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Exploring the Associations among Chinese Kindergartners between Academic Achievement and Behavioral, Cognitive and Emotional Self-Regulation

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ABSTRACT

Research Findings: Self-regulation is an important determinant of children's developmental outcomes, but little research has explored its different facets simultaneously. This study aims to explore a sample of Chinese children's behavioral, cognitive and emotional self-regulation characteristics by examining their gender and age differences, associations with academic outcomes and the moderating effects of age and gender on these associations. Results show that girls outperformed boys in behavioral and emotional self-regulation and K2 children failed to show any advantages on behavioral and emotional self-regulation compared with K1 children. All facets of self-regulation associated with children's numeracy and literacy scores, while emotional self-regulation's contribution was negative; neither age nor gender moderated these associations. *Practice & Policy*: The study considers Chinese children's characteristics of self-regulation in terms of gender and age differences in the context of the broader literature. This study supports the contention that self-regulation may consist of different facets. Findings from this study also show the significance of self-regulation in preschoolers' academic outcomes and the complex nature of these facets when they function on academic achievement.

Introduction

It is widely evidenced that social functioning, physical and mental health, and educational and occupational attainment are primarily rooted in the early years (Robson et al., 2020). Therefore, most parents and educators endeavor to foster children's development and maximize their developmental outcomes. Self-regulation refers to the capacity to control behaviors, thoughts and emotions; it has been consistently considered to be a foundation of early childhood outcomes with the potential to affect children's life-long trajectories (McClelland et al., 2007, 2010; Montroy et al., 2016; Von Suchodoletz et al., 2013). Self-regulation is a complex, multi-component construct (Blair & Diamond, 2008). However, most previous studies have mainly investigated it as a domain-general ability or simply focused on one or two components (for more details see, Edossa et al., 2018). As a result, little is known about how the internal structures of self-regulation function on child development. Furthermore, children's self-regulation skills might vary by children's gender and age. Previous research has documented that girls typically outperform boys on self-regulation tasks and that the level of self-regulation increases with age (Duckworth & Seligman, 2006; Gestsdottir et al., 2014; Matthews et al., 2009; Ponitz et al., 2009). However, whether this pattern exists across all components of self-regulation remains unknown. Accordingly, this study attempts to contribute to the growing international research on self-regulation by investigating the characteristics of behavioral, cognitive, and emotional self-regulation on a sample of Chinese preschoolers and exploring the impacts of these constructs on early academic outcomes as well as the moderating effects of gender and age.

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Understanding the Constructs of Self-Regulation

Although the study of self-regulation has a long history and is a popular area of research (Burman et al., 2015; Howard et al., 2020), there is still little agreement on the structure of self-regulation, thus making it difficult to conceptualize and leads to inconsistent findings (Hubert et al., 2017). Some researchers regard self-regulation as a domain-general ability without differentiating its components. For example, Raffaelli et al. (2005) measured children's levels of emotional, behavioral and cognitive regulation skills. They found that a single-factor model of self-regulation is sufficient due to the high factor correlations among these aspects. Under this perspective, researchers have attempted to integrate the behavioral and cognitive aspects of self-regulation and have sometimes overlooked the emotional aspects by defining self-regulation as the behavioral execution and manifestation of cognitive self-regulation in over behaviors (e.g., Day et al., 2015; Morrison et al., 2010; Weis et al., 2013). Arguably, a uni-dimensional approach to conceptualizing self-regulation overlooks its components' (i.e., behavioral, cognitive and emotional self-regulation) significant and unique contribution to the self-regulation process.

Some empirical studies have supported the multi-dimensional structure of self-regulation, including behavioral, cognitive, and emotional self-regulation – which are distinct constructs (Cicchetti & Tucker, 1994; Kalpidou et al., 2004; Shields et al., 1994). For example, after investigating various components of self-regulation in a longitudinal study involving 10,090 children, Hammer et al. (2015) found that the cognitive, emotional and behavioral aspects of self-regulation were related but had different developmental trajectories and functions. Cognitive self-regulation enables people to focus and shift attention, suppress undesirable reactions, and maintain and update information (Gunzenhauser & Saalbach, 2020). It allows individuals to eliminate task-irrelevant information in mind, resist distraction and impulses during goal attainment, and flexibly switch between different tasks and mental operations (Howard & Melhuish, 2017). Emotional self-regulation refers to the ability to monitor, control and adjust emotional reactions and expressions (Thompson, 1994). Behavioral self-regulation enables people to modify and inhibit behavioral impulses (Edossa et al., 2018). These three different self-regulatory systems inter-play with each other. Neuropsychological research has suggested the neural interconnections among the prefrontal cortex, frontal lobe, and limbic system in human brains function on behavioral, cognitive, and emotional self-regulation (Blair & Diamond, 2008; Jahromi & Stifter, 2008). Therefore, children who are predisposed to anger would be expected to be prone to adjustment and cognitive problems, which can influence classroom behaviors and academic performance – although the degree to which this is true depends on the interplay of multiple self-regulated systems across levels of function (Cicchetti & Tucker, 1994; Montroy et al., 2016). Considering this evidence, the current study adopts the multi-dimensional structure of self-regulation and aims to investigate its different components, including behavioral, cognitive and emotional self-regulation.

Self-Regulation and Academic Achievement

Unsurprisingly, there seems to be a robust relationship between self-regulation and both concurrent and later academic outcomes – such as math and literacy (Allan et al., 2014; Graziano et al., 2007; Howse et al., 2003). Furthermore, these different facets of self-regulation are associated with concurrent and later academic outcomes – such as math and literacy. The behavioral and cognitive aspects of self-regulation help children follow teachers' instructions, focus, monitor, and control their learning activities (McClelland et al., 2007). Meanwhile, emotional self-regulation promotes maintaining an optimal emotional arousal level needed for learning (Calkins, 1997; Graziano et al., 2007).

The mechanism of the association between emotional self-regulation and academic achievement is complex. It has been shown that advanced emotional regulation skills are associated with better educational outcomes (Sawyer et al., 2014). However, if children with extreme emotional lability can handle their severe reactions in an adaptive way, they may not be disadvantaged. For example,

Belsky et al. (2001) found toddlers with intense negative emotionality achieved greater school readiness (including letter knowledge, shape and color identification, and counting), but only when they had adequate attention skills. Morrison et al. (2010) also proposed higher levels of cognitive regulation, especially attentional flexibility, may regulate the effects of poor and unstable emotions – because strong attentional skills might be beneficial for children to direct their attention and overt behaviors. Studies have also found that emotional self-regulation can affect academic outcomes through several pathways – such as behavioral and cognitive self-regulation, student-teacher relationship, class participation and liking school (Diaz et al., 2017; Graziano et al., 2007; Valiente et al., 2007, 2008). For example, Trentacosta and Izard (2007) found children's emotional regulation in kindergarten predicted their attention skills in first grade, thus predicting their first-grade achievement. Similarly, Howse et al. (2003) showed that pre-school behavioral self-regulation mediated the contribution of emotional self-regulation to math and literacy outcomes in kindergartens.

Exploring Self-Regulation Skills under the Chinese Cultural Context

Socio-cultural context also influences the development of self-regulation. Vygotsky (1962) has suggested culture exerts an influence on both higher-order thinking and self-regulated behaviors. Each culture has distinct ways of solving problems and specific views on appropriate self-regulated behaviors (Bronson, 2000). Therefore, the value and standard of self-regulation may vary with the cultural context in which the individual is embedded (Chen, 2012).

Chinese culture historically emphasizes rigorous adherence to group norms and dedication to familial and social responsibilities (Chen & French, 2008). Accordingly, there is more collective teaching and group work than individual school activities (Pang & Richey, 2007). Children are required to follow the behaviors of others in the group, even if these behaviors contradict the more dominant responses (Wanless et al., 2011). Further, in individualistic societies that emphasize individuality and autonomy, children are encouraged to express their emotions. In contrast, children in collectivistic cultures such as China are socialized to control their emotional expressions to maintain group harmony (Cole et al., 2006). Given these characteristics, self-regulation may have different implied standards in the Chinese culture context.

Accordingly, the developmental patterns of self-regulation skills among Chinese children differ from those among Western children. For example, Chinese children show better performance on inhibitory control tasks than their British and US counterparts of the same age (Sabbagh et al., 2006). Extending on Sabbagh et al.'s (2006) study, Lan et al. (2011) compared Chinese and American preschoolers' performance on a comprehensive battery of EF tasks, including attentional and inhibitory control and working memory, and their associations with academic outcomes. They found that Chinese preschoolers performed better on inhibitory control tasks than American preschoolers and that the associations were similar in both countries. Lan et al.'s (2011) research design and findings also enlighten our thoughts to explore the uniquely contributions from different aspects of self-regulation on academic outcomes.

Although Western early childhood education curricula have been designed to foster the development of self-regulation, Chinese children's self-regulation is likely to be promoted more directly than their counterparts in the West. For example, Chinese children often receive intensive authoritative instructions in regular classroom practices, such as inhibiting behaviors and controlling attention (Lan et al., 2011). Lan et al. (2009) has documented Chinese teachers tend to give substantially more proactive instructions (e.g., "do something properly," "avoid doing something," and "sit quietly"). Conversely, Western teachers value free choice and self-expression, and are more likely to give reactive instructions when students misbehave (Chen et al., 2011; Lan et al., 2011). Although the original intention of such instructions is to teach children to obey the classroom rules, these instructions are also considered unintentional training of inhibition and attention skills, thus leading to higher performance on these tasks.

The Present Study

Even though the significance of self-regulation is widely accepted, most studies have failed to explore all its facets. As suggested by Howard and Melhuish (2017), 2020), self-regulation can take place in several forms, including behavioral, cognitive and emotional; however, only a limited number of researchers have explored these three aspects simultaneously. For example, although Jahromi and Stifter (2008) adopted a comprehensive battery of task-based measures to assess children's behavioral, cognitive and emotional self-regulation, they examined only the correlations among these aspects of self-regulation and their predictability of the understanding of false belief. Further, Howard et al. (2020) assessed children's behavioral, cognitive, and emotional self-regulation using the Child Self-Regulation and Behavior Questionnaire (CSBQ; Howard & Melhuish, 2017). But they averaged the scores for each subscale to achieve a single self-regulation index and reduce the number of analyses performed.

As mentioned before, girls and older children may exhibit better self-regulation skills, however, there has been limited evidence whether these characteristics emerge in all aspects of self-regulation and among Chinese children. Further, although research has provided preliminary evidence regarding the association between self-regulation and academic achievement among Chinese samples (Eisenberg et al., 2007; Liu et al., 2018; Zhou et al., 2009), there is still ambiguity regarding the role of different facets of self-regulation and the moderating effects of gender and age on that associations have often been overlooked. In addition, the characteristics of Chinese children's self-regulation might be worth exploring due to the unique cultural values and norms.

To summarize, by recruiting children from mainland China, the current study aims to investigate the characteristics of Chinese children's behavioral-, cognitive- and emotional self-regulation, their associations with early academic outcomes, and the possible moderators of these associations, as guided by the following research questions:

(i) What are the characteristics of Chinese kindergarten children's behavioral, cognitive and emotional self-regulation? Are there any gender or age differences in these aspects of self-regulation?
(ii) Do behavioral, cognitive, and emotional aspects of self-regulation predict academic outcomes? If they do, do age and gender moderate these associations?

In terms of RQ1, in the light of the findings that girls typically show better self-regulation skills than boys (Von Suchodoletz et al., 2013; Weis et al., 2013) and girls exhibit less behavioral and emotional problems (Blair & Diamond, 2008; Veijalainen et al., 2019), it can be expected Chinese girls will outperform boys at least on the behavioral and emotional aspects of self-regulation. Further, given the robust evidence regarding the association between age and self-regulation skills, the study hypothesizes that the older group will show better self-regulation skills than the younger group. In terms of RQ2, as previous studies have consistently documented self-regulation's strong predictability of academic outcomes, the present study hypothesizes that self-regulation significantly contributes to Chinese preschoolers' math as well as literacy scores, even after statistically controlling for age and gender. Finally, the study hypothesizes that gender and age play moderating roles in the associations among these aspects of self-regulation and academic outcomes, given that girls and older children tend to own better self-regulation skills than boys and younger children.

Methodology

Participants

The sample was drawn from 24 kindergartens with different service types and service classifications from six districts, which can represent low-, middle-, and upper-middle levels of socioeconomic development in Shenzhen, China. Kindergartens refer to the early years institutions, serving three to six years old children (Li et al., 2016). Twelve K1 children and twelve K2 children were randomly selected from each kindergarten with an equal number in gender. In mainland China, K1 refers to the

first stage or 1st grade of the kindergartens. It serves for children between 3 and 4 years old; K2 refers to the second stage or 2nd grade and usually enrolls children from 4 to 5 years old. In total, 576 Chinese children (M = 49.39 months, SD = 6.70 months, range = 35–69 months; 286 girls, 290 boys; 288 K1 children, 288 K2 children) were recruited.

Procedures

The measurement consists of two parts: teacher-report questionnaires about children's different aspects of self-regulation skills and direct assessment of children's emergent numeracy and literacy skills. Before the direct assessment, the consent forms were collected from parents. Research assistants who were undergraduates or postgraduates majoring in early childhood education or related areas were recruited to do the assessments. They received two days of online workshop. To ensure the inter-rater reliability, the first author paired with a senior assessor to do the child assessment at the first stage. After they got the 100% of exactly the same scores at each item level, the senior assessor started paired with other research assistants. After all of the research assistants got the 100% of exactly the same scores as the senior assessor, they started to assess child development individually. All of the children received the assessment in a big classroom in their own kindergartens.

Measures

The current study adopted the Child Self-Regulation and Behavior Questionnaire (CSBQ; Howard & Melhuish, 2017) to measure children's self-regulation. It includes 34 teacher-report items and seven subscales, including behavioral Self-Regulation, Cognitive Self-Regulation, Emotional Self-Regulation, Internalizing Problems, Externalizing Problems, Prosocial, and Sociability. Each item asks the respondent to evaluate the general frequency of target behaviors on a 5-point Likert scale from 1 (not true) to 5 (certainly true). Howard and Melhuish (2017), 2020) examined the reliability of the CSBQ with the Alpha values ranging from .83 to .89 and from .79 to 89. Howard and Melhuish (2017) also demonstrated that the CSBQ showed good convergent validity with other adult-report measures, such as the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997). In the current study, only the three self-regulation subscales of the CSBQ were used.

Behavioral self-regulation was assessed via six items, such as "regularly unable to sustain attention" and "waits their turn in activities." Two items were reversely coded, and the behavioral self-regulation index was the average of these six items. The construct of behavioral self-regulation showed good reliability (Cronbach's alpha = .837).

Cognitive self-regulation was measured by five items, for example, "persists with difficult tasks" and "chooses activities on their own." There were no reversed-coded items within this subscale, and, similarly, a single cognitive self-regulation index was generated by averaging the five items. The construct of cognitive self-regulation showed good reliability (Cronbach's alpha = .864).

Emotional self-regulation was measured by six items, for example, "is calm and easy-going" and "gets over being upset quickly." There were four reversed-coded items in this subscale, and a single emotional self-regulation index was generated by averaging the six items. The construct of emotional self-regulation showed acceptable reliability (Cronbach's alpha = .723).

The current study also utilized the International Development Early Learning Assessment (IDELA; Save the Children, 2011) to assess children's numeracy and literacy outcomes. The IDELA is a tool for measuring early child development and school readiness. It includes 22 subtasks spanning four developmental domains: motor skills, emergent literacy, emergent numeracy, and social-emotional development. Most items are scored as correct or incorrect, but a few are scored as ordered-categorical, with higher numbers indicating better performance. Previous studies in low- and middle-income countries, including Ethiopia, Afghanistan, Bolivia, Uganda, and Vietnam, support a four-factor model of the IDELA, indicating good construct validity (Halpin et al., 2019; Wolf et al., 2017). Pisani et al. (2015, 2018) have also provided evidence regarding the reliability, concurrent validity and

internal consistency of the IDELA. The IDELA has also been revised and used in China in which researchers evaluated the development and learning performance of 142 children from five areas and showed good reliabity and validity (Save the Children International China Country Office, 2016).

Emergent numeracy in IDELA consists of 40 items via seven subtasks that reflect the child's measurement and comparison, classification/sorting, shape identification, number identification, one-to-one correspondence, simple operations and puzzle completion. All subtasks are scored as correct or incorrect, except for the puzzle completion subtask, measured by children's level of completion, persistence and engagement during the puzzle task. This scale showed good validity by confirmatory factor analysis (RMSEA = .0592, CFI = .979, TLI = .969) and good reliability (Cronbach's alpha = .831).

Emergent literacy in IDELA consists of 35 items via six subtasks that assess the child's expressive vocabulary, print awareness, characters identification, phonological awareness, emergent writing and listening comprehension. Print awareness, character identification, phonological awareness, and listening comprehension subtasks are scored as correct or incorrect. Expressive vocabulary and emergent writing subtasks are marked based on the number of foods and animals the child can think of, and the quality of writing, respectively. The scale showed good validity by comfirmatory factor analysis (RMSEA = .0494, CFI = .969, TLI = .949) and acceptable reliability (Cronbach's alpha = .70).

Data Analysis

To investigate the characteristics, specifically the gender and age differences of these aspects of self-regulation, a two-way MANOVA test was performed with gender and age group (K1 and K2 grade) as between-subjects factors. The dependent variables were behavioral, cognitive and emotional self-regulation. Associations among the three aspects of self-regulation, numeracy and literacy were analyzed in two separate hierarchical regression models. Control variables, including age and gender, were entered into the first block; and the three aspects of self-regulation were entered into the second block. To test the moderating effects of age and gender on these associations, a further two models were constructed. The control variables were again entered into the first block, followed by behavioral, cognitive and emotional self-regulation in the second block. Three age-related and three gender-related interaction terms (i.e., Behavioral Self-Regulation*Age in Months, Cognitive Self-Regulation*Age in Months and Emotional Self-Regulation*Age in Months; Behavioral Self-Regulation*Gender, Cognitive Self-Regulation*Gender and Emotional Self-Regulation*Gender) were derived by computing standardized z-scores to center the data and multiplying the z-scores for the two variables (Aiken & West, 1991). These interaction terms were then entered in the third block to investigate the moderating effects of age and gender on the associations among different aspects of self-regulation, numeracy and literacy. All analyses were carried out using IBM SPSS 27.

Results

Table 1 displays the mean, standard deviations, range, skewness and kurtosis for all variables. Table 2 shows the Pearson correlation coefficients. Behavioral, cognitive and emotional self-regulation were all moderately associated with numeracy and literacy scores, with magnitudes ranging from .10 to .30 and from .13 to .30, respectively. Gender was linked to behavioral ($r = -.15$, $p < .001$) and emotional self-regulation ($r = -.14$, $p < .001$) but not with cognitive self-regulation and any academic outcomes (all $p > .05$). Age was correlated with numeracy scores ($r = .63$, $p < .001$), literacy scores ($r = .55$, $p < .001$) and the cognitive aspects of self-regulation ($r = .18$, $p < .001$). The three aspects of self-regulation were highly correlated (r range from .52 to .68, all $p < .001$).

Characteristics of Self-Regulation

A two-way MANOVA analysis was conducted to explore the possible effects of gender and age group on different aspects of self-regulation. As shown in Table 3, girls achieved significantly higher scores on behavioral ($F_{[1,\ 572]} = 13.82$, $p < .001$, partial $\eta^2 = .02$) and emotional self-regulation ($F_{(1,\ 572)} = 11.74$,

Table 1. Descriptive statistics for study variables

Variable	N	Range	Mean	Std. Deviation	Skewness (SE)	Kurtosis (SE)
Gender	576	1–2	1.50	.50		
Age (months)	576	35–69	49.39	6.60	.03 (.10)	−.93 (.20)
BehSR	576	1.17–5.00	4.01	.74	−.82 (.10)	.52 (.20)
CogSR	576	1.20–5.00	3.76	.76	−.37 (.10)	−.21 (.20)
EmoSR	576	1.67–5.00	4.06	.64	−.70 (.10)	.44 (.20)
Numeracy	576	.05–1.00	.56	.21	.08 (.10)	−.89 (.20)
Literacy	576	.00–1.00	.48	.19	.18 (.10)	−.59 (.20)

Note. SE = standard error. Gender: 1 = girl, 2 = boy. BehSR = behavioral self-regulation. CogSR = cognitive self-regulation. EmoSR = emotional self-regulation.

Table 2. Zero-order correlations of study variables

Variables	1	2	3	4	5	6	7
1. Gender	-						
2. Age	.03	-					
3. BehSR	−.15***	.07	-				
4. CogSr	−.03	.18***	.60***	-			
5. EmoSR	−.14***	.07	.68***	.52***	-		
6. Numeracy	.06	.63***	.20***	.30***	.10*	-	
7. Literacy	−.02	.55***	.23***	.30***	.13**	.72***	-

Note. *$p < .05$; **$p < .01$; ***$p < .001$.

Table 3. Comparisons of behavioral, cognitive and emotional self-regulation scores between girls and boys and between K1 and K2 age group

	BehSR	CogSR	EmoSR
	M (*SD*)	M (*SD*)	M (*SD*)
Girls (n = 286)	4.13 (.65)	3.78 (.75)	4.15 (.61)
Boy (n = 290)	3.90 (.81)	3.74 (.77)	3.97 (.65)
F statistics	13.82***	.47	11.74***
Partial η2	.02	-	.02
K1 age group (n = 288)	4.00 (.72)	3.70 (.73)	4.05 (.66)
K2 age group (n = 288)	4.03 (.77)	3.83 (.78)	4.07 (.61)
F statistics	.34	4.72*	.26
Partial η2	-	.01	-

Note. BehSR = behavioral self-regulation. CogSR = cognitive self-regulation. EmoSR = emotional self-regulation.*$p < .05$; **$p < .01$; ***$p < .001$.

$p < .001$, partial $\eta^2 = .02$) than boys, while the gender difference on cognitive self-regulation was not significant. In addition, K2 children achieved significantly higher scores on cognitive regulation than their K1 counterparts ($F_{[1, 572]} = 4.72$, $p < .05$, partial $\eta^2 = .01$). The differences between K2 and K1 children's behavioral and emotional self-regulation scores were not significant.

In terms of behavioral self-regulation, there was a significant interaction effect between gender and age group ($F_{[1, 572]} = 4.70$, $p < .05$, partial $\eta^2 = .01$). To investigate this interaction, an analysis of simple main effects was conducted. There was a significant effect of gender for the analysis on the K2 age group ($F_{[1, 286]} = 16.67$, $p < .001$, partial η2 = .06) – with K2 girls receiving higher scores of behavioral self-regulation than K2 boys. The data were then split by gender, and the effect of the age group was examined. An ANOVA with age group as a between-subjects factor revealed there was a significant effect of the age group for girls ($F_{[1, 284]} = 4.78$, $p < .05$, partial η2 = .02) – with K2 girls receiving higher scores than K1 girls.

Associations of Different Aspects of Self-Regulation with Academic Outcomes

The first regression analysis addressed whether different aspects of self-regulation are significantly and uniquely associated with numeracy outcomes. As shown in Table 4, gender did not predict numeracy scores in the first step of the model ($p > .05$) and remained a non-significant predictor in the final

Table 4. Hierarchical regression explaining numeracy from behavioral, cognitive and emotional self-regulation

	R^2	ΔR^2	$\Delta F_{(df1,\ df2)}$	Final *B*	*SE*	Final β
Block 1	.40	.40	189.86 $_{(2,\ 573)}$***			
Gender				.02	.01	.05
Age				.02	.00	.60***
Block 2	.45	.05	16.23 $_{(3,\ 570)}$***			
BehSR				.04	.01	.14**
CogSR				.05	.01	.17***
EmoSR				−.04	.01	−.11**

Note. **$p < .01$; ***$p < .001$.

Table 5. Hierarchical regression explaining literacy from behavioral, cognitive and emotional self-regulation

	R^2	ΔR^2	$\Delta F_{(df1,\ df2)}$	Final *B*	*SE*	Final β
Block 1	.30	.30	125.23 $_{(2,\ 573)}$***			
Gender				−.01	.01	−.02
Age				.02	.00	.52***
Block 2	.36	.05	15.34 $_{(3,\ 570)}$***			
BehSR				.04	.01	.16**
CogSR				.04	.01	.16***
EmoSR				−.03	.01	−.10*

Note. *$p < .05$; **$p < .01$; ***$p < .001$.

model for numeracy scores ($p > .05$). Age, however, was a significant predictor in both the first step of the model (β = 63, $p < .001$) and the final mode (β = 60, $p < .001$) for numeracy scores. Following entry of age and gender, the predictive role of behavioral, cognitive and emotional aspects of self-regulation were examined. All three aspects were uniquely and significantly associated with numeracy scores and altogether contributed an additional 5% of variance to children's numeracy scores after the effects of gender and age were statistically controlled ($\Delta F_{[3,\ 570]} = 16.23$, $p < .001$). Cognitive self-regulation was the strongest predictor of numeracy (β = .17, p < .001), followed by behavioral self-regulation (β = .14, $p < .01$) and emotional self-regulation (β = −.11, $p < .01$).

The second regression analysis addressed whether the different aspects of self-regulation are significantly and uniquely associated with literacy outcomes. Table 5 shows the results of the second regression model. Similar to the predictive pattern of numeracy, gender did not predict literacy scores in the first step of the model ($p > .05$) and remained a non-significant predictor in the final model ($p > .05$) for literacy scores. Instead, age was a significant predictor in both the first step of the model (β = .55, $p < .001$) and the final model (β = .52, $p < .001$). All three aspects of self-regulation were uniquely and significantly associated with literacy scores and altogether contributed an additional 5% of variance to children's literacy scores after the effects of gender and age were statistically controlled, ($\Delta F_{[3,\ 570]} = 15.34$, $p < .001$). Cognitive (β = .16, $p < .001$) and behavioral self-regulation (β = .16, $p < .01$) were the strongest predictors, followed by emotional self-regulation (β = −.10, $p < .05$).

Moderating Effects of Age and Gender

A further four hierarchical regression models were then conducted to determine whether age and gender interacted with the associations among any aspect of self-regulation, numeracy, and literacy. As shown in Table 6 and 7, none of the interaction terms were significant in any models (all $p > .05$), suggesting the associations among behavioral, cognitive and emotional self-regulation, and numeracy and literacy were consistent across different ages groups and gender.

Table 6. Moderation analysis of age and gender on the associations between self-regulation and numeracy

	R^2	ΔR^2	$\Delta F_{(df1,\ df2)}$	Final *B*	*SE*	Final β
Block 1	.40	.40	189.86 $_{(2,\ 573)}$***			
Gender				.02	.01	.06
Age				.02	.00	.60***
Block 2	.45	.05	16.23 $_{(3,\ 570)}$***			
BehSR				.04	.01	.13**
CogSR				.05	.01	.17***
EmoSR				−.04	.02	−.11*
Block 3	.36	.00	.61 $_{(6,\ 564)}$			
BehSR*AgeMonth				− .00	.01	.02
CogSr*AgeMonth				.01	.01	.06
EmoSR*AgeMonth				−.01	.01	−.02
BehSR*Gender				.00	.01	.02
CogSR*Gender				.00	.01	.02
EmoSR*Gender				−.01	.01	−.04

Table 7. Moderation analysis of age and gender on the association between self-regulation and literacy

	R^2	ΔR^2	$\Delta F_{(df1,\ df2)}$	Final *B*	*SE*	Final β
Block 1	.30	.30	125.23 $_{(2,\ 573)}$***			
Gender				−.01	.01	−.01
Age				.02	.00	.52***
Block 2	.36	.05	15.34 $_{(3,\ 570)}$***			
BehSR				.04	.01	.16**
CogSR				.04	.01	.16***
EmoSR				−.03	.01	−.10
Block 3	.36	.00	.52 $_{(6,\ 564)}$			
BehSR*AgeMonth				−.00	.01	−.02
CogSr*AgeMonth				.01	.01	.06
EmoSR*AgeMonth				−.00	.01	−.01
BehSR*Gender				.00	.01	.01
CogSR*Gender				.00	.01	.02
EmoSR*Gender				−.00	.01	−.01

Discussion

Characteristics of Self-Regulation

The Gender Differences on Behavioral and Emotional Self-regulation

The findings indicated that girls received significantly higher scores on behavioral and emotional self-regulation than boys, while there was no significant difference in cognitive self-regulation. These results extended previous *research findings* – which suggest girls outperformed boys in teachers' ratings of a single construct of self-regulation among Western children (Von Suchodoletz et al., 2013; Weis et al., 2013) – by suggesting any girls' advantage may mainly exist in the behavioral and emotional aspects among Chinese children. In other words, Chinese girls may own better behavioral and emotional self-regulation skills than boys, and therefore, girls are less likely to exhibit behavioral and emotional problems. Such finding is as expected because boys typically exhibit more behavioral and emotional problems than girls when they come to school (Veijalainen et al., 2019).

Research typically employed two approaches to interpretating gender differences in early developmental outcomes. First, from a social perspective, teachers may hold different behavioral and emotional expectations for boys and girls (Beaman et al., 2006). Such expectations define the behaviors and emotions seen as gender appropriate within specific cultural background. It has also been suggested that girls and boys tend to be socialized differently at home and at school (Coyne et al., 2015). For example, girls may receive more attention and they spend more time with adults, which stimulates their self-regulation skills to a higher degree (Weinberg et al., 1999). Second, these gender differences may be due to the genetic differences, such as the sexual dimorphisms within the mesocorticolimbic

dopamine pathway and sex hormones (Hosseini-Kamkar & Morton, 2014; Lenroot et al., 2007). Under this perspective, boys have higher levels of arousal than girls and they present a lower capacity for language and behavioral control in early years (Zahn-Waxler et al., 2008).

On investigating the interaction effect of gender*age group on behavioral self-regulation, the study found that girls' advantages only emerged in the K2 age group. Furthermore, we also examined whether the gender differences in emotional self-regulation also emerged in different age groups. Similarly, only K2 girls showed advantages of emotional self-regulation compared with K2 boys, while K1 girls did not. These may suggest that gender differences in behavioral and emotional self-regulation may not be static and fixed traits in individuals (Sanchis-Sanchis et al., 2020). An investigation targeting adolescents also found that gender differences in self-regulation existed in primary school, but disappeared during young adulthood (Vukman & Licardo, 2010). Neuroimaging studies have suggested that there are significant gender differences in the development of brain regions that are implicated in self-regulation, such as the frontal and temporal lobes (Cowell et al., 1994; Raznahan et al., 2010). Given relatively fewer research has explored gender differences in different aspects of self-regulation, there is a need for future longitudinal research to investigate the development of self-regulation between and within gender.

The Age Differences on Cognitive Self-regulation

When comparing the scores of different facets of self-regulation between the K1 and K2 age group, the study found K2 children were given higher teachers' ratings of cognitive self-regulation than K1 children. At the same time, there was no significant difference regarding behavioral or emotional self-regulation. Furthermore, the study found age was not significantly associated with either behavioral or emotional self-regulation, and had only small-sized correlations with cognitive self-regulation. Given it is generally assumed that older children own better self-regulation skills than younger children (Demetriou, 2000), such findings are intriguing. One possible explanation of K1 and K2 children's similar performance may be the specific characteristics of Chinese pre-school classrooms. For example, Chinese teachers often give direct instruction to regulate children's behaviors and emotions, such as: "you should not express high-arousal positive emotions" (Davis et al., 2012), "you should not speak in the classroom without raising your hand" and "you should not eat until everyone gets their meal" (Wanless et al., 2011). Children's self-regulation might develop unintentionally and rapidly under these instructions, particularly their behavioral and emotional regulation.

It is reasonable, therefore, to assume that Chinese K1 and K2 children's behavioral and emotional self-regulation is less influenced by their current ages, and more by their experiences of authoritative parenting and teaching styles (Grolnick & Ryan, 1989; Shen et al., 2018). Furthermore, several longitudinal studies have shown the growth of behavioral and emotional self-regulation is non-linear – with rapid gains in early years, followed by a decelerating rate of gain in performance (Montroy et al., 2016). Although such rapid growth often occurs during early childhood (Kopp, 1982), Chinese children may develop behavioral and emotional self-regulation skills earlier due to the Chinese teaching and parenting styles. On the other hand, children's ages still influence their cognitive self-regulation skills because self-regulation may come in different forms at different developmental stages. It has also been evidenced children generally progress from reactive or co-regulated behaviors and emotional regulation to more advanced cognitive forms of self-regulation from the ages of three to seven, which require the integration of EFs and language skills (Kopp, 1982).

Associations between Self-Regulation and Academic Outcomes

Another aim of the current study is to investigate their associations with numeracy and literacy outcomes. The study revealed behavioral, cognitive and emotional self-regulation were all uniquely and significantly associated with numeracy and literacy scores, after controlling for age and gender. Thus, although the relationships among self-regulation and numeracy and literacy

have been well documented (Robson et al., 2020), this study extended previous research by examining different contributions of behavioral, cognitive, and emotional self-regulation to early academic outcomes.

Cognitive self-regulation emerged as the strongest predictor, followed by behavioral and emotional self-regulation in terms of numeracy. Previous research targeting populations from different educational systems has suggested the mathematical problem-solving process requires intensive cognitive and metacognitive strategies (Freeman-Green et al., 2015; Ng et al., 2015; Zhou et al., 2012), leading to the relatively greater predictability of cognitive self-regulation. However, although cognitive self-regulation is more important for mathematics than literacy performance (Allan et al., 2014;Author, Siraj et al., 2016), the current study revealed cognitive self-regulation may be important to a similar extent for both numeracy and literacy, as cognitive self-regulation has similar β values in numeracy and literacy regression models. Furthermore, behavioral self-regulation also predicted literacy scores, which had a similar predictive power as cognitive self-regulation, followed by emotional self-regulation.

The study also found standardized regression coefficients for emotional self-regulation were negative in the numeracy and literacy regression models, suggesting numeracy and literacy scores are expected to decrease when emotional self-regulation scores increase. Further, the emotional aspect had the weakest correlation with numeracy and literacy compared with the other two aspects. It might exist suppressor effect – while emotional self-regulation has a weak positive correlation with academic outcomes, once behavioral and cognitive self-regulation are taken into account, higher emotional self-regulation predicts lower academic outcomes. Emotional self-regulation acts as a kind of suppressor variable due to the significant simple r and the significant multiple regression β have opposite signs. Emotional self-regulation is positively correlated with academic outcomes by itself, but higher emotional self-regulation ratings predict lower academic scores in the model. Following the studies suggesting the complex nature of the association between emotional-self-regulation and academic achievement (Belsky et al., 2001; Trentacosta & Izard, 2007), the findings of the current study suggest there seems to be some interplay among these aspects of self-regulation functioning on academic outcomes.

Moderating Effects of Age and Gender on the Associations between Self-Regulation and Academic Outcomes

The study tested the moderating effects of age and gender on the associations among behavioral, cognitive and emotional self-regulation, and numeracy and literacy scores. In terms of age, the study found that although older children achieved higher scores on numeracy and literacy than younger children, the associations among different aspects of self-regulation and numeracy and literacy were similar across ages. Further, although girls outperformed boys in behavioral and emotional self-regulation, the relationships between each aspect of self-regulation and numeracy and literacy were similar across gender.

Limitations and Implications

Some limitations of the study should be noted. First, given that the provinces and cities in China have different levels of economic conditions and early childhood education quality (Hong et al., 2020), the result may represent other Chinese cities that share similar characteristics to Shenzhen, but it is unable to represent the self-regulation characteristics of all Chinese children. It is advisable to replicate this study with a more heterogeneous sample, including children from multiple geographic areas (rural and urban) in China, to provide a more generalizable findings of Chinese children's self-regulation. Second, although the CSBQ is a beneficial tool for capturing children's three aspects of self-regulation by a single measure, there might be discontinuities between reported perceptions and actual behaviors, which may influence the veracity and accuracy of results (Faulkner et al., 2014). Moreover, given children's self-

regulation was rated by their class teachers, different teachers may hold different interpretations and applications of the standards and criteria. Therefore, any further research should consider using a combination of task-based and report-based self-regulation measures. Third, the current study has limited categories and variables. For example, it did not control for the effects of intelligence and socioeconomic status – which are both strongly associated with self-regulation and academic achievement (Lengua et al., 2015; Raikes et al., 2007). Although previous studies have shown self-regulation predicts academic outcomes beyond the influence of intelligence and SES (Blair & Razza, 2007), this study may be the first to explore behavioral, cognitive and emotional self-regulation simultaneously – either in China or in Western countries. Therefore, it is necessary to see their contributions to academic outcomes after statistically controlling for influential demographic variables.

The current study has several theoretical and practical implications. First, it supports the contention that self-regulation may consist of different facets. Further research should include these three aspects to investigate children's self-regulation skills. Second, although it is well documented that girls show advantages on self-regulation (Von Suchodoletz et al., 2013; Weis et al., 2013), this study revealed that girls' advantages emerge mainly in the behavioral and emotional aspects. This is consistent with the findings that girls typically exhibit less behavioral and emotional problems (Blair & Diamond, 2008; Veijalainen et al., 2019). Considering the social and biological approaches to understanding gender differences, girls and boys should be targeted by self-regulation interventions with different emphasis and strategies. Third, we found that there is a similar level of behavioral and emotional self-regulation between K1 and K2 children. This may provide parents and educational practitioners with new insights into understanding the development of self-regulatory skills and how to optimally promote them. Finally, behavioral and cognitive self-regulation positively contributed to Chinese children's numeracy and literacy performance. In this regard, intervention programs could focus on these facets of self-regulation to facilitate children's learning outcomes. Although the emotional aspect was also associated with academic outcomes, its contribution was negative. Therefore, based on our findings, we cannot suggest that advanced emotional regulation skills are associated with better academic outcomes when behavioral and cognitive self-regulation were also considered. But we acknowledge that there may be some interplay among these aspects of self-regulation, deserving further investigations.

Conclusion

This study explored the characteristics of behavioral, cognitive and emotional self-regulation among Chinese preschoolers. It extended previous *research findings* that girls outperform boys in self-regulation and showed that girls' advantages emerge only in the behavioral and emotional aspects of self-regulation. In contrast with some other studies, older children do not show any more behavioral and emotional self-regulation than younger children. This may be specific to the Chinese culture context, as children's development of behavioral and emotional regulation is largely influenced by their experiences of parenting and teaching styles, while age plays an important role in the development of cognitive self-regulation. In addition, by examining the associations between different aspects of self-regulation and numeracy and literacy separately, the study found that behavioral, cognitive and emotional self-regulation were all significantly associated with numeracy and literacy scores, while emotional self-regulation's contribution was negative. These findings add to a growing literature that has investigated Chinese children's self-regulation characteristics and the role of different aspects of self-regulation in early academic outcomes.

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