executive function challenges can have a lasting positive impact on a child's cognitive, academic, and socio-emotional development.

In conclusion, this study endeavors to contribute to the growing body of research on executive function by exploring its developmental trends in Chinese preschool children.

Utilizing a comprehensive assessment approach, the study aims to provide valuable insights into the cognitive growth and executive function abilities of young children in the Chinese cultural context. The implications of this research may have far-reaching benefits for educators, parents, and policymakers seeking to support the optimal cognitive development and well-being of Chinese preschoolers.

Literature Review

Executive function has emerged as a prominent research topic across various disciplines such as education, psychology, physical education, and cognitive neuroscience. However, a clear and unified definition of executive function remains elusive. Early researchers predominantly associated executive function with the prefrontal lobe, leading to a multitude of definitions. For instance, Chan et al (2008) view executive function as encompassing cognitive abilities like planning, behavior regulation, and goal achievement, primarily focused on monitoring behavior. On the other hand, Ramos-Galarza et al (2020) regard executive function as a superior ability to supervise basic mental functions in humans.

As research methods in neuropsychology advanced, executive function became linked not only to the prefrontal lobe but also to other brain regions like the limbic system. Neuroimaging studies explored the relationship between cognitive functions and frontal lobe activities (Gilbert & Burgess, 2008; Penadés et al., 2019), reinforcing the association of executive function with higher-order cognitive processes linked to the frontal lobe.

The prefrontal cortex, being a late-developing cortex, collaborates with other neocortical regions to regulate complex cognitive activities, collectively termed executive function (Nigg, 2017). It involves monitoring, controlling, synthesizing, and analyzing psychological processes and explicit behaviors (Anderson, 2010), such as integrating sensory input, generating responses, maintaining sets, goal-directed behaviors, adapting to changes, making plans, and self-evaluation. Damage to the frontal lobe can disrupt executive function, impacting cognitive processes and explicit behavior (Karbach & Kray, 2016).

While the prefrontal lobe plays a significant role in executive function, interactions with other cortical and subcortical regions are crucial (Ronan et al., 2020; Friedman & Robbins, 2022). Different executive functions involve various brain regions, with cooperation among regions shaping overall executive function (Ardila, 2019).

The frontal striatal circuit, involving regions like the dorsolateral prefrontal lobe, orbitofrontal lobe, anterior cingulate gyrus, and basal ganglia, is related to executive function (Chen, Dang & Zhang, 2021). Damage to specific frontal lobe regions can affect different aspects of executive function, such as attention, planning, inhibitory control, and emotions (Jones & Graff-Radford, 2021).

The unusual development of executive function is attributed, in part, to the delayed maturation of the prefrontal cortex, continuing into adolescence and early adulthood (Friedman & Robbins, 2022). Studies indicate early executive function in infancy and toddlerhood, evident in tasks requiring goal-directed behavior and inhibition (Aylward, Taylor, Anderson & Vannier, 2022). While this research highlights early executive functioning, applying well-known developmental tasks to study prefrontal function may not yield substantive findings (Ronan, Alexander-Bloch & Fletcher, 2020; Friedman & Robbins, 2022).

Researchers have offered various definitions of executive function, emphasizing its role in managing and controlling thoughts and behaviors to achieve established goals (Ernst & Burcak, 2019) and focusing attention on relevant information while suppressing irrelevant information (Drigas & Karyotaki, 2019). Miyake et al (2000) propose executive function as a control mechanism coordinating different cognitive processes to adapt to complex psychological activities. However, the specific cognitive functions underlying executive function remain inconclusive, and the definition may vary with assessment methods.

Executive function is widely accepted as a higher-order cognitive process that supervises various cognitive functions, but there is ongoing debate regarding its specific components (Drigas & Karyotaki, 2019). In the context of physical psychology, cognitive control is emphasized as an essential aspect of executive function. For instance, Kramer et al. (2003) defined executive function in the context of physical activity as the regulation of behavior, task coordination, planning, and semantic information processing. More recent research by Drigas and Karyotaki (2019); Friedman and Robbins (2022) has identified working memory, inhibition, scheduling, and planning as subcomponents of executive function in physical psychology. Other taxonomies of executive function focus on behaviors in novel or challenging situations, describing it as decision-making, planning, and error correction when facing novel and difficult situations that require inhibiting conditioned responses (Hughes & Graham, 2002).

Various researchers have proposed different taxonomies of executive function. For example, Pennington and Ozonoff (1996) categorized executive functions into set switching and maintenance, interference control, inhibition, spatiotemporal integration, planning, and working memory. Fuster (2002) identified attention and inhibition, working memory, and planning as executive functions. Miyake et al (2000) used latent variable analysis to investigate the central executive system and found three main executive functions: information refresh, response suppression, and task switching. Collette and Linden (2002) used neuroimaging to decompose executive function into four basic components: inhibition, conversion process, refresh, and dual-task coordination.

In general, executive function is thought to consist of five processes: (1) attention and inhibition, focusing on relevant information while suppressing irrelevant information; (2) task management, involving the organization and sequencing of complex tasks and shifting attention between them; (3) planning, making arrangements in time and space to achieve specific goals; (4) monitoring, updating and checking working memory contents to determine the next step in a sequence of tasks; and (5) encoding, organizing temporal and spatial information in working memory (Friedman & Robbins, 2022). However, some researchers propose that executive function should mainly include three dimensions: working memory, mental flexibility (cognitive flexibility), and inhibitory control (Drigas & Karyotaki, 2019; Friedman & Robbins, 2022; Ferguson, Brunsdon, and Bradford, 2021).

To be specific, working memory refers to the system or mechanism used for processing information while maintaining information relevant to the current task during the process of solving a cognitive task. Working memory has been described as the cognitive center of humanity (Cook et al., 2019; Fang et al., 2017; Stöckel & Hughes, 2016; Nesbitt et al., 2019).

At present, it has become one of the most active research fields in cognitive neuroscience and cognitive psychology (D'Esposito & Postle, 2015). Memory is a platform for individual information storage and processing. It is a system that temporarily holds and manipulates information. It plays an important role in higher cognitive activities such as creativity, imagery, speech, planning, reasoning, learning, thinking, decision making, and problem solving (D'Esposito & Postle, 2015). People need a temporary mechanism for processing and storing information in order to perform higher cognitive activities such as learning, memory, thinking and problem solving. It can preserve activated information representations for further processing. Baddeley and Hitch (1974) named this mechanism as working memory.

Inhibitory control as a core component of executive function is also the focus of researchers (Ferguson, Brunsdon & Bradford, 2021). Inhibitory control is the ability to suppress responses to extraneous stimuli in pursuit of cognitive representational goals. Other researchers refer to inhibitory control as executive control, executive inhibition, self-control, or self-regulation. Therefore, it can also be said that the broad aspect of executive function refers to a variety of higher cognitive abilities including inhibitory control. The narrow aspect of executive function refers only to inhibitory control which is the ability to maintain appropriate problem-solving patterns for achieving future goals (Noreen & Dritschel, 2022). Inhibitory control as the core component of executive function is the focus of executive function researchers. Inhibitory control is the ability to suppress responses to irrelevant stimuli in pursuit of cognitive representation goals (Noreen & Dritschel, 2022). Inhibitory control help to explain individual differences, developmental changes, and a wide range of cognitive abilities (memory, intelligence, attention, and reading comprehension) and performance on a variety of Piaget tasks (Ferguson et al., 2021). In addition, it is also involved in the development of emotional regulation, conscience and social competence (Zelazo, 2020).

Cognitive flexibility refers to the flexibility of thought and action to maintain the reaction set when changes can be appropriately reacted to meet the requirements of the new situation. Filippetti & Krumm (2020) proposed two forms of cognitive flexibility: spontaneous flexibility and reactive flexibility. Spontaneous flexibility involves the generation of equivocal response sets in the absence of external cues. Reactive flexibility requires changing the set in order to adapt to the requirements of the environment. These two types of cognitive flexibility provide the individual with the ability to generate ambiguous choices between assumptions and expectations in order to choose the most appropriate response (Drigas & Karyotaki, 2019; Friedman & Robbins, 2022).

To sum up, although scholars have different understandings on the components of executive function. However, the three components that are inhibitory control, working memory and cognitive flexibility have been recognized by most researchers and widely applied in practical research. Therefore, based on previous research results, the author also divided executive function into inhibitory control, working memory and cognitive flexibility. Inhibitory control refers to people's ability to independently restrain dominant responses in the brain and exclude irrelevant information during cognition, which is an important component of the entire executive function and the one that has been studied the most. Working memory refers to the ability to temporarily retain relevant information and perform mental manipulation and processing during cognition. Cognitive flexibility refers to the ability of people to flexibly change their internal thinking and external behavior to adapt to the current situation when the situation changes.

The development of executive function has been widely studied in developmental psychology. Carlson and Wang (2007) found that children as young as 18 months were capable of suppressing irrelevant information to achieve their goals. Inhibitory control, a core component of executive function, has been observed in children under two years old (Rhoades, Greenberg & Domitrovich, 2009). Working memory and inhibitory control have been shown to emerge around the age of three (Wiebe et al., 2011). Inhibitory control develops significantly between ages three and six (Noreen & Dritschel, 2022). Executive function experiences rapid improvement during the ages of three to six, with ages four to five being a particularly fast-developing stage (Chou et al., 2022; Lan et al., 2011).

From school age to early adulthood, executive function continues to develop, with many indicators reaching adult levels around the age of 12. However, some aspects of executive function, such as verbal fluency, action sequences, and complex planning, mature in the late teens (Friedman & Robbins, 2022). Longitudinal studies tracking the development of executive function have identified three stages in children aged 3 to 12 years: the appearance of organizational strategies and planning behavior around age 6, followed by more complex problem-solving strategies, predictive abilities, and effective impulse control at age 10 (Ólafsdóttir, Gestsdóttir & Kristjánsson, 2020). Additionally, verbal fluency, action sequence, and complex planning skills continue to mature beyond the age of 12 (Messer et al., 2018).

Executive function is also strongly associated with academic skills during early childhood and beyond. It predicts reading comprehension rather than decoding in literacy tasks and is important for developing proficient writing skills (Connor et al., 2016; Fuhs et al., 2014). In mathematics, executive function plays a crucial role in manipulating and comparing quantitative concepts and is associated with mathematical skills during early childhood (Blair & Raveret, 2015; McClelland et al., 2014; Purpura et al., 2017).

In conclusion, executive function is a multifaceted cognitive process that supervises various cognitive functions. While different taxonomies of executive function exist, most researchers recognize inhibitory control, working memory, and cognitive flexibility as core components. The development of executive function in children is characterized by distinct trajectories during preschool years, with critical periods of rapid improvement. Executive function plays a crucial role in various aspects of academic achievement and cognitive development, including reading comprehension, writing skills, and mathematical abilities, and continues to develop throughout childhood and adolescence. It is an essential cognitive resource for success in learning and problem-solving tasks.

Methodology

The research sample consists of 222 Chinese preschool children, which is determined based on the well-established sampling technique. The location of the study is in Shaanxi Province, China. From the pool of children who returned a parental approval, and with the help of the preschool teacher, one-on-one direct child assessments on cognitive outcomes were conducted. All the data of the present study were kept confidential and anonymous.

The Peabody Executive Function Assessments were used to measure children's executive function. The Peabody Executive Function Assessments are comprehensive, reliable, direct assessments for preschool children. The Peabody Executive Function Assessments comprises three subtests: Head Toes Knees Shoulders; Dimensional Change Card Sort, and Corsi Blocks. Executive function skills were measured with these three sub-assessments and analyzed as a composite in line with previous research (e.g., Nesbitt et al., 2019). For the present study, the Head Toes Knees Shoulders was used to measure children's inhibitory control. The Dimensional Change Card Sort was examine to measure children's cognitive flexibility. The Corsi Blocks was used to assess working memory. The raw total score provides more information, so the summary score was used.

In the Head-Toe-Knee-Shoulder scale of behavioral control including inhibitory control (Ponitz et al., 2009), when children were asked to touch head, they needed to touch their toes in deed. When children were asked to touch toes, they needed to touch their head instead. Five practice trials with feedback were administered, followed by 10 test trials. Children who responded exactly to more than five tests trials received two new reverse action prompts ("Please touch your shoulder" and "Please touch my knees") were added. After 10 test trials, the feedback of the four practice trials was given. Each trial had a score of 0 if the child gave a wrong answer While 1 was given if the child corrected the incorrect answer himself, 2 was given if the child gave a correct answer. The total score was ranging form 0 to 40.

The Dimensional Change Card Sort is a measure of cognitive flexibility(Zelazo, 2006). In this test, children need to sort cards in one dimension (red and blue colors) and then in another dimension (stars and tracks). When the children were able to switch the sorting rules, they received sets of cards with or without black borders around the cards. If the cards had black borders, the children had to classify the cards by color. If the cards had no black borders, they had to classify the cards by shape. The rules to classify cards were taught through both oral instruction and demonstration. If a child classify a card correctly according to different rules, he or she would receive one score. Whereas a children classify a card incorrectly according to different rules, he or she would receive zero score.

Corsi Block task is a visual spatial task of working memory (Corsi, 1972). During the task, a child was required to point to a series of blocks attached to a board in random order. The child had to reverse patterns given by a examiner. The children performed her two trials to complete each pattern. The total score was the longest backward pattern that the child was able to repeat accurately. The total score is ranging from zero to nine.

The Peabody Executive Function Assessments was normed on a large, representative sample of American preschool children. The subtests of the Peabody Executive Function Assessments are highly correlated within domains, suggesting sound construct validity. Test-retest and interrater reliability of Head-Toes-Knees-Shoulders have been established at Cohen's $k = .79$ (McClelland et al., 2014) and $r = .80$ (Lipsey et al., 2017). Test-retest reliability of the Dimensional Change Card Sort following a 2- and 3-week delay with preschoolers has been established at $r = .48$ (Lipsey et al., 2017). Reliability for a verbal variation of of the Corsi Blocks task has been established at $r = .73$ (Lipsey et al., 2017).

Data collected from these instruments was coded, computed and analyzed using the Statistical Packages for the Social Science (SPSS) version 22.0. To be specific, independent sample T test was used for testing the difference on valuables between boys and girls in SPSS firstly. Secondly, one-way ANOVA was used for testing the difference on valuables among different age groups in SPSS. Thirdly, multiple comparison in terms of manifest valuables among age 3; age 4; and more than age 5 is conducted using Scheffe test, one-way ANOVA in SPSS. These results provide developmental features and norm scores on cognitive outcomes for Chinese preschool children from 3 to 5 years old.

Finding

An independent sample t-test was conducted in SPSS to examine the differences in executive function between boys and girls. The total sample consisted of 114 boys and 108 girls, with similar sample sizes for both groups. Table 1 presents the results of the t-test, showing the significance levels for inhibitory control, cognitive flexibility, and working memory. The analysis revealed a significant difference between boys and girls in terms of inhibitory control ($p < 0.05$). Specifically, girls (mean is 31.35) demonstrated significantly better inhibitory control than boys (mean is 28.39) during the preschool period. This indicates that inhibitory control, which is the ability to control impulses and regulate attention, develops faster and more effectively in girls compared to boys.

However, there were no significant differences between boys and girls in terms of cognitive flexibility and working memory ($p > 0.05$). These results suggest that both boys and girls perform similarly in cognitive flexibility, which involves the ability to adapt to changing situations and switch between different tasks. Similarly, no significant gender differences were observed in working memory, which pertains to the capacity to temporarily store and manipulate information. Overall, the findings indicate that while boys and girls exhibit similar levels of executive function in the aspects of cognitive flexibility and working memory during the preschool period, there is a notable gender difference in inhibitory control, with girls demonstrating superior performance.

Table 1
Gender Difference on Executive Function

	t-test for Equality of Means				Sex	N	Mean	SD
	t	df	Sig.	MD				
Inhibitory Control	-2.159	220	0.032	-2.957	Male	114	28.39	11.199
					Female	108	31.35	9.029
Cognitive Flexibility	1.785	220	0.076	0.589	Male	114	19.24	2.362
					Female	108	18.65	2.552
Working Memory	-1.313	220	0.191	-0.35	Male	114	6.63	2.058
					Female	108	6.98	1.904

Table 2 presents the mean scores, sample size, and standard deviations of executive function for each age group: age 3, age 4, and more than age 5. However, due to the limited sample size of age group 6 (only 15 participants), statistical results may be inaccurate due to the large difference in group sample size compared to age group 4 (106). To address this issue, age group 5 and age group 6 were combined into a single category labeled "more than 5 years." The mean scores and standard deviations of inhibitory control for each age group were as follows: 24.8 ± 11.061 for age 3, 28.69 ± 10.411 for age 4, and 19.43 ± 2.446 for more than 5 years. On the other hand, for cognitive flexibility, the mean scores were 18.24 ± 2.252 for age 3, 19.05 ± 2.527 for age 4, and 20.33 ± 2.143 for more than 5 years. Finally, for working memory, the mean scores were 5.64 ± 1.671 for age 3, 6.52 ± 1.853 for age 4, and 8.34 ± 1.493 for more than 5 years.

It is evident from the data that the mean scores of every aspect of executive function increase gradually with age. Inhibitory control, cognitive flexibility, and working memory all show developmental improvements as children grow older during the preschool period. By combining age group 5 and age group 6 into a single category, more accurate statistical analyses can be conducted to represent the developmental changes in executive function across the preschool age groups. These findings offer valuable insights into the developmental trajectories of different aspects of executive function in young children.

Table 2
Mean Score of Executive Function among Age Groups

Age		Inhibitory Control	Cognitive Flexibility	Working Memory
	Mean	24.8	18.24	5.64
3	N	55	55	55
	Std. Deviation	11.061	2.252	1.671
	Mean	28.69	19.05	6.52
4	N	106	106	106
	Std. Deviation	10.411	2.527	1.853
	Mean	36.36	19.43	8.34
5	N	61	61	61
	Std. Deviation	4.583	2.446	1.493
Total	Mean	29.83	18.95	6.8
	N	222	222	222
	Std. Deviation	10.285	2.468	1.988

A one-way ANOVA analysis was conducted in SPSS to examine the differences in executive function among the different age groups: age 3, age 4, and more than age 5. The results are presented in Table 3, which shows the significance levels for cognitive flexibility, working memory, and inhibitory control. The analysis revealed that the differences in cognitive flexibility, working memory, and inhibitory control among the three age groups were statistically significant ($p < .05$). This finding indicates that all aspects of executive function, including cognitive flexibility, which involves adaptability and task-switching, working memory, which pertains to temporary information storage, and inhibitory control, which relates to impulse control and attention regulation, show noticeable development during the preschool period. Specifically, the scores for cognitive flexibility, working memory, and inhibitory control in the age group more than 5 were significantly higher than those in the age 4 and age 3 groups. This suggests that as children grow older, there are substantial improvements in their executive function skills, making them more proficient in these cognitive processes.

As a result, it suggested that age-related differences in cognitive flexibility, working memory, and inhibitory control, respectively, are all supported by the data. The results of the one-way ANOVA analysis provide valuable insights into the developmental trajectories of different aspects of executive function during early childhood.

Table 3
The Difference of Executive Function among Different Age

		Sum of Squares	df	Mean Square	F	Sig.
Inhibitory Control	Between Groups	4131.241	2	2065.621	23.503	0
	Within Groups	19247.592	219	87.889		
	Total	23378.833	221			
Cognitive Flexibility	Between Groups	42.845	2	21.423	3.599	0.029
	Within Groups	1303.609	219	5.953		
	Total	1346.455	221			
Working Memory	Between Groups	228.319	2	114.16	38.764	0
	Within Groups	644.96	219	2.945		
	Total	873.279	221			

To further explore the differences in inhibitory control, cognitive flexibility, and working memory among the age groups (age 3, age 4, and more than age 5), a multiple comparison analysis was conducted using the Scheffe test and one-way ANOVA in SPSS. The results are presented in Table 4, with a confidence level of 95%. The analysis revealed that inhibitory control and working memory showed significant differences between each pair of age groups at the $p < 0.05$ level. For inhibitory control, the scores in age group 3 were significantly different from those in age group 4, and the scores in age group 4 were also significantly different from those in the age group more than 5. Similarly, for working memory, there were significant differences in scores between age group 3 and age group 4, as well as between age group 4 and the age group more than 5. These findings indicate distinct developmental changes in inhibitory control and working memory between each age group, with scores increasing as children grow older.

On the other hand, for cognitive flexibility, no significant differences in scores were observed between age group 3 and age group 4, as well as between age group 4 and the age group more than 5, at the $p < 0.05$ level. However, there was a significant difference in scores between age group 3 and the age group more than 5. This indicates that cognitive flexibility does not exhibit significant developmental changes between age group 3 and age group 4, but there is a noticeable improvement in this aspect of executive function when comparing age group 3 to the age group more than 5. In summary, the multiple comparison analysis provides valuable insights into the developmental trajectories of inhibitory control, cognitive flexibility, and working memory among preschool children. While inhibitory control and working memory show distinct variations with age, cognitive flexibility appears to remain relatively stable between age group 3 and age group 4, but it significantly improves in the age group more than 5.

Table 4
Multiple Comparison on Executive Function Using Scheffe

Dependent Variable	Age(I)	Age (J)	Mean Difference	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Inhibitory Control	3	4	-3.889*	1.558	0.046	-7.73	-0.05
		5+	-11.561*	1.743	0	-15.86	-7.26
	4	3	3.889*	1.558	0.046	0.05	7.73
		5+	-7.672*	1.507	0	-11.39	-3.96
	5+	3	11.561*	1.743	0	7.26	15.86
		4	7.672*	1.507	0	3.96	11.39
Cognitive Flexibility	3	4	-0.811	0.405	0.138	-1.81	0.19
		5+	-1.190*	0.454	0.034	-2.31	-0.07
	4	3	0.811	0.405	0.138	-0.19	1.81
		5+	-0.379	0.392	0.627	-1.35	0.59
	5+	3	1.190*	0.454	0.034	0.07	2.31
		4	0.379	0.392	0.627	-0.59	1.35
Working Memory	3	4	-.883*	0.285	0.009	-1.59	-0.18
		5+	-2.708*	0.319	0	-3.49	-1.92
	4	3	.883*	0.285	0.009	0.18	1.59
		5+	-1.825*	0.276	0	-2.51	-1.15
	5+	3	2.708*	0.319	0	1.92	3.49
		4	1.825*	0.276	0	1.15	2.51

Note, * The mean difference is significant at the 0.05 level.

Discussion

The results suggest that there were no significant differences between boys and girls in terms of cognitive flexibility and working memory in this sample of Chinese preschool children aged three to five. This suggests that boys and girls exhibit similar levels of cognitive flexibility and working memory during the preschool period. However, there was a significant difference in inhibitory control, with girls demonstrating better inhibitory control than boys. This indicates that inhibitory control develops faster and more effectively in girls compared to boys during this developmental stage. The finding regarding cognitive flexibility and working memory aligns with previous studies. For instance, Osorio-Valencia et al. (2017) also reported no significant differences between boys and girls in executive function, specifically cognitive outcomes evaluated using the McCarthy Scale in five-year-old preschool children.

On the other hand, the discrepancy in inhibitory control results between our study and previous research may be attributed to methodological differences in assessing executive function. Our research utilized experimental tests of executive function, while other studies may have employed parent-report assessment tools for cognitive outcomes. Parent-report assessments tend to evaluate various aspects of cognitive outcomes, and they may capture how these processes naturally unfold in real-world settings (Toplak et al., 2013; Mahone et al., 2009). Conversely, performance-based assessments focus on specific aspects of cognitive function, such as inhibitory control, in controlled experimental conditions. The use of different assessment methods can yield varying results, leading to potential inconsistencies in the findings. Therefore, it is essential for researchers to carefully consider the assessment tools they use and to ensure that they align with the specific cognitive processes being investigated. By adopting standardized and validated assessments, researchers can enhance the comparability and reliability of their findings.

Additionally, the study revealed significant differences in executive function, including cognitive flexibility, working memory, and inhibitory control, among the three age groups of Chinese preschool children. This finding indicates that these aspects of executive function undergo substantial development during the preschool period, with scores for children older than five significantly higher than those for children aged four and three. While there is limited research on preschool children, results from studies conducted on older children and adolescents show similar patterns. For instance, measurements designed to test executive function for preschoolers may be considered too easy for school-aged children (Carlson, 2005).

The argument that inhibitory control is not fully integrated in preschool children is supported by previous studies (Zelazo, 2020; Diamond, 2013). The increased difficulty in regulating emotional responses to designed tasks may interfere with children's ability to exhibit effective inhibitory control (Zelazo, 2020; Diamond, 2013). This notion was confirmed by Carlson et al (2005) in a series of experiments, including an executive function task named "less-is-more." In this research, preschool children were asked to choose a smaller reward to receive a larger one. The results showed that four-year-old children performed significantly better than three-year-old children on this task, indicating a developmental progression in inhibitory control. This suggests that executive function becomes more integrated as children grow older, leading to a gradual improvement in cognitive flexibility, working memory, and inhibitory control during the preschool period (Carlson et al., 2005).

The study's findings, as presented in Chapter four, highlight the importance of considering age differences in research involving preschool children. Chronological age was also identified as an essential predictor of executive function, specifically cognitive flexibility, working memory, and inhibitory control, each considered separately. The nature of the relationship between physical well-being and executive function in preschool children appears to differ from that observed in older children (Stuhr, Hughes, & Stöckel, 2020; McClelland et al., 2014). While there is significant overall development of executive function during childhood, the rate of development varies considerably between different components of executive function and among individual children (Van der Ven et al., 2012).

Furthermore, it's important to note that the sample size for the age three and more than age five groups is only half as large as that for the age four group. Additionally, children aged six in this study were included in the more than age five group, as they were just over six years old and would start primary school in September following the policy of compulsory education in China. Potential sampling errors could contribute to the observed age-based differences between the more than age five group and the age three and four groups. Despite these challenges, the results from the present research indicate that age-independent individual differences in executive function, physical well-being, and cognitive outcomes are more crucial than chronological age in understanding the developmental nature of these variables in preschool children.

To sum up, age and gender has a significant impact on executive function for preschool children in China. As children grow older, their cognitive flexibility, working memory, and inhibitory control show notable improvements. While boys and girls perform similarly in cognitive flexibility and working memory, girls demonstrate better inhibitory control abilities during early childhood. This suggests that age and gender play vital roles in shaping the developmental trajectory of executive function in young children, emphasizing the importance of considering these factors in research and understanding cognitive development in this age group.

Conclusion

In conclusion, this study examined the developmental trends of executive function in Chinese preschool children aged three to five years. The results indicate that girls demonstrate better inhibitory control compared to boys during this period, while cognitive flexibility and working memory do not show significant gender differences.

Furthermore, the study highlights the importance of age differences in executive function development. As children grow older, their cognitive flexibility, working memory, and inhibitory control exhibit notable improvements. This suggests that executive function becomes more integrated and advanced with increasing age during the preschool years.

Considering these findings, researchers and educators should account for age and gender differences when assessing and supporting executive function development in young children. By understanding the unique cognitive profiles of preschoolers, appropriate interventions can be designed to foster cognitive skills and promote successful cognitive functioning during this crucial developmental stage.

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