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A study on the outcomes of Montessori education in China

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Abstract

Montessori education has been acclaimed as one of the best methods of training students. Despite its widespread, little is known about Montessori education and its effects in mainland China. This research aims to spur more research on Montessori education outcomes in China. A quasi-experimental method was applied in this study, to compare the executive function (EF) development of children who had attended Montessori preschool to their non-Montessori peers. The study used a behavior rating inventory of executive function, second edition (BRIEF2) Parent Form to compare parents' observations of their child's executive functions (EF). Parents of Chinese elementary-aged children (6-8 years old) at the time of the study of both Montessori and non-Montessori preschool backgrounds participated in the survey. According to the results, children of Montessori preschool backgrounds had some statistically significant better-scored EF indexes than their non-Montessori peers. While the remaining indexes were not statistically significant, mean scores were still better for children who had attended Montessori preschool overall.

Keywords: Educational software; executive function; Montessori; perceptions; teacher.

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1. Introduction

China has the most extensive education system globally, educating 260 million children, and employing over 15 million teachers nationwide (Gu et al., 2016; OECD, 2016). Since 1986, preschool education has remained at the forefront of education policy in mainland China (Ministry of Education, 2011) as research confirms the importance of the first six years of life (Hackman & Carneiro, 2003; Goleman, 2006; Montessori, 1967) and China seek the best methods for educating its youngest citizens. One preschool method used in China, though not universal, is the Montessori method. According to some sources, China has the most Montessori schools worldwide (Whitescarver & Cossentino, 2010; Song, 2019; Chen, 2021), which means China educates more children using the Montessori method and employs more Montessori teachers than any country in the world. Interestingly, information concerning the outcomes of children who have been educated using the Montessori method in China remains rare.

Montessori education is an education system founded in 1907 by Maria Montessori of Italy. Predominantly used at the preschool level, Montessori education was first introduced in mainland China in 1913 but stayed underdeveloped until the late 1980s (Tian et al., 2014; Chen & Guo, 2021; Lau, 2017; Greenburg, Hines & Winsler, 2020). Since the late 1980s, Montessori education has enjoyed popularity in China, as parents look for alternative teaching methods for their preschool-aged children (Chen & Guo, 2021).

International research on Montessori education has focused intensively in the last decade on student outcomes as researchers hope to show the benefits of the Montessori education method (Diamond & Lee, 2011; Moody & Riga, 2011; Lillard, 2012; Diamond, 2013; Ansari & Winsler, 2014; Mallett & Schroeder, 2015; Lillard & Heise, 2016; Demangeon et al., 2023). However, of these studies, none looked at the outcomes of students in China. Moreover, in Chinese core journals, there is no research in the last decade on the outcomes of students who were educated using the Montessori method. As the country with the most Montessori schools, students, and teachers, evaluating student outcomes is valuable to discover whether Montessori education in China is an advantageous method.

The research conducted here strives to be a starting point for assessing the outcomes of students who were educated using the Montessori education method in mainland China. This study used a quasi-experimental method using simple difference impact estimates to compare the executive function (EF) development of children who had attended Montessori preschool to their non-Montessori peers at a single point in time to discover whether differences could be found between the two groups.

1.1. Conceptual Background

Chinese Montessori research since the 2000s is predominantly theoretical with limited empirical research in core journals. One topic that is repeatedly discussed in academic circles is localization. Localization is the term used to define how to implement Montessori education in a Chinese context taking into consideration Chinese cultural, social, and national identity (Deng et al., 2016; Huo, 2001; Liu & Lin 2003; Tian, 2007; Tian, 2008; Tian et al., 2014; Wang, 2012; Yang, 2002; 2004). Only one article was found in the Chinese literature that focused on the outcomes of Montessori education in mainland China. Liu and Zhang (2010) measured academic performance in language and mathematics, social development, and sensory-motor development as indicators and compared test scores and observation reports from teachers and parents of first and third-grade children of both Montessori and non-Montessori preschool backgrounds. They found no significant difference

between Montessori and non-Montessori preschool background children, and although not significant, in all cases, Montessori children performed poorer in all areas than children of non-Montessori backgrounds.

In the research of Liu and Zhang (2010), the authors state a possible reason for the lack of significant difference in outcomes for Montessori children in the study could be connected to the type of Montessori program the children attended. Current international research about Montessori implementation practices addresses program authenticity using the term implementation fidelity (Lillard & McHugh, 2019a; 2019b). Applying this concept to Montessori education, implementation fidelity means how a classroom or preschool adheres to the original intent of Montessori education as described in Montessori's writings (Anderson, 2017; O'Donnell, 2008; Lillard & McHugh 2019a; 2019b; Knauf, 2020). While implementation fidelity is a crucial issue to ensure program outcomes are reached, a program's ability to adapt to local cultural needs is also essential to a program's survival (Dunsebury et al., 2003; Patton & Winter, 2022). Simultaneously, current international research has propagated that high implementation fidelity Montessori classrooms positively correlate to student outcomes (Lillard, 2012; Lillard & Else-Quest, 2006; Lillard et al., 2017; Owojori & Gbenga-Akanmu, 2021). Therefore, an important issue to discover is what is being adapted in Montessori classrooms in China regarding localization practices and whether or not this is influencing outcomes.

A recent study discovered that Montessori programs in China do not reflect high-fidelity practices concerning work cycle times, teacher ratios, and co-teaching (Chen, 2021). Teachers (*n*=210) reported shortened work cycle times, lower ratios of students to teachers, and co-teaching, which means more than one teacher giving lessons in the classroom. These changes show divergence from high-fidelity Montessori education (Association Montessori Internationale USA, 2020; Feez & Miller, 2011; Lillard & McHugh 2019a; Montessori, 1966; 1967a; 1967b). It can also be argued that these changes are the result of localization (Chen, 2021), as researchers argue that traditional Montessori classrooms operate counter to Chinese values and educational culture (Chen and Guo, 2021) and therefore need to undergo particular adaptations (Deng et al., 2016; Huo, 2001; Yang, 2004; Choy, 2017; Liu, 2010). Whether or not these alterations jeopardize the effectiveness of the Montessori program in China has not been analyzed.

1.1.1. Executive Function

One area often shown as producing better outcomes in Montessori education is executive function (EF). EF has become a popular topic as educators contemplate the skills and abilities children need to develop to be successful in their lifetime. To answer this question, many are pointing to EFs. While there is no one agreed-upon definition of EF, most definitions state EF as a group of mental abilities connected to conceiving, organizing, and executing goal-oriented behavior (Anderson, 2002; Barkley, 2012; Denckla & Mahone 2018, Gioia et al., 2015). Housed in the prefrontal cortex, these mental abilities include inhibition (knowing when to act and when to refrain from acting), working memory (keeping information in mind and manipulating it), shift (or cognitive flexibility), self-monitoring (staying on task), planning (mentally anticipating what is needed and acting accordingly) and many others (Barkley, 2012; Blair et al., 2005; Diamond, 2013; Gioia et al., 2015; Meltzer, 2018). EF, traditionally of interest to neuropsychologists, has become of interest to educators as EF is connected to academic success, economic independence, health, and all-around flourishing (Denckla & Mahone, 2018; Diamond, 2010; 2013; Moffitt et al., 2011). EFs are developed throughout a person's life span and are mainly influenced in the early years of life by caregivers (parents and

preschool teachers) as well as the environment (home and preschool) (Otero & Barker, 2014; Ehlert et al., 2022; Koepp et al., 2022).

1.2. Purpose of study

The research presented here assessed the EF development of children who attended a localized version of Montessori education in mainland China compared to their non-Montessori peers to assess whether the Montessori program showed benefit to children's EF development.

This research seeks to answer the following questions:

1. Is there a difference in EF development of children in mainland China who have attended localized Montessori preschools compared to children who attended non-Montessori preschools based on parents' observations of their elementary school-aged child?
2. Is executive dysfunction more or less common in children educated using the Montessori method?
3. In areas where children from Montessori backgrounds are stronger in EF development than their non-Montessori peers, what are the possible reasons for this difference?

While there are multiple studies on the outcomes of Montessori children in the Western world, little is known about Montessori education practices and their outcomes in mainland China. This research aims to spur more research on Montessori education outcomes in China.

2. Materials and Methods

2.1. Participants

Parents of sixty-three children ranging in age from six to eight years old at the survey date participated in the study. Table 1 shows demographic information categorized by Montessori and non-Montessori preschool types. Maternal education was reported for 100% of the sample. About 20% of mothers reported having an associate's degree (AA) or lower, 62% a bachelor's degree (BA), and 19% a graduate degree or higher. All children were Chinese (100%) and entering the first, second, or third grades in September 2020.

Table 1

Demographic features of children and program

Variable	Program type	
	Montessori	Traditional
N (girls)	32 (16)	31 (16)
Number of children by age (6, 7, 8)	3, 12, 18	4, 16, 11
Maternal Education	≤ AA: 7; ≥ BA: 25	≤ AA: 5; ≥ BA: 26
Percent Chinese	100	100
Teacher education	≤AA: 14; ≥BA: 18	≤ AA: 13; ≥ BA: 18

Parents of children from two preschool program types were targeted for this study. Preschools were located in Shandong, China.

2.1.1. Montessori Preschool

The Montessori children whose parents participated in the study had all attended the private Montessori preschool affiliated with a large localized Montessori organization in mainland China. The localized Montessori society has no reliance on international Montessori experts or organizations and

is known for implementing localization adjustments to the Montessori preschool program. All head teachers were Montessori trained.

The Montessori classrooms were staffed similarly to non-Montessori ECE classrooms in China in that each classroom had a standard three teachers. At least one of the teachers in each classroom was Montessori trained, sometimes all three (observations in 2017 showed that each classroom had one to two trained teachers, while observations in 2020 showed that all three teachers were trained). Each classroom had a standard set of Montessori materials (Lillard, 2011), and children engaged in small group lessons or individual activities throughout the morning. While the preschool implements mixed-aged classrooms reflecting adherence to Montessori's writings (Montessori, 1967a), the school implements an approximate two-hour or less work cycle in the morning and has no afternoon work cycle. The remaining time is spent in whole-class activities, including outside playtime, circle time activities, and afternoon group lessons. It was observed that children have about two hours each morning to work with Montessori materials.

2.1.2. Non-Montessori Preschool

Parents of children who had attended non-Montessori preschools also participated in the study. The term *traditional preschool* was used to describe non-Montessori public preschools as this is a common term used to describe preschools with classrooms of same-aged children, and children receive lessons the majority of the time as a group. Each classroom had a minimum of two academic teachers and a third caregiver whose primary responsibility was cleaning the classroom, serving lunch, and other service-type responsibilities. Children spent the whole day as a group, including organized outdoor exercises, indoor classroom lessons, free play, and even drinking water and going to the bathroom. Classrooms follow a block schedule, meaning a specific time is allotted daily for each activity that varies minimally day-to-day.

2.2. Procedures and Ethics

Parents of Montessori children were first contacted by the preschool administrator and asked to join the study. Next, parents of traditional preschool were recruited through elementary school teachers. Parents who agreed to participate were then put in contact with the researcher. Parents received information about the survey ("you will be asked questions regarding your child's behavior that parents typically observe"), requirements to participate (three years in Montessori school or traditional school, the child will enter the 1st-3rd grade in September, preschool was located in a city in Shandong/had attended Montessori affiliated preschool in a city in Shandong). Personal information was then gathered from parents of children who fit the requirements. Parents received the survey via text message that could only be opened according to the phone number provided and, once submitted, could not be opened again.

An initial total of 67 responses were received. Demographic information was analyzed, and raw scores were hand-calculated. Four errors were found. One response did not conform to internal validity according to the *BRIEF2 Handbook* (Gioia et al., 2015), two children had not attended preschool in the specified city, and one child was five years old (minimum age requirement was six, parents had initially given nominal age). These errors were deleted, and the remaining 63 results were computed using SPSS 22.

2.3. Data Collection Instrument

This study used the *Behavior Rating Inventory of Executive Function, Second Edition* (BRIEF2) Parent Form, a rating scale that assesses EF development in children from ages 5-18. The BRIEF2 asks

questions concerning everyday behavior in children as observed by parents, and parents are asked to rate the behavior description according to observations of their child using a three-point scale of never, sometimes, and often. The lower the score reported, the better, while *t* scores over 60 in one index indicate possible executive dysfunction.

The BRIEF2 covers nine executive function indexes and three summary indexes, and a Global Executive Composite (GEC) profile. The nine scales of executive function assessed were *inhibit*, measured as the ability to not act on an impulse; *self-monitor*, the awareness of one's own behaviour and its effect on others and the awareness of how others interpret the behaviour; *shift*, described as flexibility and the opposite of rigidity; *emotional control*, the ability to regulate emotional responses; *initiate*, behaviour related to "beginning a task or activity and to independently generating ideas, responses, or problem-solving strategies" (Gioia et al., 2015, p 34-5); *working memory*, the ability "to hold information in mind for the purpose of completing a task" (Gioia et al., 2015, p 35); *plan/organize*, which measures plan as the ability to make and take steps in order to fulfil a specific goal for a desired outcome and organize as the ability to make sense of materials and learned information and utilizing them in meaningful ways; *task-monitor*, the ability to effectively monitor one's work production; and *organization of materials* as "orderliness of work, play and storage spaces" and "the manner in which children order or organize their world…and belongings" (Gioia et al., 2015, p 36).

The three summary indexes were also analyzed. They are the *Behavioral Rating Index* (BRI), which includes inhibiting and self-monitor indexes; the *Emotional Rating Index* (ERI), which includes shift and emotional control indexes; and the *Cognitive Rating Index* (CRI), which includes initiative, working memory, plan/organize, task-monitor and organization of materials indexes. In addition, the GEC profile was also evaluated.

The nine measures on the BRIEF2 fit with Naglieri and Goldstein's definition of executive function as the following:

> Executive function is best represented as a single phenomenon, conceptualized as the efficiency with which individuals go about acquiring knowledge as well as how well problems can be solved across nine areas (attention, emotion regulation, flexibility, inhibitory control, initiation, organization, planning, self-monitoring, and working memory) (as quoted from Goldstein et al., 2014, p 4).

The BRIEF2 was purchased in June 2020 and administered to parents in July 2020.

3. Results

There were 32 Montessori preschool participants and 31 traditional preschool participants. Mean scores and standard deviations are found in Table 2.

Table 2

Means (and SDs) for executive function measures by preschool type

Measure	Preschool Type	
	Montessori (n=32)	Traditional (n=31)
Inhibit	11.7188(2.38590)	12.7742 (2.95194)
Self-Monitor	6.8125(1.74942)	6.9677(1.53805)
Shift	11.8750(2.07520)	12.1935(2.82158)
Emotional Control	11.5000(3.11086)	11.7097(3.08970)
Initiate	7.7500(1.93441)	8.2903(2.03623)
Working Memory	11.9688(2.54615)	13.5484(3.15001

Plan/Organize	13.8125(3.23726)	14.5806(3.14933
Task-Monitor	9.7813(1.69885)	10.2258(2.17117)
Organization of Material	8.8125(2.02305)	10.3871(2.37595)
BRI	18.5313(3.65429)	19.7419(3.94941)
ERI	23.3750(4.36814)	23.9032(5.50972)
CRI	52.1250(8.51090)	56.2581(10.99990)
GEC	94.0313(13.87149)	99.9032(18.59813)

Indexes and summaries that were normally distributed were analyzed using independent samples *t*-tests and are found in Table 3.

Table 3

Independent samples t-test results

	Levene's Test		*t*-test for Equality of Means			
					95% CI	
	F	Sig.	*t*	*df*	Lower	Upper
Initiate	.619	.434	-1.080	61	-1.54068	.46003
Self-Monitor	.663	.419	-.374	61	-.98614	.67565
Task-Monitor	.499	.483	-.907	61	-1.42495	.53583
BRI	.039	.844	-1.263	61	-3.12674	.70537
ERI	3.818	.055	-.421	57.151	-3.04158	1.98513
CRI	3.241	.131	-1.671	61	-9.07865	.84061

A Mann-Whitney *U* test was run to evaluate statistical differences for indexes and summaries that were not normally distributed. GEC was not normally distributed and was also assessed using a Mann-Whitney *U* test. Due to all responses having internal validity as assessed by the *BRIEF2 Handbook*, non-normally distributed results were not deleted from the study. Individual index scores of each response were also analyzed for executive dysfunction according to preschool type.

All indexes were tested for homogeneity. The shift was tested as having heterogeneity as assessed by Levene's test of variances (p=.037) and was removed from the analysis. The remaining eight indexes were used in the analysis, such as the three summary indexes and GEC.

First, ANOVAs were run for each of the eight individual indexes to check for differences in parents' education, as parents' educational level is an important factor in child outcomes (Hernandez & Napierala, 2014). Father's education level showed as having a statistically significant influence on the organization of materials F (3, 59) = 3.027, p = .036. Mother's education level showed a statistically significant influence on working memory F (3, 59) = 2.937, p = .041, plan/organize F (3, 59) = 3.671, p = .017, task monitor F (3, 59) = 3.686, p = .017, and organization of materials F (3, 59) = 2.966, p = .039.

Next, independent samples *t*-tests and, when necessary, Mann-Whitney *U* tests were used to analyze for differences concerning preschool type.

3.1. Executive Function Indexes

Mean inhibit scores were lower for Montessori preschool participants (M= 11.72, SD=2.39) in comparison to traditional preschool participants (M= 12.77, SD= 2.95), but without a statistically significant difference, M=-1.0554, t (61) =-1.563, 95% CI [-2.406 to .295], p=.123, d=.39.

Similar to inhibit scores, mean self-monitor scores were lower for Montessori participants (*M*=6.81, *SD*=1.75) than traditional participants (*M*= 12.19, *SD*= 2.82), but the difference was not significant, *M*=-1.5524, *t* (61) =-.137, 95% *CI* [-.986 to .676], *p*=.710, *d*=.06.

Emotional control scores for each level of preschool were not normally distributed. A Mann-Whitney *U* test was run to confirm differences in emotional control scores between children of Montessori and traditional preschools. Median emotional control scores were not statistically significantly different between Montessori (*Mdn*= 26.78) and traditional (*Mdn*=37.39) preschool, *U*= 516, *z*= -.277, *p*= .782.

Due to the non-normal distribution for the initiate index, a Mann-Whitney *U* test was run to verify if there were differences in initiate scores between children of Montessori and traditional preschool. Median initiate scores were not statistically significantly different between Montessori (*Mdn*=29.67) and traditional (*Mdn*=34.40) preschool, *U*=570.5, *z*=-1.045, *p*=.296.

Working memory scores for Montessori preschool responses were not normally distributed. A Mann-Whitney *U* test was run in the case for working memory to determine if there were differences in working memory scores between children of Montessori and traditional preschools. Median working memory scores were statistically significantly different between Montessori (*Mdn*= 26.78) and traditional (*Mdn*=37.39) preschool, *U*=663, *z*= 2.314, *p*=.021.

Plan/organized scores for Montessori preschools were not normally distributed. A Mann-Whitney *U* test was run to determine if there were differences in plan/organize scores between children of Montessori and traditional preschools. Distribution of plan/organize scores between children of Montessori and traditional types were similar, as assigned by visual inspection. Median plan/organize scores were not statistically significantly different between Montessori preschools (*Mdn*=29.17) and traditional preschools (*Mdn*=34.92), *U*=586.5, *z*=1.252, *p*=.211.

Task-monitor scores were slightly lower for Montessori participants (*M*= 9.78, *SD*=1.7) than traditional participants (*M*= 10.23, *SD*= 2.17), a non-statistically significant difference, *M*=-.44456, *t* (61) =-.907, 95% *CI* [-1.425 to .5.36], *p*=.368, *d*=-.02.

The organization of materials was not normally distributed; thus, a Mann-Whitney *U* test was run to determine if there were differences in the organization of material scores between children of Montessori and traditional preschools. Median organization of materials scores was statistically significantly different between Montessori (*Mdn*=26.17) and traditional (*Mdn*=38.02)*, U= 682.5, z*= 2.588, *p*= .01.

Results from Mann-Whitney *U* Tests can be seen in Table 4.

Table 4

Summary of differences between Montessori and traditional preschool indexes that were not normally distributed (Mann-Whitney U Test)

	Preschool Type		
	Montessori (n=32)	Traditional (n=31)	
Index	Mean Rank	Mean Rank	*Z*-value
Emotional Control	31.38	32.65	-.277
Initiate	29.67	34.40	-1.045
Working Memory	26.78	37.39	-2.314*
Plan/Organize	29.17	34.92	-1.252
Organization of Materials	26.17	38.02	-2.588**

$^{*}p<.05$; $^{**}p\leq.01$

3.2. Summary Indexes

Upon analysis of the Behavioural Rating Index (BRI), Montessori participants had lower mean scores (*M*=18.53, *SD*= 3.65) than traditional participants (*M*= 19.74, *SD*= 3.95), a statistically significant difference *M*= -1.21, 95% CI [-3.13, .71], *t* (61) = -1.263, *p*= .844.

Looking at the Emotional Rating Index (ERI), ERI mean scores for Montessori participants (*M*= 23.36, *SD*= 4.37) and traditional participants (*M*= 23.90, *SD*= 5.51) were about the same and showed no statistical difference *M*= -.53, 95% CI [-3.04, 1.99], *t*= (61) = -.421, *p*= .055.

Analysis of the Cognitive Rating Index (CRI) showed that Montessori participants had lower mean scores (*M*= 52.13, *SD*= 8.51) than traditional participants (*M*= 56.26, *SD*=11.00), a statistically significant difference *M*= -4.13, 95% CI [-9.08, .81], *t* (61) = -1.67, *p*= .131.

Lastly, looking at the Global Executive Composite (GEC), GEC score assessment using a Mann-Whitney *U* test revealed that Montessori scores (*Mdn*= 91) and traditional scores (*Mdn*=95) did not display a statistically significantly different *U*= 402.5, *z*= -1.287, *p*= .198.

3.3. Executive Dysfunction

Each of the 63 responses was also evaluated for possible executive dysfunction. *T* scores for each response were evaluated, and tallies were made for each index concerning the preschool background. In general, children from non-Montessori backgrounds had higher occurrences of potential executive dysfunction (Table 5).

Table 5

Rate of possible executive dysfunction by preschool type (scores individual t scores over 60)

	Montessori	Traditional
Inhibit	2	6
Self-Monitor	4	5
Shift	6	8
Emotional Control	5	5
Initiate	7	10
Working Memory	4	7
Plan/Organize	5	10
Task-Monitor	11	11
Organization of Material	2	6

4. Discussion

This study used the BRIEF2 Parent Form to assess EF development and compared children of Montessori and non-Montessori preschool backgrounds to discover whether or not there was a difference in executive function development between the two groups based on parents' assessment of their child's behavior.

During the first step of the analysis, it was discovered that the mother's education level influenced working memory, planning/organizing, task monitoring, and organization of materials, which interestingly represents four of the five EFs categorized as the CRI of the BRIEF2 (Gioia et al., 2015). According to Gioia et al. (2015), "The CRI represents a child's ability to control and manage cognitive processes and problem solve effectively" (p 37).

Chinese mothers place greater emphasis on academic success (Rao et al., 2003) and are more involved in strategies to support their child's academic learning (Huntsinger & Jose 2009) as well as

display more involvement in their child's play with the goal of teaching (Liu et al., 2005). In addition, Chinese parents naturally scaffold for their children, especially mothers of higher education and mothers of higher educational levels who also practice parenting strategies that are more child-centered and based on current scientific childrearing theories (Sun & Rao, 2017). These parenting practices would positively influence a child's cognitive development, as can be seen in these results.

Father's education level also influenced the organization of materials. The involvement of Chinese fathers has also changed in recent years due to the influence of Western ideas of parenting, and Chinese "fathers are more engaged with young children than in the past" (Sun & Rao, 2017, p 17), which is a good sign as fathers' parenting styles influence EF development (Meuwissen & Carlson, 2015). This trend is also reflected in this research that shows the effect of a father's education on the organization of materials. Fathers typically take on the role of "playmate," which would lead to engagement in games or activities that would positively influence children's development of the organization of materials. Higher-educated fathers would more likely be aware of the importance of their role toward their children and make an effort to take action (Sun & Rao, 2017).

Looking at differences in EF development between preschool types, the main focus of this research, of the eight evaluated EFs, only working memory and organization of materials showed statistically significantly better scores for children of Montessori backgrounds, while the remaining six assessed, having better mean scores overall, were of no statistical significance.

Working memory and organization of materials are two EFs used in the Montessori classroom daily as activities exercising these skills happen throughout the day. For example, after learning numbers one to ten, children of four-and-a-half years old begin learning the decimal system and work with numbers into the thousands carrying out addition, subtraction, multiplication, and division. A precursor to the mathematic operations activities called "Collective Exercises" (or more colloquially, "the Bank Game") is the practice of forming these large numbers with beads (beads of thousands, hundreds, tens, and units) and number cards (also of thousands, hundreds, tens and units) to represent given quantities. This activity uses the child's working memory as the child is given a verbal number, then required to hold the number in mind while walking to the shelf to collect the corresponding beads and cards.

Organization of materials is also consistently exercised in the Montessori classroom. There is great emphasis placed in Montessori education on the *prepared environment*. Each activity placed on the shelf is arranged on an individual tray and has all the components necessary for completion. Materials are placed in a specific order on the tray to give clarity to the sequential steps of the activity, and each activity also has a specific clean-up order to follow and is shown to the child so that he or she can return the material as originally found, leaving it ready for the next child to use.

Both the BRI and CRI showed Montessori participants as having statistically significantly better scores (lower) than traditional participants. However, the ERI for Montessori and traditional preschools was almost the same, and the GEC scores, while Montessori backgrounds were lower, were not statistically significant. In Montessori classrooms, children are influenced by the environment to inhibit and self-monitor behavior as the rules instilled in the environment inherently develop self-control and inhibition. For example, in a Montessori classroom, children are not allowed to interrupt others working, are not allowed to touch activities on the shelf that they have not been taught and have to wait their turn, as there is only one of everything in the environment. These ingrained rules of a Montessori classroom are possible reasons why in this study, children who had attended Montessori preschool were rated as having better behavioral regulation, as seen in the BRI results.

Activities in the Montessori classroom also repeatedly flex and strengthen children's cognitive capabilities, which is why we see the CRI showing statistically better scores for Montessori children. Again, reasons may be found in the structure of the Montessori classroom as children are allowed to decide their activities (initiate), complete their activities (task-monitor, plan/organize), and activities are set out on the shelf in an organized manner for children to complete from start to finish on their own (plan/organize, working memory, organization of materials).

It can be seen from this study that children of a localized version of Montessori education had overall better EF development scores than their non-Montessori peers, although only a few showed statistical significances. When looking at individual *t* scores amongst the nine EF indexes, traditional preschool children, in general, had higher individual rates of possible executive dysfunction (scores of 60 or higher) than Montessori children (Table 5). These findings are noteworthy as research confirms the influence the environment has on brain development in the first six years of life (Families and Work Institute 1996), including home environments and preschool environments (Otero & Barker 2014).

The unique finding in this study is that in what can be considered an adapted version of Montessori education, when evaluated in elementary school, children of the Montessori preschool background had some better EF assessment results than that of non-Montessori background children, showing children of Montessori educational backgrounds in this study to have equal to and in some cases, a slight advantage in EF development than their non-Montessori peers.

5. Conclusion

Montessori education has been growing in mainland China since the late 1980s, but little remains known about the outcomes of children who have attended Montessori preschool in China. Addressing outcomes is necessary to prove the value and benefit of Montessori education. As the Chinese nation actively makes policies to improve and advance science-based preschool education methods (, Montessori education in China must show its value as a versatile and beneficial educational choice for preschool-aged children.

EF is recognized as an essential contributor to academic success and overall success throughout one's life, making it essential to prove Montessori education's benefit to EF development. The research presented here shows that children from Montessori preschool backgrounds at elementary age (six to eight years old) had better EF assessment scores than their non-Montessori peers, validating the Montessori program in this study as being beneficial to EF outcomes. This research serves as a start to promoting more studies on outcomes of Montessori education in mainland China and hopes to encourage more interest, not only in understanding the theory of Montessori education but to validate its benefits as an early childhood education method.

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