ASSOCIATIONS BETWEEN PARENTING STYLE, PSYCHOPHYSIOLOGY, AND EFFORTFUL CONTROL: THE MODERATING ROLE OF RSA

A Thesis in
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by
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ABSTRACT

Effortful control (EC) is a critical component of success in middle childhood, a time of great uncertainty and transition towards less interdependence for both parents and children. While EC has been explored as a temperamental predictor or moderator for social and academic outcomes, less research has examined factors underlying early individual differences in EC. Parents are arguably the most influential social relationship of early childhood and are key players in socializing children’s self-regulation development. Baseline respiratory sinus arrhythmia (RSA) is thought to represent a child’s unique ability to regulate internal bodily processes related to temperamental reactivity at rest. We examined biological and contextual factors contributing to EC development, and more specifically took a diathesis-stress perspective to examine vulnerability factors for low EC. We conducted three multiple moderated regression analyses to examine the moderating role of child baseline RSA in the relation between authoritarian, authoritative, and permissive parenting as a predictors of child EC. We found an interaction between authoritarian parenting and baseline RSA, such that higher authoritarian parenting and lower baseline RSA was associated with lower EC. Additionally, and contrary to our hypotheses, we found that across all three models, higher baseline RSA was associated with lower EC. Overall, the results highlight the role that both individual psychophysiological differences and contextual factors may play in children’s development of self-regulation, and support the stress-diathesis model by identifying biological vulnerabilities and environmental stressors that lead to low EC.

Keywords: Self-regulation, psychophysiology, parenting style, respiratory sinus arrhythmia, effortful control
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CHAPTER 1.

Associations between Parenting Style, Psychophysiology, and Effortful Control:
The Moderating Role of RSA

Introduction

Effortful control (EC) is a critical component of individual temperamental self-regulation
due to its impact on socioemotional (Rothbart & Bates, 2006; Rothbart et al., 2000), cognitive,
and academic functioning (Blair & Razza, 2007; Liew, 2012). Formally, EC encompasses a
child’s ability to inhibit a dominant response and perform a subdominant response, to plan, and
to detect errors. EC can be measured starting in infancy and continues to develop throughout
adulthood (Rothbart, Sheese, Rueda & Posner, 2011). EC plays a critical role in shaping
outcomes particularly in middle childhood as children become more independent from their
parents, transition to school, and begin to place more emphasis on peer relationships. While EC
has been explored largely as a temperamental predictor or moderator for social and academic
outcomes, less research has been done to examine factors underlying early individual differences
in EC.

Before formal schooling begins, EC allows young children to learn from and successfully
participate in play and preschool activities (Coolahan, Fantuzzo, Mendez & McDermott, 2000).
During school age, characteristics encompassing EC, particularly inhibitory control, motivation,
attentiveness, persistence, activity level, and the absence of distractibility are positively
associated with academic and social success (Blair & Razza, 2007; Rothbart & Jones, 1998;
Martin, Drew, Gaddis & Mosely, 1998; Normandeau & Guay, 1998). These remain critical to
success in middle childhood, as academic environments demand children to self-regulate in
social interactions with more structure (Blair & Razza, 2007). Normative changes in effortful
control occur with age, partially due to external influences of socialization (Eisenberg et al., 2005; Nigg 2006; Rothbart and Bates, 2006) via dominant social influences, such as parents, peers, and teachers (Skinner & Belmont, 1993). Parents teach children how to manage thoughts, behaviors, and emotions in positive ways that lead to adaptive outcomes in accordance with both personal goals and the demands of the social context (Zeman, Cassano & Adrian, 2013). Internal psychophysiological factors, including children’s respiratory sinus arrhythmia (RSA), have also been associated with self-regulation (Hastings, Nuselovici, Utendale, Coutya, McShane & Sullivan, 2008; Calkins & Keane, 2004). However, it is unclear how external social factors may interact with internal psychophysiological factors to predict EC, and which of these factors act as contextual vulnerabilities to low EC, which could later negatively impact academic and socio-emotional functioning.

A psychobiological perspective (Gottlieb, Wahlsten & Lickliter, 2007) accounts for both “intra-organismic” and “extra-organismic” contributors to children’s development. Within this theoretical framework, temperament researchers have noted evidence that internal and external factors in the early years of life shape may EC outcomes (Fox & Calkins, 2003). The current study takes a psychobiological perspective to examine how RSA moderates the relation between parenting style and EC. More specifically, a stress-diathesis perspective within the psychobiological framework allows us to examine biological mechanisms associated with our response to stressors (i.e. baseline RSA) and contextual vulnerability factors (i.e. parenting style) as they contribute to EC in a normative population. A better understanding of these early vulnerability factors can be applied to developing early childhood interventions to promote EC development and prevent cascading negative outcomes.

**Effortful Control in Middle-Childhood**
EC fits under the broader umbrella of self-regulation, as a process which maximizes an individual’s capacity to act advantageously across contexts (Blair & Ursache, 2011). In the self-regulation literature, EC is often used interchangeably with emotion regulation (ER; processes by which emotions themselves are regulated; Gross, 1999) and executive functioning (EF; cognitive processes such as inhibitory control, working memory, and set shifting, that are orchestrated in the prefrontal cortex and underlie goal-directed behavior; see Best & Miller, 2010). Typically, EC represents the self-regulatory component of the psychobiological model of temperament (Rothbart, Derryberry & Posner, 1994), conceptually encompassing attentional focus and behavioral regulation, and serving to modulate initial reactivity to input. Neurobiologically, EC has been linked with the executive attention network, which consists of the anterior cingulate gyrus and the prefrontal cortex (Botvinick, Nystrom, Fissel, Carter & Cohen, 1999; Fan, Flombaum, McCandliss, Thomas & Posner, 2002). The executive attention network and EC are thought to come online during the first year of life (Rothbart, Sheese, Rueda & Posner, 2011), and their relatively slow maturation leads to improvements in EC throughout middle childhood and beyond (Lengua, 2006).

As stated above, EC is a critical component of success in middle childhood, which can be a time of great uncertainty and transition for both parents and children (Weisner, 1996). Also known as the “5-to-7-year shift,” this period is a developmental transitional stage when children are thought to be particularly susceptible to environmental influences, due to increased expectations for independence and self-regulation. According to the family adaptation hypothesis, it is evolutionarily adaptive for juveniles of this age to help adult caregivers to care for other younger juveniles, which would allow for the survival of the social group if caregivers were unable to provide continuing support (Pereira, 1993; Weisner, 1996). These new
evolutionary-based responsibilities make self-regulatory competency of utmost importance in middle childhood for the survival of species. At this age, children learn to better regulate their behavior to become caregivers and fulfil increasing responsibilities, and this adaptation is associated with normative cognitive and maturational changes. In modern times, families and communities recognize these changes in children by assigning more responsibility for tasks and chores around the house (Rogoff et al., 1980; Rogoff et al., 1975). Additionally, the transition to full-time school also requires greater levels of autonomy and self-control, or EC abilities. Children are expected to become more capable in completing structured domestic and academic tasks, as well as functioning socially in the wider community, while facing new peers and a greater separation from home and family (Weisner, 1996). By age ten, children begin to demonstrate self-regulation abilities on par with the quality and skill of those shown in adulthood (Saarni, 1984).

Most studies to date examine EC as a contributor to various developmental outcomes, across academic, socioemotional, and health-related outcomes. For example, children high in EC at 22-45 months developed a stronger conscience at 56 months and fewer internalizing problems at 73 months (Kochanska & Knaack, 2004). In toddlers, higher levels of effortful control were associated with lower levels of externalizing problems (Olson, Sameroff, Kerr, Lopez & Wellman, 2005). This inverse relation between EC and externalizing problems is also present in school-age children (Rydell, Berlin & Bohlin, 2003). EC has also been shown to be inversely related to negative affect (Eisenberg, Sadovsky, Spinrad, Fabes, Losoya, Valiente, Reiser, Cumberland & Shepard, 2005). In a sample of six-year-old children, boys in particular, high EC was related to high sympathy (Eisenberg, Michalik, Spinrad, Hofer, Kupfer, Valiente, Liew, Cumberland & Reiser, 2007).
Additionally, higher EC at age six predicts lower rates of internalizing problems at age eight, as well as academic achievement (higher grades) at age ten (Valiente et al., 2011). In an academic setting examining 7-to-12-year-old children, higher EC was positively predictive of higher GPA in the following semester (Valiente et al., 2008). A study conducted in mainland China found similar results indicating that EC in grades 1 and 2 predicted GPA at grades 5 and 6, respectively. This relation was mediated by social competence, such that higher social competence skills facilitated increases in achievement that corresponded with EC increases (Zhou et al., 2010).

One argument is that EC influences adjustment outcomes (i.e. internalizing and externalizing problems, prosocial behavior, academics) by contributing to information processing, and the adaptive modulation of emotion and behavior. One key component of self-regulation is a child’s abilities to shift attention from negative thoughts and focus on neutral or positive thoughts and activities (Eisenberg et al., 2009), which is part of EC. This ability is thought to be particularly important in planning and coping with stressful situations, challenges, or distress (Eronen et al., 1997; Allhusen & Belsky, 2005). The inhibitory and attentional control aspects of EC also serve to reign in behavioral impulses, and subsequently prevent or minimize externalizing behaviors (Eisenberg et al, 2000; 2001). Focusing on new stimuli or engaging in a new activity may reduce stress (Erber & Tesser, 1992), and could facilitate better socioemotional and academic functioning. Clearly, EC plays an important role in socioemotional and academic functioning, however the underlying internal and external mechanisms shaping EC itself remain understudied.

**Parenting Style and Child Self-Regulation**

The development of self-regulation occurs in a social context (Bronfenbrenner, 1979; Kessen, 1979), particularly via the mechanism of parental socialization of emotion and self-
regulation. Parents play a significant role as arguably the most influential social relationship of early childhood (Thompson & Meyer, 2007; Collins, Madsen, Susman-Stillman, 2002). They provide structure to a child’s emotional world, and shape knowledge, understanding, and strategies to regulate emotions (Morris, Silk, Steinberg, Myers & Robbins, 2007) through their reactions to children’s emotions and experiences, as well as discussions surrounding emotions, and modeling behavior (Eisenberg, Cumberland & Spinrad, 1998).

The existing literature suggests that parents tend to fall within a distinct parenting “style” based on characteristics reflecting their interactions with their children, their attitudes and values about parenting, their beliefs about the nature of children, as well as specific practices they use to socialize and discipline their children (Baumrind, 1978). These parenting styles influence children’s socioemotional and academic functioning (Baumrind, 1978). In this model, parents are classified within three main parenting styles, authoritative, authoritarian, and permissive (Robinson et al., 1995).

Authoritative parenting is characterized by positive emotional support, high standards, appropriate autonomy granting, and clear, bidirectional communication, and is typically associated with favorable socioemotional outcomes in children (Darling & Steinberg, 1993; Baumrind, 1971). Authoritarian parenting is associated with harshness, discipline, low warmth toward the child, and is associated with fearful, timid behavioral consequences in children (Darling & Steinberg, 1993; Baumrind, 1971). Permissive parenting can be characterized by ineffective communication skills, lower maturity demands, and relative detachment (Darling & Steinberg, 1993; Baumrind, 1971). Parents can show characteristics from each of the three parenting styles and may not fall exactly into one category. Parenting style may also differ between two parents of a child (Winsler et al., 2005). However, while studies use the term
“parents” or “parenting” in most work, like the current study, they focus almost exclusively on mothers.

A few studies have examined the direct relation between parenting style and effortful control. In a large-scale phone survey study with parents of children under eight years old, parents who relied on nurturing behaviors (i.e. authoritative) had children with stronger regulation skills, parents who were over-controlling (i.e. authoritarian) had children with weaker self-regulation skills, and parents who were absent or lacked control were more likely to have children reported to have regulatory deficits (Piotrowski, Lapierre & Linebarger, 2013).

Additionally, parental autonomy support and maternal involvement with school-age children has been positively related to self-regulation, school achievement, teacher-rated competence (Grolnick & Ryan, 1989). In a study done with Pakistani 7th, 8th, and 9th graders, maternal and paternal authoritative parenting had a positive effect on self-regulation, maternal and paternal permissive parenting had a negative effect on self-regulation, and maternal and paternal authoritarian parenting style were not associated with self-regulation outcomes (Jabeen, Anis-ul-Haque & Riaz, 2013). In a study with Australian adolescents, strict parenting and the parent-granted autonomy did not appear to be significant contributors to adolescent self-regulatory behaviors (Purdie, Carroll & Roche, 2004). These mixed results suggest that parenting style plays an important role when children are younger, but may have less of an impact on self-regulation outcomes as their children become adolescents, in comparison to other factors contributing to individual differences in EC at that age.

Yet, in studies conducted with college students and their parents, permissive parenting was negatively associated with self-regulation in drinking behaviors, and authoritative parenting was associated with higher self-regulation in drinking behaviors (Patock-Peckham, Cheong,
Balhorn & Nagoshi, 2001). Similar results have been found for the relation between parenting style and their children’s self-regulatory behavior related to smartphone addiction (Kwan & Leung, 2017) and eating self-regulation and body mass index (BMI; Connell & Francis, 2014). The wide array of these findings speaks to the important role of parenting style in child self-regulation across several developmental contexts, including socio-emotional, academic, and health outcomes.

**Respiratory Sinus Arrhythmia (RSA)**

In tandem with the social influences of parenting style, psychophysiological processes play a role in self-regulation (Beauchaine, Gatze-Kopp & Mead, 2007; Porges, 2007). Polyvagal theory emphasizes the flexibility of the nervous system in regulating autonomic activity, and claims that affective states, social behavior, and emotion regulation are evolutionarily related to autonomic structure and function (Porges, 2001). The autonomic nervous system (ANS) regulates homeostatic functioning and is composed of opposing sympathetic and parasympathetic branches, which influence the body’s fight-or-flight response (Porges, 2007; Zisner & Beauchaine, 2016). The myelinated vagal nerve (the fast-acting, down-regulatory structure of the mammalian autonomic nervous system) serves as the primary link between neural (i.e. limbic and hypothalamic) and visceral organs, including cardiovascular structures. The vagus nerve has an inhibitory influence on the heart acting to moderate an individual’s visceral state and enable them to promote self-soothing behaviors (Porges, 2001). Measuring respiratory sinus arrhythmia (RSA), parasympathetic activity of the vagal nerve determined by variation of the inter-beat intervals of the heart in tandem with respiration, provides insight into children’s regulatory capacity at baseline. RSA may moderate the relation between specific contextual factors and child outcomes.
Baseline RSA has been linked to individual differences in self-regulation (Beauchaine, 2001). It is thought to represent a child’s unique capacity to regulate internal bodily processes related to temperamental reactivity during non-engagement (Liew, Eisenberg, Spinrad, Eggum, Haugen, Kupfer, Reiser, Smith, Lemery-Chalfant & Baham, 2011; Burt & Abrodovic, 2013), and has been measured as a stable individual difference variable (Doussard-Roosevelt et al., 2013; El-Sheikh, 2005). Previous studies show that baseline RSA has been positively related to parent report of EC from children and adolescents (Chapman et al., 2010), performance on complex cognitive tasks in toddlers (Marcovitch et al., 2010), EF and processing speed in school-age children (Staton et al., 2009), and negatively related to adults processing time during a Stroop task (Matthewson et al., 2010). Additionally, school-age children and adults both show positive relations between the attentional control aspect of EC and baseline RSA (Hansen et al., 2003; Suess et al., 1994).

In the current study, parasympathetic ANS activity, as measured by baseline RSA, is used as a potential marker of children’s ability to regulate negative arousal associated with stressful parenting environments. Higher baseline RSA is thought to reflect increased sensitivity to the environment (Beauchaine, 2001), and is associated with increased capacity for self-regulation (Graziano & Derefinko, 2013). Hastings and De (2008) found that better maternal and paternal emotion socialization strategies were associated with better preschool adjustment for children with less parasympathetic self-regulatory capacities, compared to better physiologically regulated children. That is, among children showing lower physiological regulation, those with parents who demonstrated better emotion socialization strategies were better adjusted in preschool than children with parents who showed worse emotion socialization strategies. Additionally, in a study examining physiological and environmental predictors of children’s
sympathy, Taylor and colleagues (2015) found that higher baseline RSA predicted higher sympathy in children through effortful control, and that higher authoritative parenting and baseline RSA uniquely predicted higher EC. Particularly relevant to the current study, Skibo and colleagues (2020) found that insensitive caregiving in early childhood predicted lower EC at 3.5 years, and subsequently poorer anger regulation at age 5. In this sample, low baseline RSA and high maternal insensitivity together at 18 months also predicted lower EC at 3.5 years.

The Current Study

As stated above, we are interested in taking a psychobiological approach to examine individual differences in EC, and more specifically, interactions between physiological or contextual vulnerabilities that lead to low EC. The diathesis-stress model is a framework which considers interactions between individual characteristics and environmental stressors as vulnerability factors for a specific outcome, in this case low EC. While originally proposed as a model for clinical populations with schizophrenia (Nuechterlein & Dawson, 1984) and depression (Monroe & Simmons, 1991), the stress-diathesis model can be applied to non-clinical samples as well (Sameroff, 1983) The model states that vulnerable individuals or children are most likely to develop or function poorly, when exposed to specific stressors. For example, in this study, we consider low baseline RSA as a vulnerability factor, while authoritarian and permissive parenting styles act as environmental stressors. In vulnerable children, low baseline RSA would interact with authoritarian and permissive parenting, and this interaction would be associated with low EC, an outcome indicating poor developmental functioning. Better understanding internal and external contributors to children’s EC will allow us to work toward effective targeted interventions to prevent cascading negative outcomes.
Additionally, previous studies show that, on average, boys tend to have lower EC than girls in toddlerhood (Kochanska, Murray & Harlan, 2000), and up to age thirteen (Else-Quest, Hyde, Goldsmith & Van Hulle, 2006). Because of this association, child gender will be added to the models as a covariate. Since EC shows normative increases with age (Jones, Rothbart & Posner, 2003; Rothbart & Posner, 2006; Zhou et al., 2007; Rueda et al., 2004), children’s age in months will also be included as a covariate.

The first model included authoritative parenting style, baseline RSA, child gender, and child age in months predicting child EC. The second and third models included the same structure, switching in authoritarian parenting style and permissive parenting style, respectively. All variables were examined continuously, except for child gender, which was dummy coded.

Based on previous evidence, we predicted that higher authoritative parenting and children’s higher baseline RSA would be associated with higher EC. We also predicted that permissive parenting and authoritarian parenting would be associated with lower EC, especially if children have low baseline RSA. However, the associations between authoritarian parenting and permissive parenting with lower EC may not be as strong for children who have higher baseline RSA, and subsequently higher internal regulatory capacity to protect them from the negative consequences of harsh or absent parenting. We also predicted that boys would have lower EC than girls, and that there may be slight increases in EC from 5 to 7 years.

Methods

Participants

The participants in this study include a community sample of primarily white, middle-class 5-to-7-year-old children (N=65, \(M_{age}=6.10, SD_{age}=0.75\)) and their parents (93.75% mothers) living in Central PA. Participants were recruited for a larger cross-sectional study on
child temperament and social behavior via newspaper birth announcements, flyers posted at daycares, and a database of local families who had identified interest in participating in research studies, consisting of 118 total children and their parents (see Table 1). Families participated in a laboratory visit that included additional tasks not mentioned here. Parents provided informed consent, after which an experimenter placed electrodes for cardiac data recording on children. Parents completed questionnaires as children performed the study tasks.

**Measures**

**Effortful Control.** Parents completed the Children’s Behavior Questionnaire-Short Form (CBQ-SF; Putnam & Rothbart, 2006), a caregiver report measure of temperament in children 3-7 years of age. The CBQ-SF identifies 15 primary temperament characteristics: Positive Anticipation, Smiling/Laughter, High Intensity Pleasure, Activity Level, Impulsivity, Shyness, Discomfort, Fear, Anger/Frustration, Sadness, Soothability, Inhibitory Control, Attentional Focusing, Low Intensity Pleasure, and Perceptual Sensitivity. We calculated a mean EC score for each participant, based upon the total sum across sub-scale items divided by the number of items on the questionnaire. EC scores were examined continuously. Chronbach’s alpha was .65.

**Parenting Style.** Mothers self-reported information on their parenting styles by completing the Parenting Practices Questionnaire (PSQ; Robinson et al., 1995). This questionnaire assesses three global parenting dimensions consistent with Baumrind’s (1971) parenting styles: Authoritative, authoritarian, and permissive. The authoritative subscale consists of 27 items measuring warmth and involvement, clear communication of expectations, reasoning, democratic participation, and general pleasantness. The authoritarian subscale consists of 20 items measuring verbal hostility, corporal punishment, punitive strategies, and directiveness. The permissive subscale consists of 15 items measuring lack of follow through,
ignoring misbehavior, and lack of self-confidence about parenting. For each participant, we calculated a mean score for each parenting style, based on the sum total points for each style divided by the total number of questions for each style. Each parenting style was examined continuously. Chronbach’s alphas for the authoritative, authoritarian, and permissive subscales were .88, .58, and .66, respectively.

**Respiratory Sinus Arrhythmia.** After parents left the room to complete other study tasks, researchers placed three disposable pre-gelled spot electrodes on the children’s torsos in the appropriate locations. Cardiac data were collected over the 5-minute continuous baseline session, during which children were instructed to sit quietly in a chair in the lab, with an experimenter present. Researchers acquired the electrocardiograph (ECG) signal with Mindware Technologies LTD ambulatory Impedance Cardiographs (MW1000a) using the WiFi ACQ software, Version 3.0.1 (Gahanna, OH). The ECG signal was sampled at 500 Hz and the ECG time series was transmitted wirelessly to a computer for offline processing. The Mindware HRV analysis program (Version 3.0.17) is used to process the data. First, the HRV software identified the interbeat intervals (IBIs). Second, the HRV software detected physiologically improbable intervals based on the overall IBI distribution using a validated algorithm (Berntson, Quigley, Jang, & Boysen, 1990). Researchers then manually visually inspected all data to identify artifacts for removal and corrected any erroneous or missing beats. The HRV software detrended data using a first-order polynomial to remove the mean and any linear trends, then cosine taper the data, and submit to Fast Fourier Transform (FFT). Finally, the HRV software defined RSA as the natural log integral of the .24 to 1.04 Hz power band and calculated RSA in 30s epochs. An average of the RSA of all epochs at baseline for each child provide an overall baseline RSA value, which was measured continuously.
Data Analysis

We conducted three multiple moderated regression analyses to examine the moderating role of child baseline RSA in the relation between authoritarian, authoritative, and permissive parenting as predictors of child EC. Child gender and age were incorporated as control variables. Predictor variables (baseline RSA, authoritarian parenting, authoritative parenting, permissive parenting, age in months) were mean-centered for analyses and examined continuously, except for child gender, which was dummy coded (male = 1, female = 0). Missing data from the initial sample of 118 children were excluded in R using listwise deletion, to give rise to the final sample of 65 children examined in these analyses.

Results

Mean values and standard deviations for the main study variables are noted in Table 1. Inter-correlations for the main study variables are noted in Table 2.

Table 1.

Demographic Characteristics and Descriptive Statistics.

<table>
<thead>
<tr>
<th></th>
<th>Included Participants (n = 65)</th>
<th>Excluded Participants (n = 53)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Gender (M/F)</td>
<td>(28/37)</td>
<td>(32/21)</td>
</tr>
<tr>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Age in Months</td>
<td>75.24</td>
<td>8.99</td>
</tr>
<tr>
<td>Effortful Control</td>
<td>5.46*</td>
<td>0.66</td>
</tr>
<tr>
<td>Baseline RSA</td>
<td>7.32</td>
<td>0.85</td>
</tr>
<tr>
<td>Authoritarian Parenting</td>
<td>2.25</td>
<td>0.64</td>
</tr>
<tr>
<td>Authoritative Parenting</td>
<td>5.03</td>
<td>0.57</td>
</tr>
<tr>
<td>Permissive Parenting</td>
<td>1.98</td>
<td>0.71</td>
</tr>
</tbody>
</table>
Note: Raw values are presented for ease of interpretation. The 65 participants included in the analysis showed significantly higher EC ($M = 5.46$, $SD = 0.66$) compared to the 53 participants not included in the analysis ($M = 5.11$, $SD = 0.81$), $t(81) = 2.44$, $p = .02$.

$M =$ Mean. $SD =$ standard deviation.

Table 2.

Summary of Correlations between Variables.

<table>
<thead>
<tr>
<th></th>
<th>Baseline RSA</th>
<th>Effortful control</th>
<th>Authoritarian parenting</th>
<th>Authoritative parenting</th>
<th>Permissive parenting</th>
<th>Age in months</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline RSA</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effortful control</td>
<td>-0.24*</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Authoritarian parenting</td>
<td>-0.08</td>
<td>-0.09</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Authoritative parenting</td>
<td>-0.14</td>
<td>0.10</td>
<td>-0.49***</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permissive parenting</td>
<td>-0.07</td>
<td>0.02</td>
<td>0.17</td>
<td>-0.13</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age in months</td>
<td>0.04</td>
<td>0.06</td>
<td>-0.02</td>
<td>0.19</td>
<td>0.11</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>0.00</td>
<td>0.49***</td>
<td>0.23</td>
<td>-0.28*</td>
<td>0.23</td>
<td>0.08</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Note: $N = 65$. * $p < .05$, ** $p < .01$, *** $p < .001$. $M =$ Mean. $SD =$ standard deviation. Child gender was dummy coded (male = 1, female = 0).

To test the hypothesis that psychophysiological processes play a critical role in 5-to-7-year-old children’s development of self-regulation, and more specifically whether children’s baseline RSA moderates the relation between parenting style and children’s EC, we conducted three moderated multiple regression analyses (see Tables 3a, 3b, 3c, and Tables 4a and 4b for results) using the lm function in R (R Core Team, 2013).

Results from the authoritarian parenting style model are shown in Table 3a and Table 4. In the authoritarian parenting style model, we found that children’s RSA at baseline moderated the relation between authoritarian parenting and EC, $F(5, 59) = 7.914$, $p < .001$, such that children with low baseline RSA (-1 SD) with parents higher in authoritarian traits showed significantly lower EC ($b = -.43$, $t = -3.06$, $p < .001$; Figure 1b) than children with high (+1 SD)
baseline RSA. Specifically, when RSA is between -0.15 and 0.50, the slope of authoritarian parenting (-0.82) is significantly associated with lower EC (Figure 1b). Authoritarian parenting approached significance in its association with child EC (b = -19, t = -1.82, p = .07), over and above the effects of baseline RSA, gender, age in months, and the interaction between authoritarian parenting and baseline RSA. Higher baseline RSA was significantly associated with lower EC (b = -19, t = -2.49, p = .02), over and above the effects of authoritarian parenting, gender, age, and the interaction between authoritarian parenting and baseline RSA. Age was not significantly associated with children’s EC. Males showed lower EC than females, while accounting for baseline RSA or authoritarian parenting, age in months, and the interaction between baseline RSA and authoritarian parenting (b = -65, t = -4.70, p < .001); Figure 1a.

Results from the authoritative parenting style model are shown in Table 3b and Table 4b, as well as Figure 2a and 2b. In the authoritative parenting style model, authoritative parenting was positively associated with child EC (b = .28, t = 2.11, p = .04). Additionally, baseline RSA approached significance to a negative association with EC (b = -.15, t = -1.91, p = .06). Again, males showed lower EC than females (b = -.73, t = -5.02, p < .001). The interaction between authoritative parenting style and baseline RSA was not significant (b = .07, t = .42, p < .67; Figure 2a). However, when RSA is between -0.15 and 0.50, the slope of authoritative parenting (.03) is associated with higher EC (b = .28, t = 2.13, p < .04; Figure 2b).

Results from the permissive parenting style model are shown in Table 3c and Figure 3a and 3b. In the permissive parenting style model, higher baseline RSA was significantly associated with lower EC (b = -.18, t = -1.91, p = .03). Additionally, males again showed lower EC than females (b = -.67, t = -4.55, p < .001). The interaction between permissive parenting style and baseline RSA was not significant (b = -.07, t = -.43, p < .66; Table 3c).
Table 3a.

Main Effects Results from Multiple Moderated Regression Analyses Examining Authoritarian Parenting Style.

<table>
<thead>
<tr>
<th></th>
<th>Est.</th>
<th>SE</th>
<th>t-value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Authoritarian Parenting</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>5.72</td>
<td>0.09</td>
<td>64.44</td>
<td>0.001***</td>
</tr>
<tr>
<td>Authoritarian Parenting</td>
<td>-0.20</td>
<td>0.11</td>
<td>-1.82</td>
<td>0.07</td>
</tr>
<tr>
<td>Baseline RSA</td>
<td>-0.20</td>
<td>0.08</td>
<td>-2.49</td>
<td>0.02**</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.65</td>
<td>0.13</td>
<td>-4.70</td>
<td>0.001***</td>
</tr>
<tr>
<td>Age in Months</td>
<td>0.00</td>
<td>0.01</td>
<td>0.38</td>
<td>0.70</td>
</tr>
<tr>
<td>Authoritarian Parenting*Baseline RSA</td>
<td>0.28</td>
<td>0.11</td>
<td>2.54</td>
<td>0.01**</td>
</tr>
</tbody>
</table>

Note: N = 65. * = p < .05, ** = p < .01, *** = p < .001. M = Mean. SD = standard deviation. Child gender was dummy coded (male = 1, female = 0).

Table 3b.

Main Effects Results from Multiple Moderated Regression Analyses Examining Authoritative Parenting Style.

<table>
<thead>
<tr>
<th></th>
<th>Est.</th>
<th>SE</th>
<th>t-value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Authoritative Parenting</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>5.78</td>
<td>0.09</td>
<td>62.29</td>
<td>0.001***</td>
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<tr>
<td>Authoritative Parenting</td>
<td>0.28</td>
<td>0.13</td>
<td>2.11</td>
<td>0.04*</td>
</tr>
<tr>
<td>Baseline RSA</td>
<td>-0.16</td>
<td>0.08</td>
<td>-1.91</td>
<td>0.06</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.73</td>
<td>0.15</td>
<td>-5.02</td>
<td>0.001***</td>
</tr>
<tr>
<td>Age in Months</td>
<td>0.00</td>
<td>0.01</td>
<td>-0.22</td>
<td>0.82</td>
</tr>
<tr>
<td>Authoritative Parenting*Baseline RSA</td>
<td>0.07</td>
<td>0.17</td>
<td>0.42</td>
<td>0.67</td>
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</tbody>
</table>
Table 3c.

Main Effects Results from Multiple Moderated Regression Analyses Examining Permissive Parenting Style.

<table>
<thead>
<tr>
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<th>SE</th>
<th>t-value</th>
<th>Sig.</th>
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<tbody>
<tr>
<td><strong>Intercept</strong></td>
<td>5.75</td>
<td>0.09</td>
<td>60.60</td>
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<tr>
<td>Permissive Parenting</td>
<td>-0.06</td>
<td>0.11</td>
<td>-0.50</td>
<td>0.62</td>
</tr>
<tr>
<td>Baseline RSA</td>
<td>-0.19</td>
<td>0.08</td>
<td>-2.20</td>
<td>0.03**</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.67</td>
<td>0.15</td>
<td>-4.55</td>
<td>0.001***</td>
</tr>
<tr>
<td>Age in Months</td>
<td>0.00</td>
<td>0.01</td>
<td>0.27</td>
<td>0.79</td>
</tr>
<tr>
<td>Permissive Parenting*Baseline RSA</td>
<td>-0.07</td>
<td>0.16</td>
<td>-0.43</td>
<td>0.66</td>
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</tbody>
</table>

Note: N = 65. * = p < .05, ** = p < .01, *** = p < .001. M = Mean. SD = standard deviation. Child gender was dummy coded (male = 1, female = 0).

Table 4a.

Simple Slopes Results from Table 3a Interaction (Authoritarian Parenting*Baseline RSA).

<table>
<thead>
<tr>
<th>Level</th>
<th>Slope</th>
<th>Est.</th>
<th>SE</th>
<th>t-value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Baseline RSA (-1 SD)</td>
<td>-0.82</td>
<td>-0.43</td>
<td>0.14</td>
<td>-3.06</td>
<td>0.001***</td>
</tr>
<tr>
<td>Average Baseline RSA</td>
<td>0.03</td>
<td>-0.19</td>
<td>0.11</td>
<td>-1.74</td>
<td>0.09</td>
</tr>
<tr>
<td>High Baseline RSA (+1 SD)</td>
<td>0.88</td>
<td>0.05</td>
<td>0.15</td>
<td>0.36</td>
<td>0.72</td>
</tr>
</tbody>
</table>

Note: N = 65. * = p < .05, ** = p < .01, *** = p < .001. M = Mean. SD = standard deviation.

Table 4b.

Simple Slopes Results from Table 3b Interaction (Authoritative Parenting*Baseline RSA).

<table>
<thead>
<tr>
<th>Level</th>
<th>Slope</th>
<th>Est.</th>
<th>SE</th>
<th>t-value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Baseline RSA (-1 SD)</td>
<td>-0.82</td>
<td>0.22</td>
<td>0.19</td>
<td>1.16</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Note: N = 65. * = p < .05, ** = p < .01, *** = p < .001. M = Mean. SD = standard deviation.
<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>SD</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Baseline RSA</td>
<td>0.03</td>
<td>0.28</td>
<td>0.13</td>
<td>2.13</td>
</tr>
<tr>
<td>High Baseline RSA (+1 SD)</td>
<td>0.88</td>
<td>0.34</td>
<td>0.20</td>
<td>1.71</td>
</tr>
</tbody>
</table>

*Note:* N = 65. * = p < .05, ** = p < .01, *** = p < .001. M = Mean. SD = standard deviation.
Figure 1a. Plot of the significant interaction between authoritarian parenting and baseline RSA.

Children with low baseline RSA (-1 SD) with parents higher in authoritarian traits showed significantly lower EC.
Figure 1b. Johnson-Neyman plot of the interaction between authoritarian parenting and baseline RSA. When RSA is between -0.07 and 3.83, the slope of authoritarian parenting is significantly associated with higher EC.
Figure 2a.

Plot of the non-significant interaction between authoritative parenting and baseline RSA.
**Figure 2b.** Johnson-Neyman plot of the interaction between authoritative parenting and baseline RSA. When RSA is between -0.15 and 0.50, authoritarian parenting is significantly associated with higher EC.
Figure 3a.

Plot of the non-significant interaction between permissive parenting and baseline RSA.
Figure 3b.

Johnson-Neyman plot of the interaction between permissive parenting and baseline RSA.

The slope of permissive parenting is unrelated to EC across the range of RSA values.
Discussion

The overall goal of the study was to employ a psychobiological perspective to examine internal and external factors that influence self-regulation. More specifically, we took a stress-diathesis approach to examining the moderating role of baseline RSA in the relation between parenting style and EC, in hopes of identifying mechanisms underlying self-regulation that make children more vulnerable to poor social, academic, and cognitive outcomes later on. We predicted that higher authoritative parenting and children’s higher baseline RSA would be associated with higher EC. It was also predicted that permissive parenting and authoritarian parenting would be associated with lower EC, especially if children had low baseline RSA. As expected, we found an interaction in the authoritarian model between authoritarian parenting and baseline RSA, such that higher authoritative parenting and lower baseline RSA was associated with lower EC. Additionally, authoritative parenting was positively associated with child EC. The interaction between authoritative parenting style and baseline RSA was not significant. The interaction between permissive parenting style and baseline RSA was also not significant. Additionally, and contrary to our hypotheses, we found that across all three models, higher baseline RSA was associated with lower EC. Overall, the results highlight the role that both individual psychophysiological differences and contextual factors may play in children’s development of self-regulation, and support the diathesis-stress model by identifying biological vulnerabilities and environmental stressors that lead to low EC. Additionally, the results provide a basis for future exploration of mechanisms underlying EC, and call for a more in-depth examination of individual differences in psychophysiology and parenting processes.

Interaction Between Authoritative Parenting and Low RSA
Consistent with our hypothesis, the results indicate an interaction between authoritarian parenting style and baseline RSA, such that high authoritarian parenting and low baseline RSA were significantly associated with lower EC. In accordance with the stress-diathesis model, these results support the notion that low baseline RSA is a vulnerability factor, and authoritarian and parenting style acts as environmental stressors. On the whole, a wide body of research has studied the role of parental anger, hostility, and lack of sensitivity in predicting low self-regulation in children. Parental negativity likely elicits negative emotions in children (Eisenberg et al, 2005). Subsequently, children high in negative emotionality experience difficulty with higher order cognitive processes. One explanation for this relation is that skills for reflective planning and problem solving are underused and therefore underdeveloped in these children (Blair, 2002).

Hoffman (1960) suggested that parental hostility or punitive negative expressivity leads children to become routinely over-aroused. This over-arousal, over time, disrupts focus and attention, compromising self-regulation (Moore & Dunham, 1995). Over aroused children in negative environments show decreased joint attention abilities, leaving them less able to respond to parent scaffolding (Moore & Dunham, 1995), and likely less receptive to parent socialization of self-regulation. Physiologically, the over-arousal associated with high parental hostility or punishment likely contributes to disengagement of the vagal brake in children, and subsequently lower EC. Additionally, children with lower baseline RSA (i.e. with a substantially “weaker” vagal brake) to begin with, have a lower threshold for self-soothing, and harsh parenting and over-arousal renders them further unable to employ physiological self-soothing behaviors, resulting in lower EC. Low RSA is likely associated with low EC for children of authoritarian parents because these children are unable to regulate their emotional arousal. It is the
combination of low baseline RSA constituting a psychophysiological vulnerability, with the added contextual stress of authoritarian parenting, that is associated with lower EC. Overall, our results from the interaction supported the diathesis-stress model, and the notion that harsh parenting combined with lack of psychophysiological regulatory capacity, may contribute to an escalation of dysregulated negative affect, and low reported self-regulation. If explored longitudinally in future studies, perhaps the low EC we see in this cross-sectional study of children of authoritarian parents with low baseline RSA would translate to flatter, less rapid increases in EC development over time.

**Higher Authoritative Parenting Associated with Higher EC**

As expected, higher levels of authoritative parenting were positively related to EC. The positive emotional support, high standards, autonomy-granting, and clear communication associated with authoritative parenting are likely mechanisms by which an authoritative parenting style fosters higher EC outcomes. Warm and supportive parents, in contrast to harsh parents, are thought to better support an optimal level of emotional and physiological arousal in children, which leaves children able to respond to attentional and behavioral scaffolding, which may also occur more frequently with this type of parenting behavior (Eisenberg et al., 2005). This means that children are also more likely to process emotional messages or bids, internalize requests for desirable behavior, and better control their emotions when interacting with warm sensitive parents (Dix, 1991; Grusec & Goodnow, 1994). With children in this highly receptive state, they are also likely more motivated and better able to attend to, and learn from, parents (Eisenberg et al 2005). Previous research with young children also points to the role of parental responsiveness to children’s emotional cues in children’s use and repertoire of self-regulatory behaviors (Cohn & Tronick, 1983; Gable & Isabella, 1992). Variations in this parental
responsiveness, such as higher acceptance, support, and sympathy are linked to active support-seeking in school-age children (Kliewer, Fearnow, & Miller, 1996), and a wider repertoire of self-regulation strategies in older children (Hardy, Power, & Jaedicke, 1993).

**Baseline RSA was Associated with Lower EC in all Models**

Interestingly, in all three models, higher baseline RSA was associated with lower EC, which was the opposite of our predicted outcome. There are several reasons why this may be the case, and these results yield considerations for future research. While existing research frequently reports that baseline RSA is positively associated with higher capacity for self-regulation (Graziano & Dereflinko, 2013; Liew et al., 2011; Burt & Abrodovic, 2013), individual differences research may help explain why this might not always be the case. For example, Sulik and colleagues (2013) found that higher RSA in preschool-age children was positively associated with EC only for children high in shyness. Previous studies have also shown baseline RSA and EC to be unrelated in a sample of low-income preschoolers enrolled in Head Start as measured in two behavioral tasks (Blair & Peters, 2003), as well as in college students in a cognitive signal detection task (Duschek et al., 2009). Sulik and colleagues (2013) suggest that RSA may be more strongly related to EC for participants who are prone to emotional reactivity in the measurement context, due to the effects of stress on RSA (Pieper et al., 2007). Because of this, children who find the measurement context to be particularly stressful may be likely to show reduced RSA because they are unable to use attentional resources to control emotional reactivity (White et al., 2011). This emotional reactivity associated with the measurement context could be impacting the relation between baseline RSA, and EC. Emotional reactivity from measurement could be due to interactions with strange experimenters, electrode placement, and/or fatigue from completing additional tasks. Considering the transitional stage that these children are in as they adjust to
increased autonomy and separation from home and family, the combination of this stress compounded with measurement stress could be driving this unexpected negative association between baseline RSA and EC across all models.

Another interpretation builds on the notion that high baseline RSA is positively associated with an individual’s ability to flexibly engage and respond to their environment (Porges, 2007; Thayer & Lane, 2000), as well as the physiological toughness theory (Dienstbier, 1989; Dienstbier & Zillig, 2002), which suggests that individuals who experience mild to moderate stress in an intermittent fashion may develop more adaptive biological systems, in this case higher baseline RSA. As the children in this sample live in a primarily white, middle-class, and well-educated area, they may not have experienced significant acute stressors prompting adaptive changes in their biological functioning. This could likely be the case for the authoritative model, where the children are the least likely to experience acute stress. Additionally, the levels of authoritarian and permissive parenting may not be high enough in this sample for the stress to impact the children’s biological systems.

While these speculations can potentially explain the unexpected the negative association we see in our sample between baseline RSA and EC, it is important to keep in mind that RSA is a dynamic process, and that perhaps the static measure of baseline RSA does not paint the most complete picture of a child’s EC, or reflect how an individual child will self-regulate in real-time and under a variety of different circumstances. Several recent studies (Fortunato et al., 2013; Gatzke-Kopp & Ram, 2018; Buss et al., 2017) highlight the utility of examining autonomic functioning on both a micro- and macro-longitudinal scale and across emotion-eliciting contexts to provide insight to reactivity and self-regulation development, while considering individual differences. Future research should consider steps to reduce stress in measurement and take into
account the amount of emotional and physiological reactivity in tandem with regulation. Additionally, dynamic changes in RSA can be examined across tasks to gain a better understanding of psychophysiological processes that occur on a micro-longitudinal scale that contribute to child self-regulation across contexts.

More broadly, it is important to practically and theoretically consider what we are capturing during a baseline measure of “rest,” particularly in developing populations over time. Measuring rest in children involves a period of increased inhibitory control. Camacho and colleagues (2020) highlight that baseline measures are overlooked as cognitive states that change across development. Additionally, they highlight the fact that resting activity does not represent a consistent cognitive state across the lifespan, and involves entirely different neurobiological processes in younger individuals. Neural activity at rest is theorized to represent preparatory cognitions, mind-wandering or other inward-directed cognition, and physiological noise. Importantly, baseline neurobiological activity may also represent preparatory activity for the next task, and for children who are developing cognitive control, high levels of cognitive activity are required for both baseline and task conditions (Camacho et al., 2020). Ultimately, proper baseline measurement and change score calculation is critical to properly interpret true change in RSA from baseline to task measures (Burt & Obradovic, 2013), so it is particularly important to consider the developmental context of resting baseline measures moving forward.

Limitations and Future Directions

This study identifies factors that may affect children’s ability to cope with the new demands of the school transition and increased independence. Children ages 5-to-7 are faced with significant changes in their social and academic lives which require the ability to self-regulate to succeed. These changes include increased domestic and academic expectations, as
well as greater autonomy and separation from home and family. Children of authoritarian parents who demonstrate low psychophysiological regulatory capacity may be particularly vulnerable or unequipped to adapt to the new demands they face in middle childhood, and may be at particular risk for later socioemotional, cognitive, and academic struggles.

One limitation of this research is the use of global parenting style, rather than a more comprehensive evaluation of parent-child interactions, which may capture additional pathways by which parent behavior and practice may shape child EC. Firstly, parenting style alone is not a comprehensive measure of all behaviors, practices, and day-to-day interactions involved in a parent’s role in the socialization of self-regulation. While parents can be grouped generally into one parenting style, parents are also likely to show some qualities of each parenting style, and individual parenting behaviors will likely differ in real-time practice due to contextual factors. For example, parenting style does not provide real-time information on dyadic interactions in emotional situations, but rather a global measurement of attitudes and beliefs. Thus, it is important to consider differences in parenting style and actual parenting practice. While parenting styles provide context for parenting practices, they do not necessarily reflect all day-to-day behaviors involved in parenting a child (Darling & Steinberg, 1993). It is the overall accumulation of parent-child interactions across time that have the greatest influence on children’s development, rather than measurement of singular episodes of interaction or parents attitudes and beliefs about their children.

It is also possible that there is mismatch between parent’s attitudes and beliefs, and how parenting behaviors are executed in real-time. While parenting style represents how parents believe they should be parenting their children in an ideal world and influence parenting behavior indirectly, real-time situational demands and individual situational motivations may
undercut this ideal. Parent-child relationships are characterized by bidirectional transactions (Scarr & McCartney, 1983). While parenting style may guide transactional processes between parents and their children, it is also possible that individual child traits may elicit different types of parenting behaviors or parenting styles, and the direction of this influence may change in accordance with individual goals. Moving forward, perhaps parenting style and real-time parenting behaviors should be used as complementary measures to better understand how perceptions of parenting versus actual behavior play a role in shaping child outcomes.

An additional limitation of the measure of parenting style is the lack of generalizability and consistency of results beyond European American samples. Findings from cross-cultural work suggest that parenting style may not be culturally relevant and meaningful in examining African American, Hispanic American, and Asian American child outcomes. Asian American parents have been found to show the highest authoritarian parenting, while their children have the highest academic achievement (Dornbusch et al., 1987; Steinberg et al., 1992). One explanation for this is that Chinese mothers partake in a parenting style depicted by high involvement, concern, and support, as well as high obedience, monitoring, and guidance, which overlap with the authoritarian concept. Additionally, Baumrind (1972) found a positive relation between authoritarian parenting and preschooler’s prosocial maturity in African American families. Another paper by Brody and colleagues (1998) examined “no-nonsense” parenting in rural, single-parent, African American families by high parental control, including the use of physical restraint and punishment that occur along with affectionate behaviors. The discipline and high control of no-nonsense parenting overlaps with authoritarian parenting style and is thought to protect children from dangerous environments and antisocial behavior while promoting self-regulatory competency. They found no-nonsense parenting style was associated
with higher self-regulation outcomes in school-age children from rural, single-parent, African-American households, suggesting a cultural discrepancy in how parenting styles affect child outcomes. Parenting style encompasses a broader long-term goal of what parents want their children to be like, and how they can parent to achieve that goal, rather than a short-term situational goal represented via behavior and interactions. More recent research leans toward examining specific behaviors and dimensions of parenting, which can complement parenting style studies. Overall, it is important to consider how relations between parenting styles and child outcomes may vary across groups and cultures.

One additional limitation is the potential for shared method variance due to parent-report of both parenting style and child EC. Parent report is perhaps one of the only ways to gain information on parenting style, because it allows us to accurately capture information about parent’s beliefs and attitudes that cannot be captured via direct observation of behavioral measures. Parent report of EC captures a parent’s perception of a child’s EC, rather than directly measuring real-time behavior or self-regulatory abilities (Kagan & Fox, 2006). Children at this age and younger ages may not be accurate reporters of their own EC abilities and behavioral measures provide more sensitive measurement of EC in young children (Kochanska, Coy & Murray, 2001; Rueda et al., 2004). Shared method variance poses potential difficulty in detecting any true moderation effects associated with RSA, due to the baseline high concordance between the questionnaire measures. Despite this, we still found that RSA moderated the relation between authoritarian parenting and child EC. Additionally, in this sample we see less variance in parenting style for authoritative and permissive parenting, compared to what we see for authoritarian parenting. Perhaps if we saw more variation, particularly with permissive parenting,
the relation between parenting style and EC may be negative, and perhaps moderated by baseline RSA.

To address these limitations, future research should include direct behavioral observation of child EC, as well as parenting behavior and practice. Observing behavior in the lab or in a naturalistic setting can provide additional complementary information about parent-child interactions beyond parenting style, such as real-time dyadic processes. The inclusion of individual and dyadic behavioral measures can provide insight to real-time interactions between parent and children that shape EC outcomes more directly and dynamically than parenting style. Additionally, examining these both micro- and macro-longitudinally can provide insight to impact or mechanisms that occur on varying timescales.

Future studies examining psychophysiological vulnerabilities in stressful environments should also consider simultaneous measurement of neural mechanisms or reactivity (i.e. sympathetic regulation of the heart) as well as neuro-chemical mechanisms (i.e. HPA axis) to examine additional phylogenetic substrates of regulation that may be employed by individuals unable to regulate by sympathetic activity. Expanding on this could also further biologically explain links between self-regulation and health (Moffit et al., 2011) that are compounded by environmental stressors, and provide an avenue for future diathesis-stress oriented research, and expanding on previously noted relations between parenting style and health behaviors related to smartphone addiction, alcohol abuse, and eating behaviors.

While the current study provides a “broad strokes” examination of these constructs, moving forward it will be important to examine more specific components. For example, more recent research in the field tends to focus on particular individual components of EC, including inhibitory control and attentional processes. Examining aspects of EC with increased specificity
will allow us to uncover internal and external factors that may differentially affect these more finite aspects of EC. Additionally, incorporating specific parenting behaviors and practices can complement our knowledge of parenting style. It is also important to note that self-regulatory processes develop earlier than the 5-7 year shift, which should also be studied. However, we focus on the 5-to-7-year shift because it is the age of transition to formal school and subsequently increased independence of both children and their parents. Moving forward, a better understanding of factors underlying individual differences in temperament, especially interactions with the environment and across multiple levels of analysis, will be useful for understanding risk and resilience processes for later outcomes (Uher, et al., 2018).

**Conclusion and Broader Implications**

Understanding mechanisms underlying EC development is critical to identify vulnerable children who are at risk for low self-regulation, and subsequent socioemotional, academic, and cognitive outcomes. This study highlights internal and external factors contributing to self-regulation outcomes in children, particularly vulnerability factors associated with low EC, which has implications for identifying mechanisms to target in creating self-regulation interventions for children. The study also addresses important questions about the measurement and interpretation of baseline RSA in a normative sample. Building on these findings and interpretations, future work can be applied to examining early childhood interventions to promote EC development and prevent maladaptive outcomes, as well as incorporating novel measurement techniques to examine autonomic reactivity and regulation as is relates to individual temperament, behavior, and contextual factors.
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