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Parenting Styles and Children's Hot and Cool Self-Regulation: The Moderating Role of Parenting Stress

Jin Sun[1] · Xiaohui Xu[2] · Kerry Lee[3] · So Sum Chow[3] · Yushu Wang[3] · Li Zhang[4]

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Abstract

The development of self-regulation is influenced by children's experiences at home, with parenting styles and parenting stress being important contextual factors. However, little is known about how parenting styles and stress are related to the emotional (hot) and cognitive (cool) aspects of self-regulation. This study examined the relationships between different parenting styles (authoritative, authoritarian, and permissive) and children's performance on hot and cool self-regulation tasks and the role of parenting stress in moderating this relationship in Chinese households. The participants included 310 preschoolers (51% girls/49% boys; $M_{age}=4.96$ years; $SD=0.96$) enrolled in four kindergartens in Beijing, China. The hierarchical regression results showed that after controlling for demographic variables, the level of authoritative parenting positively predicted children's cognitive flexibility performance, while parenting stress moderated the relationship between authoritative parenting and children's inhibitory control performance. The positive association between authoritative parenting and children's inhibitory control was found only among children who experienced a lower level of parenting stress. Parenting styles were not associated with children's hot self-regulation or working memory performance. These findings provide nuanced evidence on the relationships between parents' parenting style, parenting stress, and children's performance on hot and cool self-regulation. The implications for parenting education and future studies are discussed.

Keywords Cool self-regulation · Hot self-regulation · Parenting styles · Parenting stress

Self-regulation (SR) is an individual's ability to regulate cognitive processes (cool SR) and processes that involve emotional or motivational arousal (hot SR) to achieve particular task goals (McClelland et al., 2010). It encompasses cognitive, social-emotional, and physiological skills and lays the foundation for children's learning and development (Skibbe et al., 2019). SR develops rapidly in early childhood (McClelland et al., 2010; Ursache et al., 2012) and is influenced by the combination of both biological and contextual variables (Zelazo et al., 2004). Family is one of the major contextual elements influencing the early development of SR (Grolnick & Farkas, 2002), but few studies have considered how parenting-related variables influence cool and hot aspects of SR. The present study explored the associations between different types of parenting styles and children's performance on hot and cool SR tasks; the potential moderating role of parenting stress was also examined.

Early Development of Self-Regulation: Hot Versus Cool

SR is a multidimensional construct, with researchers conducting SR studies using different paradigms, terminology, and methods. This study focuses on the ability to remember and use information, pay attention, and inhibit inappropriate responses (Ponitz et al., 2009). The regulation of thoughts and emotion-neutral behaviors is usually referred to as the cool aspect of SR. Cool SR is thought to be required when children (or adults) must solve abstract problems that are emotionally neutral (McClelland & Tominey, 2016) and includes the ability

✉ Xiaohui Xu
hui72@126.com

[1] Faculty of Education, University of Macau, Zhuhai, China

[2] School of Preschool Education, Capital Normal University, Beijing, China

[3] Department of Early Childhood Education, The Education University of Hong Kong, Ting Kok, Hong Kong

[4] Faculty of Education, East China Normal University, Shanghai, China

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to hold information in working memory, resist interference and distraction, and shift the focus of attention. Tasks that assess executive function (EF) are usually considered a measurement of cool SR, while cool SR captures a broader spectrum of regulatory capacities than individual EF components. Numerous studies have identified the crucial role of cool SR for academic achievement. Children's cool SR, as measured with the Head-Toes-Knees-Shoulders (HTKS) task, for example, has been found to be a predictor of early literacy skills (Lonigan et al., 2017), vocabulary, and mathematics performance (McClelland et al., 2007; Zhang and Rao, 2017). Components of EF, including working memory, inhibitory control, and cognitive flexibility, have been shown to predict children's early performance in mathematics (Bull & Lee, 2014), analytical reasoning (Simms et al., 2018), language and literacy (Purpura et al., 2017), school readiness (Pellicano et al., 2017), and social behaviors (Rohlf et al., 2018).

Hot SR is a "bottom-up," or automatic, regulatory skill used during activities related to impulse control, delay discounting, and risk-taking (McClelland & Tominey, 2016). Hot SR is related to motivational and emotional processes (Zelazo & Müeller, 2011) and is associated with behavioral problems (Murray & Kochanska, 2002). Children with higher levels of effortful control at age three have been found to externalize fewer problems, as reported by preschool teachers (Choe et al., 2014). However, children's hot SR as measured through adults' reports or direct assessments have been shown to predict children's academic learning in some studies (e.g., Valiente et al., 2011), but not in others (e.g., Duncan et al., 2007).

The regulation of both cool and hot aspects of SR is required in most everyday situations. A holistic approach to understanding SR through integrated analyses of cool and hot aspects is therefore recommended (McClelland et al., 2010), but only a limited number of studies have done so. Sun and Kang (2022) compared the associations between children's cool and hot SR and early achievement in a sample of Chinese preschoolers. They found that hot and cool aspects of SR predicted children's achievement in different ways. Cool SR positively predicted performance in academic achievement, general knowledge, and gross and fine motor skills, whereas hot SR only positively predicted gross motor skills; both of them negatively predicted hyperactivity. In this study, we further examined the associations between children's hot and cold SR skills and parenting-related factors.

Parenting Styles and Children's SR

Parenting style refers to the patterns of parents' behaviors toward their children. Baumrind's (1971) model emphasized two aspects of parenting: warmth, responsiveness, or sensitivity, and degree of control. Different combinations or degrees of these aspects were classified as three distinct parenting styles: authoritarian, authoritative, and permissive. Authoritarian parents were characterized as having low warmth but high control; permissive parents as having high warmth but low control; and authoritative parents as having high warmth and high control.

Many studies have found that authoritative parenting supports children's ability to regulate their behaviors and emotions (e.g., Jabeen et al., 2013; Moilanen et al., 2015), such that children with authoritative parents are better adjusted to the environment. Similarly, Sosic-Vasic et al. (2017) found that children with authoritative parents were more likely than other children to exhibit lower error rates in the Erikson Flanker task, a task typically used to assess children's inhibitory control. In a longitudinal study, Moilanen et al. (2015) found that children with authoritarian parents had lower levels of behavioral, emotional, and cognitive SR than children with authoritative parents. Interestingly, lower SR also predicted a later increase in mothers' authoritarian parenting practices. Regarding the three components of EF, Cordero's (2018) found that an authoritative parenting style was positively associated with children's inhibitory control and cognitive flexibility but not with working memory. Vučković et al. (2021) found that children raised by authoritarian parents were more likely to exhibit difficulties with inhibitory control and working memory. Permissive parenting was also found to be negatively associated with children's SR. For example, parents' adoption of permissive parenting styles negatively impacted children's cognitive and emotional SR, which was in turn related to more adverse developmental outcomes (Almutairi, 2019; Moilanen et al., 2015; Sosic-Vasic et al., 2017).

Studies on the associations between different parenting styles and children's SR have documented the important role that parenting has in the early development of SR. However, they have usually focused only on parents' preferred parenting styles; that is, on which of the three styles receives the highest scores. This approach limits the findings to associations between particular parenting styles and SR and cannot address complexities involving the use of multiple parenting styles. In addition, most studies have only examined either the cool or the hot aspect of SR. The present study aimed to fill these gaps by considering the level of each type of parenting style exhibited and their relationship to both hot and cool SR.

Parenting Stress, Parenting Styles, and Children's SR

Parenting stress is typically defined as parents' feelings about the difficulties of being a parent (Abidin, 1995; Gao & Lee, 2021). Studies have established the relationship

between parenting stress and parenting styles and found that excessive parenting stress was related to fewer instances of positive parenting behaviors and more instances of negative behaviors. Fonseca et al. (2020), for example, found that highly stressed parents were less likely to adopt authoritative parenting approaches and relied more on authoritarian or permissive parenting practices. Mak et al. (2020) also found that parenting stress was associated with less active parental involvement and lower levels of warmth.

In the literature on parenting stress and child development, parenting stress is primarily considered a risk factor for children's behavioral problems (e.g., Liu & Wang, 2015; Mackler et al., 2015). Neece et al. (2012) found a bidirectional relationship between parenting stress and children's behavioral problems across time for both mothers and fathers. In the family stress model (Conger et al., 2010), the family stress process that includes parenting stress is considered a major mechanism in determining how family economic hardship influences children's outcomes. Duran et al. (2020) examined how economic hardship can affect SR through the family stress process, and parenting stress was one element of that process. They found that family stress processes had cascading effects on children's HTKS task performance. Encinger et al. (2020) also found that parents' concerns about financial sufficiency influenced children's performance on hot SR tasks through parenting stress.

Nevertheless, few studies have demonstrated the interaction effects of parenting stress and parenting styles on children's SR performance. Parenting styles determine the quality of experiences that children have during parent–child interactions. As an index of dysfunctional family systems or nonoptional caregiving environments (Ostberg & Hagekull, 2000), parenting stress reflects multiple aspects of the family system (Tsotsi et al., 2019). Therefore, it would be meaningful to investigate whether parenting stress serves as a risk factor in the relationship between parenting styles and children's SR performance, including both hot and cool aspects.

Parenting and Early Development of SR in Chinese Contexts

Parenting practices and child development are shaped by broad social and cultural dynamics. In the popular book, *Battle Hymn of the Tiger Mother* by Amy Chua (2011), Chinese parents are described as intensively controlling their children's learning and casual activities to ensure their academic excellence. Chinese parents were also described as experiencing high levels of parenting stress. Such descriptions are consistent with findings showing that Chinese parents are more authoritarian and less authoritative than their Western counterparts (Chen & Luster, 2002), although both authoritative and authoritarian parenting are evident in Chinese approaches (Huang et al., 2017).

The Confucian culture that embraces academic excellence is considered a major factor driving Chinese parents' parenting styles. However, since China adopted an open-door policy in the 1980s, Western ideology that emphasizes children's autonomy has been increasingly recognized, especially by middle-class families. Studies found that Chinese parents asserted little power and were highly responsive in their interactions with their children (Sun & Rao, 2012). Although parents with a permissive style do exist in China (Chen et al., 2000), Chinese parents still hold high academic expectations for children and experience a high level of parenting stress (Gao & Lee, 2021). The long-lasting one-child policy, which was repealed in 2019, may also contributes to Chinese parents' excessive parenting stress, as they have only one chance to raise a successful child (Lin et al., 2022). In addition, the high costs related to raising a child in contemporary China (Kuan, 2015) and the peer pressure from tiger parents (Mocan & Yu, 2020) may further lead to high levels of parenting stress.

Due to the emphasis on interdependence, collectivism, and respect for authority, Chinese society values children who are modest, introverted, obedient, and cooperative (Rao et al, 2014). Children are expected to obey teachers' instructions, to be self-disciplined, and to control their impulses. Lan et al. (2011) found that American primary teachers provided reactive feedback to solicit children's reflections on their misbehaviors, but Chinese teachers tended to offer proactive instructions, such as how to do something properly or to avoid doing something. Both educational expectations and teachers' instructions facilitated children's control of their emotional and motivational impulses, which is related to the hot aspects of SR. Sun and Kang (2022) found that Chinese children exhibited a high level of hot SR as early as preschool, while the cool aspects of SR developed gradually as children grew up.

The Present Study

Against this background, it is meaningful to investigate how the cool and hot aspects of SR are influenced by parenting-related factors in the Chinese context. The present study examined the correlations between different types of parenting styles and children's performance on hot and cool SR tasks and further investigated whether parenting stress moderated these relationships. Given the previous findings regarding the positive relationship between authoritative parenting and SR (e.g., Moilanen et al., 2015; Sosic-Vasic et al., 2017) as well as the negative relationship between negative parenting and SR (e.g., Almutairi, 2019; Vučković et al., 2021), we hypothesized that authoritative parenting

would be positively associated with children's SR performance, while authoritarian and permissive parenting would be negatively associated with SR performance. We further hypothesized that parenting stress would moderate these associations as parenting stress was associated with both parents' parenting styles (Fonseca et al., 2020; Mak et al., 2020) and children's SR (Duran et al., 2020).

Methods

Participants

The sample consisted of 310 children from 310 families: 157 girls (51%) and 153 boys (49%). The children were recruited from four kindergartens in Beijing, China. Two of the kindergartens were located in urban Beijing ($n = 151$) and two were in suburban Beijing ($n = 159$). The participants ranged from 3.17 to 6.83 years old, with a mean age of 4.96 years ($SD = 0.95$). Around half (47.6%) of the children's mothers held a bachelor's degree or above, around one third (30.3%) had a middle- or secondary-school degree, 20% had an associate degree, and the remaining 2.3% only had a primary school education.

Variables and Measures

Parenting Styles

Mothers' parenting styles were measured using the Parenting Styles and Dimensions Questionnaire/Short-Form (PSDQ/SF) (Robinson et al., 2001). The PSDQ/SF is a 32-item instrument for identifying parenting styles and has been validated in a Chinese context (Fu et al., 2013). Each item of the PSDQ/SF describes a parental behavior that is representative of authoritative (e.g., "Encourages child to talk about the child's troubles"; 15 items in total), authoritarian (e.g., "Slaps child when the child misbehaves"; 12 items in total), or permissive (e.g., "Gives into child when he/ she causes a commotion about something"; 5 items in total) parenting style. The internal consistency reliabilities for the three styles were as follows: $\alpha_{\text{Authoritative}} = 0.94$; $\alpha_{\text{Authoritarian}} = 0.92$; and $\alpha_{\text{Permissive}} = 0.73$. The mothers described their use of each style in terms of a 5-point scale (1 = Never, 5 = Always), with the total score for each type of parenting calculated and used in the analyses that follow.

Parenting Stress

Parenting stress was assessed using the Simplified Parenting Stress Index/Short Form (SPSI/SF) (Yeh et al., 2001). The SPSI/SF contains 15 items scored on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). It assesses three aspects of parenting stress: parental distress (e.g., "I feel trapped by my responsibilities as a parent"; 5 items in total), parent–child dysfunctional interaction (e.g., "My child doesn't seem to smile as much as most children"; 5 items in total), and difficult child (e.g., "My child gets upset easily over the smallest thing"; 5 items in total). The overall internal consistency reliability was 0.90. The total score of the parents' responses on the SPSI/SF was used in the analyses described below.

Children's SR

Six typical SR tasks that tapped either the hot or cool aspects of SR were used in this study. Five tasks examined the children's cool SR skills, including the HTKS task (inhibitory control), the Go/No-Go task (inhibitory control), the Not This task (working memory), the Mr. Ant task (working memory), and the Card Sort task (cognitive flexibility). The Go/No-Go, Not This, Card Sort, and Mr. Ant tasks were iPad-based tasks developed in the Early Years Toolbox (EYT, Howard & Melhuish, 2017). The hot SR skill (resistance to temptation) was assessed using the Gift Task. All of the tasks were conducted in kindergarten classrooms, and all of the children were assessed individually. The task sequence was counterbalanced.

Cool SR

HTKS The HTKS task measures children's inhibitory control (Ponitz et al., 2009). Similar to Sun and Kang (2022), a modified version of the HTKS was used in this study to overcome the possible ceiling effects of the original version, as detected in prior studies. In the first part (five trials), the children were instructed to touch their heads when told to "touch your toes," and vice versa. In the second part (five trials), the children were asked to touch their shoulders when told to touch your knees, and vice versa—in addition to the head–toe commands. The third part (six trials) was added to the first two parts, which were extracted from the original HTKS task. In this third part, the children were instructed to act oppositely only when the assessor started a sentence with, "teacher says." Otherwise, the children were to act as instructed. For example, upon the instruction, "teacher says, touch your head," children should have touched their toes; while they should have touched their head if the instruction were simply, "touch your head." The task stopped if the child consecutively failed five trials in each part. For each trial, the children earned 2 credits if they acted correctly and without self-correction, 1 credit if they acted correctly with self-correction, and 0 credits if they only acted incorrectly. The total score for the three sessions was used for further analyses. Following Sun and Kang (2022), the HTKS task was used to measure children's cool SR. The

Cronbach's alphas for the three sessions were 0.95, 0.96, and 0.92, respectively.

EYT EF Tasks: Go/No-Go, Not This, Mr. Ant, and Card Sort The four EF tasks included in the EYT collection were all included to capture the three EF components. The instruction language in the EYT app is English. Therefore, the assessor wrote down the instructions for each trial and gave the instructions verbally in Chinese while the iPads were muted. The app recorded the children's responses for each trial. Each correct response was given a score of 1, while incorrect responses were given a score of 0.

The *Go/No-Go* task taps children's inhibitory control. Fish and sharks were presented on the iPad screens and the children were instructed to tap the screens whenever a fish appeared to "catch a fish." When sharks appeared, the children were instructed to avoid them and not touch the screen. As most stimuli were Go trials (80% fish), this created a prepotent tendency to respond, requiring the participants to suppress this response on No-Go trials (20% sharks). An impulse control score indexed the children's ability to inhibit this tendency. The Go/No-Go task contained 75 trials ($\alpha = 0.92$). The total score on the Go/No-Go and the HTKS tasks were used to as an index of the children's inhibitory control.

The *Not This* task measures children's phonological working memory. In this task, the children were asked to perform according to increasingly complex auditory instructions. An example of a simple auditory instruction is, "Find a shape that is not blue," whereas a relatively complex instruction would be, "Find a shape that is not a circle." An example of the most complex instruction is, "Find a shape that is not small, not blue, and not a circle. Different shapes with cartoon expressions were presented on the iPads for each trial, and a total of 40 trials were completed ($\alpha = 0.81$). The total score achieved for the two working memory tasks was calculated as the index of each child's working memory.

The *Mr. Ant* Task taps visual-spatial working memory. A cartoon character, Mr. Ant, which has a number of colored stickers placed on different parts of its body, was presented on the iPad. The stickers disappeared after a preset amount of time, and the children were asked to recall the locations of these stickers by tapping the different parts of Mr. Ant's body on the screen. There was a total of 24 trials, and the internal consistency reliability was 0.78.

For the *Card Sort* task, the children were presented with cards that were different in two dimensions, either in shape (rabbit or boat) or color (blue or red), and were asked to sort each card by one dimension first and then the other. A total of 18 items were included in this task with a Cronbach's alpha of 0.90. Again, the total score was used as an index of the children's performance on cognitive flexibility. The children spent less than 30 min completing the iPad-based tests. More details of the EYT and its validation information can be found at: http://www.eytoolbox.com.

Hot SR

Gift Task This task integrated the Gift Delay and Forbidden Toy tasks (Carlson & Wang, 2007) to assess the children's resistance to temptation, a key aspect of hot SR, as described in Sun and Kang (2022). In the first part of this task, the children were asked to sit together with the assessor but were asked not to peek while the assessor noisily wrapped some gifts for them, which lasted 60 s. Latency to the first peek and the total number of peeks (reversed coded) were recorded. The peeking time was recorded as never turned around (2 credits), peeked over the shoulder for less than 30 s (1 credit), or peeked over the shoulder for more than 30 s (0 credit). The total number of the peeks was recorded as not peeked at all (2 credits), peeked over the shoulder once (1 credit), or peeked more than once (0 credit). In the second part, a wrapped gift was placed in front of each child and they were asked to wait another 60 s before touching the gift. The assessor pretended to read some notes while the children were waiting. The children's behaviors were coded as follows: waited quietly without touching the gift (3 credits), asked for permission to touch but did not do so when told it was not allowed (2 credits), touched the gift but did not take it away (1 credit), and took the gift away (0 credit). The total credits earned in the two parts were summed for the analyses.

Demographic Information

All parents were invited to complete a questionnaire on the demographic characteristics of their child and family, including their child's gender (1 = male; 0 = female) and age, the context of their residence (1 = urban, 0 = suburban), and the mother's highest education level (1 = primary school; 2 = junior secondary school; 3 = high school, vocational high school, or technical school; 4 = college diploma or associate degree; 5 = bachelor's degree; 6 = master's degree; 7 = doctoral degree). These variables were used as covariates.

Although the kindergartens were chosen for convenience, we tried to include kindergartens in both urban and suburban areas and schools that reflected the average quality of kindergarten programs in each area. Consent to participate in this study was obtained from both the school principals and the children's parents before data collection. Only children whose parents agreed to participate in the study were invited to the test sessions. All tasks were administered by seven postgraduate students who had majored in early childhood education and were trained in

task administration through a series of workshops. Several trial testing sessions were conducted with each assessor before the actual trials began. Each assessor had to achieve at least 80% scoring agreement with the second author of the training sessions, known as the golden standard. The second author observed and monitored the postgraduates' assessments in the training sessions and in some of the actual study trials to ensure the quality of data collected. The questionnaires were disseminated to parents after the child assessment sessions when they picked up their children at kindergarten. The homeroom teachers were responsible for collecting the finished questionnaires.

All data were analyzed using IBM SPSS Statistics version 27.0. First, a set of Pearson correlation analyses was conducted to explore the associations between all of the study variables. A hierarchical multiple regression was then used to examine how parenting styles predicted the hot and cool aspects of SR and whether parenting stress moderated such associations, while controlling for covariates. Upon the detection of significant moderating effects, simple slopes tests were conducted to reveal how parenting stress moderated the relationship between parenting styles and children's SR.

Results

Descriptive and Correlational Statistics

Table 1 shows the descriptive statistics and correlations among the variables considered in this study. There were significant correlations among the three parenting styles: authoritative parenting was negatively correlated with authoritarian ($r = -0.23$, $p < 0.001$) and permissive ($r = -0.17$, $p < 0.01$) styles, and authoritarian parenting was positively correlated with permissive parenting ($r = 0.73$, $p < 0.001$). The children's scores on cool and hot SR tasks were all significantly positively correlated ($r_s \geq 0.20$, $p < 0.01$). Parenting stress had a negative correlation with authoritative parenting ($r = -0.32$, $p < 0.001$), but a positive correlation with both authoritarian ($r = 0.66$, $p < 0.001$) and permissive parenting ($r = 0.59$, $p < 0.001$). Parenting stress was found to be negatively correlated with children's working memory ($r = -0.18$, $p < 0.01$) and cognitive flexibility ($r = -0.19$, $p < 0.01$), but not other skills. Authoritative parenting was significantly correlated with children's performance on all three cool SR aspects ($|r|_s \geq 0.18$, $p < 0.01$), but not on the hot SR task. Authoritarian parenting was only found to be negatively correlated with children's cognitive flexibility ($r = -0.13$, $p < 0.05$). Permissive parenting was not correlated with children's performance on either set of SR tasks.

Parenting Styles Predict Self-Regulation and the Moderating Role of Parenting Stress

Hierarchical linear regressions were conducted to examine how the three parenting styles predicted children's hot and cool SR performances, while controlling for the key demographic variables. Parents' authoritative parenting was found to significantly predict children's cognitive flexibility ($\beta = 0.13$, $p < 0.05$), and this was the only significant predictor detected (see Table 2). Parenting stress was also not a significant predictor of children's SR performances.

The interaction terms for each parenting style and parenting stress level were then added into the regression models, respectively. A significant moderating effect of parenting stress was found in the relationship between authoritative parenting and children's inhibitory control ($\beta = -0.73$, $p < 0.05$). The follow-up simple slopes analysis showed a significant difference between the slopes of children with low-stressed and high-stressed parents ($t = -2.35$, $p < 0.05$), which indicated that the relationship between authoritative parenting and children's inhibitory control depended on the level of parenting stress that parents experienced, although the main effects of authoritative parenting and parenting stress on children's inhibitory control were not detected. As shown in Fig. 1, the children of parents experiencing a low level of parenting stress were more likely to benefit from their parents' high level of authoritative parenting and performed better on inhibitory control than their counterparts.

Discussion

Authoritative Parenting in Early Development of SR

This study first examined how different parenting styles were associated with children's cool and hot aspects of SR. It was surprising to find that only authoritative parenting was found to significantly predict children's performance on cognitive flexibility (one component of cool SR). Authoritative parenting in conjunction with parenting stress was further found to predict children's inhibitory control skills.

It is the general consensus that early childhood is a key period for understanding the influences of parenting on SR, which is the product of both biological and contextual processes, including different parenting styles (Zelazo et al., 2004). Authoritative parenting is characterized by high acceptance, adaptive control, and appropriate granting of autonomy (Hart et al., 2003). With such support from the parents, children are able to explore their ideas and initiatives more freely and experience fewer behavioral restrictions than those with less authoritative parents. The supportive nature of authoritative parenting is essential for the formation of cognitive flexibility (Wu et al., 2021). This

Table 1 Descriptive statistics and correlations for study variables

Variable	*N*	*M* (*SD*)	1	2	3	4	5	6	7	8	9	10		
												a	b	c
1. Age (max = 6.83)	309	4.96 (0.95)	–											
2. Gender (0 = girl; 1 = boy)	310	0.49 (0.50)	.01	–										
3. Urbanicity (0 = rural; 1 = urban)	310	0.49 (0.50)	.45***	− .02	–									
4. Maternal education (max = 7)	310	4.15 (1.43)	.35***	.03	.73***	–								
5. Parenting stress (max = 75)	309	35.02 (9.85)	− .11	.01	− .37***	− .43***	–							
6. Authoritative parenting (max = 75)	309	60.15 (9.46)	.17***	− .04	.36***	.38***	− .32***	–						
7. Authoritarian parenting (max = 60)	309	23.98 (7.72)	.04	.07	− .20***	− .18**	.66***	− .23***	–					
8. Permissive parenting (max = 25)	309	11.46 (3.17)	.03	.10	− .12*	− .13*	.59***	− .17**	.73***	–				
9. Hot SR[a] (max = 7)	248	4.98 (1.96)	.33***	− .17 ***	− .04	− .02	.04	.02	.05	.03	–			
10. Cool SR														
a. Inhibitory control[b] (max = 107)	258	74.3 (18.77)	.77***	− .04	.36***	.31***	− .09	.18**	.05	.05	.32***	–		
b. Working memory[c] (max = 64)	252	14.29 (5.71)	.68***	.00	.37***	.32***	− .18**	.18**	− .06	− .01	.26***	.67***	–	
c. Cognitive flexibility[d] (max = 18)	261	12.52 (4.22)	.48***	− .04	.30***	.31***	− .19**	.27***	− .13*	− .09	.20**	.56***	.44***	–

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

Table 2 Hierarchical linear regressions of associations between parenting styles and parenting stress on children's SR

Variable	Hot SR				Cool SR: inhibitory control				Cool SR:working memory				Cool SR: cognitive flexibility			
	B	*SE*	*β*	R^2	*B*	*SE*	*β*	R^2	*B*	*SE*	*β*	R^2	*B*	*SE*	*β*	R^2
Step 1				.19***				.60***				.47***				.25***
Constant	1.21	.70			− 2.13	4.72			− 6.25	1.70			1.34	1.44		
Age	.93***	.13	.46***		15.26***	.90	.79***		3.95***	.32	.66***		1.92***	.27	.44***	
Gender	− .76***	.23	− .19***		− 2.39	1.50	− .06		− .19	.53	− .02		− .49	.46	− .06	
Urbanicity	− .99**	.36	− .25**		− 3.88	2.38	− .10		− .48	.87	− .04		− .57	.73	− .07	
Maternal education	− .02	.11	− .01		.96	.74	.08		.36	.27	.09		.55*	.23	.19*	
Step 2				.19***				.60***				.48***				.29***
Constant	1.04	1.17			− 6.04	7.62			− 4.41	2.67			− .36	2.28		
Age	.93***	.14	.46***		15.18***	.91	.79***		4.01***	.33	.68***		1.97***	.27	.45***	
Gender	− .76***	.23	− .19***		− 2.42	1.52	− .06		− .17	.54	− .02		− .33	.45	− .04	
Urbanicity	− .98**	.36	− .24**		− 4.04	2.42	− .11		− .73	.87	− .06		− .87	.72	− .10	
Maternal education	− .01	.12	.00		.81	.79	.06		.23	.28	.06		.43	.24	.15	
Parenting stress	.01	.02	.03		− .04	.11	− .02		− .06	.04	− .10		.00	.03	.00	
Authoritative parenting	.00	.01	.00		.07	.09	.03		.00	.03	.01		.06*	.03	.13*	
Authoritarian parenting	.00	.02	.00		.01	.16	.01		− .06	.06	− .08		− .06	.05	− .10	
Permissive parenting	− .01	.05	− .01		.18	.35	.03		.13	.12	.08		− .02	.11	− .01	

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

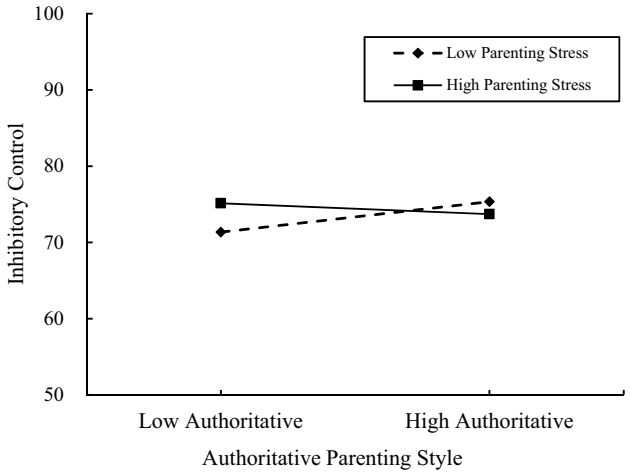

Fig. 1 The relationship between parenting stress, authoritative parenting, and children's inhibitory control

finding is also in line with prior studies that show a positive relationship between parents' positive parenting (e.g., warmth, responsiveness, and sensitivity) and children's EF (Valcan et al., 2018).

Authoritative parenting was not found to be associated with children's working memory, as indexed by visual-spatial and phonological working memory, or with hot SR, as measured by the Gift Task. Working memory is the ability to hold information temporarily for retrieval when needed. The enhancement of working memory capabilities might rely more on children's development and refinement of strategies for storing information (Alloway et al., 2006), rather than the supportive contextual process. Children's performance on hot SR tasks in this study showed a similar pattern to that of Sun and Kang (2022) when administering the same hot SR task with a group of Hong Kong preschoolers. Both studies showed that children had high levels of hot SR skills even at three years old. This was attributable to the behaviors explicitly required in family and preschool settings, such as being obedient and controlling impulses. We therefore considered that the Gift Task might not be sensitive enough to capture Chinese children's emotional and motivational regulation (Sun & Kang, 2022).

Authoritarian and permissive parenting styles were not associated with either cool or hot aspects of SR in this study, which was also partially in line with the inconclusive findings of previous studies on the relationship between negative parenting (featured in authoritarian and permissive parenting) and early SR. For example, the meta-analysis by Valcan et al. (2018) found that negative parental behaviors that feature in authoritarian and permissive parenting styles, such as control, intrusiveness, and detachment, had a significant negative association with children's EF—a cool aspect of SR in this study with an effect size of − 0.22. Similarly, the meta-analysis by Karreman et al. (2006) showed that parental control had a weak association with children's SR, while responsiveness and parenting control were not related to children's emotional regulation and inhibition. However, the review by Fay-Stammbach et al. (2014) pointed out that few studies have examined the association between the parental control/discipline featured in authoritarian parenting and EF and the results were mixed, with negative and null relationships.

Indeed, studies with Chinese samples have shown a similar pattern for the relationship between negative parenting and children's SR. With the China Family Panel Study data, a nationally representative household survey in China, Heimpel et al. (2018) found that parents' behavioral control featured in authoritarian parenting was unrelated to children's SR, but the perceived responsibility and responsiveness featured in authoritative parenting was related to children's SR. The null relationship between negative parenting (authoritarian and permissive) and children's SR found in this study might be due to the small variances in the prevalence of such parenting behaviors in our sample. Compared with the authoritative parenting practices ($M = 60.15$, out of 75, $SD = 9.46$), parents reported that they were less frequently engaged in either authoritarian ($M = 23.98$, out of 60, $SD = 7.72$) or permissive parenting ($M = 11.46$, out of 25, $SD = 3.17$). In addition, as both authoritarian and authoritative parenting styles are present in Chinese parenting (Chen & Luster, 2002), authoritarian parenting is well endorsed by both Chinese parents and children. As a result, its potentially negative influences on children's SR might be less evident than found in Western children. Further studies are needed to understand whether different parenting styles are associated with a wider range of child outcomes, beyond SR.

Parenting Stress, Parenting Styles, and SR

Authoritative parenting was found to predict children's inhibitory control, together with parenting stress, which reflects the complexity of the relationship between parenting and early development of SR. Although authoritative parenting is more strongly related to healthier and positive developmental outcomes than either authoritarian or permissive parenting (Williams et al., 2009), a lower level of parenting stress facilitates its positive influences on children's inhibitory control. This result supports the claim that parenting style and parenting stress are both essential elements in shaping children's development over time (Hutchison et al., 2016).

Correlational analyses showed that parenting stress was negatively associated with authoritative parenting, but positively associated with parents' authoritarian and permissive parenting. As suggested by de Cock et al. (2017), elevated parenting stress contributes to negative parenting behaviors

and reduced parental sensitivity, both of which are essential for a beneficial transactional process between the parent and the child.

In this study, a significant interaction effect between parenting stress and authoritative parenting on children's inhibitory control was detected after controlling for the demographic variables. This finding furthers our understanding of how the development of different aspects of SR is influenced by parenting experiences, focusing on the role of parenting style and parenting stress. The results indicated that parenting stress was more important for children's inhibitory control than for other components of SR and that children of parents experiencing a lower level of parenting stress were more likely to benefit from a higher level of authoritative parenting. These finding echoes those of previous studies showing that the development of inhibitory control is particularly vulnerable to elevated stress levels within the family (Brown et al., 2013; Evans & Kim, 2013). Blank et al. (2020) argued that parenting stress may threaten some domains of behavioral adjustment and neurocognitive outcomes. To inhibit a dominant response in favor of a subdominant one, inhibitory control requires more behavioral adjustment than working memory or cognitive flexibility, which might explain its vulnerability to parenting stress.

Based on the series of analyses conducted in this study, we only identified limited associations between parenting factors and early SR development in Chinese children. Future studies are needed to examine whether consistent findings will be attained with samples of children and parents from more diverse backgrounds and using other SR measures. As SR develops with the support of both biological and contextual processes, the results also suggest the importance of biological processes in the early development of SR. It is important to integrate both biological and contextual variables into future examinations.

Limitations and Future Directions

This study provides unique insights on how parenting styles and parenting stress are related to children's cool and hot SR skills. This is one of the first studies that enhances understanding of how detailed family processes influence different components of SR. Nevertheless, there are some limitations we need to acknowledge. First, the sample was recruited from four kindergartens in Beijing that were chosen for convenience. Although we recruited participants from both the urban and suburban areas to capture the diverse socio-economic status of families, caution should be taken when generalizing the findings to the broader population. Second, we included a battery of tasks to evaluate children's cool and hot aspects of SR, yet only one to two tasks were used to measure specific aspects of SR. The EYT shows good reliability and validity in measuring the early development of different components of EF. However, only the English version was accessible. The task instructions were therefore provided by the trained assessors before the children completed the tasks on the iPads. This procedure might have influenced children's performance on these tasks. As discussed, the hot SR task adopted in this study may not have fully captured children's emotional and motivational self-regulation. Therefore, future studies involving larger and more demographically diverse samples and involving a wider range of SR tasks with better administrative procedures and validity may provide further insights into how parenting processes are related to different aspects of SR. Finally, the current study adopted a cross-sectional design and no causal relationship could be identified. For example, the association between authoritative parenting and children's cognitive flexibility identified in this study might also be a function of children's better cognitive flexibility eliciting more authoritative parenting. Transactional influences between parents and children are highlighted in theories emphasizing a bidirectional process (Sameroff, 2009) and have been found in studies addressing parenting and children's behavioral problems (Hails et al., 2018). Future studies adopting a longitudinal design will delineate whether reciprocity also exists in the relationship between parenting and early SR development.

Conclusion

This study examined the relationship between different types of parenting styles, parenting stress, and children's cool and hot SR skills in a sample of Chinese preschoolers. Significant associations were found between authoritative parenting and children's cognitive flexibility, and parenting stress was found to moderate the relationship between authoritative parenting and children's inhibitory control. The findings demonstrate the importance of authoritative approaches and lower parenting stress levels. It is also critical to integrate both biological and contextual processes in examining early development of SR, given the limited associations found in this study.

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