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The relation between physiological regulation, caregiver emotional support, and task engagement was examined among a diverse sample of 4-year old children (N = 244). It was predicted that physiological regulation and caregiver emotional support would facilitate greater behavioral task engagement. It was also hypothesized that caregiver emotional support would moderate the relation between physiological regulation and engagement, as children who receive greater support would be less reliant on their physiological resources. Children were observed on six dimensions of engagement during a frustrating puzzle task, during which child vagal tone was also measured. Primary caregivers were observed for emotional responsiveness during a parent-child problem-solving game. Factor analysis was conducted to examine factor structure of task engagement. The resulting engagement factor was predicted by child physiological regulation: Children with greater vagal withdrawal exhibited greater behavioral engagement. However, caregiver emotional support was unrelated to engagement and its moderating effect on the relation between physiological regulation and task engagement was not significant. This study demonstrates the role of physiological regulation in facilitating observable behavioral engagement among preschool age children, but failed to replicate a relation between caregiver support and engagement.

BIOPSYCHOSOCIAL ANALYSIS OF TASK ENGAGEMENT AMONG PRESCHOOL-AGE CHILDREN

by

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Approved by

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Committee Chair

To my grandmother and grandfather. Thank you for showing me the meaning of love, dedication, and strength.

APPROVAL PAGE

This thesis written by Simone E. Halliday has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

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CHAPTER I

INTRODUCTION

Engaged behavior during goal-oriented tasks and learning activities is critical for children to succeed academically. Broadly, engagement is hypothesized to mediate the effect of parents, peers, teachers, and community structures on important developmental outcomes, such as school completion and success (Appleton, Christenson, & Furlong, 2008; Reschly & Christenson, 2012). However, although early engagement is predictive of future engagement (Ladd & Dinella, 2009) and achievement (Li-Grining, Votruba-Drzal, Maldonado-Carreño, & Haas, 2010), little focus has been given to the development of engagement in early childhood. As the pre-school years comprise an important period for the development of self-regulatory skills at the behavioral, affective, and cognitive levels (Calkins & Fox, 2002), this stage may also be central to the development of adaptive, goal driven task engagement. On an empirical level, indicators of engagement during early childhood, such as persistence, have been negatively related to behavioral problems (Eisenberg et al., 2001a/2001b; Zhou et al., 2007) and positively related to cognitive and academic skills (Deater-Deckard, Petrill, Thompson, & DeThorne, 2005; Mokrova, O'Brien, Calkins, Leerkes, & Marcovitch, 2013; Sigman, Cohen, Beckwith, & Topinka, 1987). Thus, early task engagement appears to be a critical yet understudied factor contributing to school readiness and success, and gaining a better understanding of the mechanisms driving engagement in early childhood may help inform early interventions and preschool programing.

Current research suggests that caregivers help influence the development of engagement (Bempechat & Shernoff, 2012; Grolnick & Ryan, 1989). In early childhood, parental emotional support may be particularly important for promoting the behavioral, affective, and motivational processes needed to effectively engage in goal-driven tasks (Mokrova, O'Brien, Calkins, Leerkes, Marcovitch, 2012). However, little research has focused on how characteristics of the child may influence early task engagement. Indeed, in order to be engaged with a task, one must have the capacity to control one's attention and frustration. Thus, physiological processes that influence self-regulatory ability, such as the parasympathetic system, may be particularly helpful in explaining the development of engagement during early childhood. Furthermore, in accordance with a biopsychosocial perspective (Sameroff, 2010), these caregiver and biological factors may interact to influence the development of task engagement. Indeed, developmental processes are rarely one-dimensional and likely involve a dynamic interplay between both internal and environmental factors (Nowakowski, Schmidt, & Hall, 2010). Thus, the goal of the current study was to explore the relation between physiological regulation and task engagement and to examine how maternal emotional support may moderate the effect of physiological regulation on a child's ability to engage.

Task Engagement

Research on engagement during school and learning activities crosses the fields of both psychology and education. As such, the operational definitions of engagement used among many of these studies have historically varied in substantial ways (Appleton et al., 2008). However, current theory generally describes engagement as a multidimensional construct that operates on several inter-related levels, all of which dynamically interact to influence one another (Finn & Zimmer, 2012; Fredricks, Blumenfeld, & Paris, 2004). Although various components of engagement have been hypothesized, the three most agreed upon dimensions differentially operate at the behavioral, affective, and cognitive levels (Appleton et al., 2008; Fredricks et al., 2004; Jimerson, Campos, & Greif, 2003; Reschly & Christenson, 2012). According to Fredricks and colleagues (2004), behavioral engagement is commonly qualified by such indicators as on-task and persistent behavior, attention to instructions, adherence with rules, and active cooperation. The precise indicators used by different researchers to measure behavioral engagement tend to vary based on the context of the task and developmental age of interest. Among preschoolers, staying on task and following rules may be specific, developmentally appropriate markers by which behavioral engagement may be measured (Mahatmya, Lohman, Matjasko, & Farb, 2012).

In contrast to behavioral engagement, affective and cognitive engagement refer to more internal processes that may be more difficult to observe. Affective engagement is thought to be driven by the valuation of and identification with either the task itself or the social environment in which the task is conducted (Fredricks et al., 2004). Furthermore, as affective engagement specifically concerns intrinsic interest, positivity, and identification, it may thus have some relation to motivational processes. Cognitive engagement may also be conceptualized through a motivational perspective: It may be characterized by internal investment, effort, and a desire for challenge (Connell & Wellborn, 1991; Jimerson et al., 2003; Newmann, Wehlage, & Lamborn, 1992). However, research following Self-Regulated Learning Theory (SRL; Zimmerman, 1990) describes cognitive engagement in terms of cognitive self-regulation. As such, a cognitively engaged child may strategically plan her behaviors and evaluate her performance (Cleary & Zimmerman, 2012; Pintrich & De Groot, 1990). In early childhood, when these skills are still beginning to develop, displays of effortful control may offer an observable manifestation of cognitive engagement (Mahatmya, et al., 2012). Despite the two distinct interpretations of cognitive engagement, both motivation and cognitive control processes are necessary for engagement. For example, Cleary and Zimmerman (1990) suggest that both the *will* to engage and the *skill* to strategically regulate one's level of engagement are interrelated processes that are both critical for successful learning.

Although motivation is often integrated into definitions of cognitive and affective engagement (Connell & Wellborn, 1991; Fredricks et al., 2004; Jimerson et al., 2003), current theory largely agrees that engagement and motivation are two separate constructs (Appleton et al., 2008; Bempechat & Shernoff, 2012; Reschly & Christenson, 2012). Some researchers have suggested that motivation represents internal drives, whereas engagement is the behavioral result of these drives (Reeve, 2012). As such, motivation is considered a more abstract psychological process, whereas engagement is more tethered to action and task involvement. (Appleton et al., 2008; Finn & Zimmer, 2012; Newman et al., 1992). Thus, motivation may be considered the unobservable mediator of engagement (Reeve, 2012). Although motivation is often operationalized by behavior, such as persistence on a laboratory task (Deci, Driver, Hotchkiss, Robbins, & Wilson, 1993; Frodi, Bridges, & Grolnick, 1985; Morgan, Harmon, & Maslin-Cole, 1990), these behaviors may be more accurately described as measures of engagement. In general, motivation and engagement are considered two separate but highly overlapping constructs, whereby motivation is necessary but not sufficient for engagement (Appleton et al., 2008).

Although the current multidimensional model of engagement is well accepted, many researchers do not consistently measure aspects of each component of engagement or only measure a single indicator within one component. These methodologies may thus obscure the complexity of the engagement construct and lead to false conclusions about its mechanisms. Indeed, a single behavior may mean different things within different contexts. For example, a common method of measuring engagement or motivation in the laboratory setting is by calculating the time or proportion of time that a child remains on task. However, measuring on-task behavior in this way obfuscates any differences in engagement when task difficulty changes and therefore ignores potentially important variation in effort and reaction to challenge. This methodology also ignores emotional responses to success and the energy with which the task is completed. Furthermore, it may overlook instances of perseveration, whereby a child may be task focused, but engaging in repetitive behaviors that are inappropriate for the task at hand. Thus, assessing multiple indicators of engagement, across its three domains, is not only more faithful to current theory but also more empirically informative.

Despite these methodological problems, the construct of engagement has been validated through both its theoretical and empirical links to positive developmental outcomes. Indeed, engagement is theorized to mediate the effects of contextual factors, such as family and school environment, on academic success (Appleton et al., 2008; Reschly & Christenson, 2012). Longitudinal studies suggest that engagement in school is predictive of future achievement (Li-Grining et al., 2010) and school completion (Finn, 2006; Reschly & Christenson, 2006). Furthermore, Ladd and Dinella (2009) not only found that engagement predicted achievement, but also that behavioral and affective engagement reciprocally predicted changes in one another between the first and third grade. Indeed, engaged behaviors, such as active participation within a classroom and involvement with class assignments, are necessary in order to learn and successfully achieve. This success may in turn satisfy the drive for competence and elicit greater interest in and identification with specific tasks or the social environment in which those tasks were completed. Specifically, identification with teachers, peers, and parents may encourage greater interest and participation. Furthermore, feelings of positivity and interest in a task should promote both greater on-task behavior and deeper cognitive effort with regard to that task. Thus, engagement and success cyclically reinforce one another, particularly in environments that support positive social and learning experiences.

Although much of the current research has focused on how engagement affects academic outcomes in middle childhood and adolescence, there is also evidence for the importance of task engagement in early childhood. Indeed, indicators of engagement in kindergarten were found to predict not only concurrent achievement (Howse, Calkins, Anastopoulos, Keane, & Shelton, 2003), but also both math and reading performance in the fifth grade (Li-Grining et al., 2010). Furthermore, observed on-task behavior in preschool was predictive of academic achievement in kindergarten (Mokrova et al., 2013). As with older children, greater on-task behavior and regulated participation with goal-driven tasks offer greater opportunities for success and identification, which may launch cascading cycles of success and engagement throughout development.

Engagement may also have a direct impact on socio-emotional development. Among a sample of children whose ages ranged from 4.5 to 8 years of age, greater persistence on a task that could easily be cheated on was related to better social competence, as rated by both parents and teachers (Eisenberg et al., 2001b). Eisenberg and colleagues (2001a) also found that children classified as high on externalizing or on both externalizing and internalizing behaviors were less persistent than control children. It is possible that goal-driven task engagement may therefore generalize to social tasks as well, in that children who display greater learning engagement also display greater engagement during social play. However, it is also possible that engagement during a learning or goal-driven task may promote more positive emotions about the social environment in which the task is completed, thus leading to more positive social behavior. Taken altogether, these finding suggest that engagement plays a key role in successful school adjustment, both in the academic and social domains.

Thus, understanding the development of task engagement and the mechanisms that support it will provide crucial insight into patterns of adaptive school success and adjustment. Furthermore, given the hypothesized cyclical nature of engagement and success, investigating the predictors of engagement before enrollment in formal school may elucidate how trajectories of achievement begin. In assessing these predictors of engagement, it is important to consider factors both extrinsic and intrinsic to the child. Of specific importance may be the child's caregiving environment and internal biological mechanisms.

Physiological Regulation and Engagement

Although current definitions of engagement acknowledge the importance of processes at the behavioral, cognitive, and emotional levels, the hypothesized metaconstruct of engagement may be missing an important fourth dimension on the biological level. Indeed, the biopsychosocial perspective of development highlights the importance of both biological and psychological processes within the individual's self-system and suggests that these internal processes interact to influence behavior and developmental change (Sameroff, 2010). With respect to learning engagement, one's physiological capacity to regulate attention and emotion while involved in a task may either constrain or promote the ability to remain behaviorally on task, positively oriented, and cognitively regulated.

As task engagement may be interpreted as the behavioral result of motivational (Reeve, 2012) and regulatory (Cleary & Zimmerman, 2012) processes, it may be particularly informative to investigate the biological systems that influence behavioral manifestations of engagement. Specifically, behavior may be constrained by one's physiological capacity to regulate attention and emotion while involved with a task, as the inadequate allocation of internal physiological resources during challenge may impede optimal coping and attentional focus. Using a biobehavioral framework may also be particularly valuable for understanding the internal processes that support behavioral manifestations of engagement during early stages of development, as young children may not be able to reliably and validly report upon their internal thoughts and motivations (Fox, Hane, & Pérez-Edgar, 2006). As biological indicators can be used to measure affective regulation and focus (Beauchaine, 2001; Suess, Porges, & Plude, 1994), measuring these processes during task involvement may provide additional insight into the internal, unobservable processes that underlie behavioral engagement.

Neurobiological processes are integral to the expression and development of both simple and complex regulatory processes (Calkins & Fox, 2002). Specifically, neural and physiological processes provide the basis of reactivity and regulation, and these systems collectively operate to control attention and arousal. Although many biological systems may influence self-control processes, vagal withdrawal, an indicator of parasympathetic activity, is widely used in the psychobiology literature as a measure of physiological regulation. Vagal tone is a neuro-cardiac process, whereby the cranial vagus nerve exerts an inhibitory influence on the sinoatrial node of the heart. According to Polyvagal Theory, the cranial vagus nerve suppresses its cardio-inhibitory influence during stress, thus allowing the heart to beat faster (Porges, 2003). This elevated heart rate allows greater physiological resources to be dedicated to the resolution of current challenge (Calkins & Fox, 2002; Suess et al., 1994). Accordingly, studies have demonstrated a decrease in vagal influence on the heart, measured by changes in respiratory sinus arrhythmia (RSA), during several types of laboratory procedures, including frustration, problem solving, sustained attention, social, and cognitive tasks (Calkins & Keane, 2004; Graziano & Derekfinko, 2013; Suess et al., 1994).

Both resting vagal tone and changes in vagal tone during challenge have important behavioral implications. The amount of influence that the vagus nerve exerts on the heart during rest is often associated with temperamental reactivity, where higher resting vagal tone indicates greater reactivity and environmental sensitivity than lower resting vagal tone (Beauchaine, 2001; Porges, Doussard-Roosevelt, & Maiti, 1994). In contrast to resting measures, the change in vagal tone from baseline to task, known as vagal withdrawal (VW), is commonly used as a measure of physiological regulation. As the vagus nerve withdrawals its inhibitory influence on the heart during challenge, homeostasis is reorganized so that greater energy can be dedicated to emotional coping and attentional control (Calkins & Fox, 2002; Suess et al., 1994). As such, vagal withdrawal is thought to regulate internal resources. Individual differences in vagal withdrawal during challenge may have important implications for child adaptability (Graziano & Derefinko, 2013). Indeed, high vagal withdrawal is generally considered protective, as it is associated with fewer concurrent behavioral and emotional problems, greater sociability (Calkins, 1997; Calkins & Dedmon, 2000; Doussard-Roosevelt, Montgomery, & Porges, 2003; Hastings et al., 2008a; Musser et al., 2011; Porges, Doussard-Roosevelt, Portales, & Greenspan, 1996) and academic ability (Katz & Gottman, 1997). Furthermore, longitudinal studies have demonstrated that vagal regulation in toddlerhood is predictive of behavioral outcomes in pre-k and kindergarten (Calkins, Blandon, Williford, & Keane, 2007; Calkins & Keane, 2004).

Vagal withdrawal may also have important consequences for task engagement, via its effects on attention and emotion. Specifically, increased suppression of the vagus nerve may allow the body to refocus its resources and dedicate greater energy towards coping with negative emotions, such as frustration, and attending to task goals and strategy selection. Indeed, physiological processes may be particularly important for promoting regulated activity during goal driven tasks among young children, as more advanced cognitive control strategies needed to monitor behavior and effort may not yet have developed. As such, vagal withdrawal may represent a form of physiological engagement, where higher levels of withdrawal promote greater cognitive, affective, and behavioral engagement.

Although much of the empirical literature on vagal withdrawal has focused on its relation to broad social-emotional adjustment and, to a lesser extent, cognitive and academic ability, less research has examined its relation to engagement during goal-driven activities. However, focusing on the theoretical link between vagal withdrawal and engagement may be critical to understanding the mechanisms through which physiological regulation affects broader developmental outcomes. For example, children with increased vagal withdrawal may have greater resources to remain behaviorally on-task, cope with frustration, and devise appropriate strategies. As such, this increased task engagement will provide children with greater opportunities to learn and promote greater chances of success.

Several studies provide theoretical support and empirical evidence for this relation between vagal withdrawal and task engagement in children. Suess and colleagues (1994) found that vagal tone significantly decreased during a sustained attention task and therefore suggested that vagal withdrawal is associated with mental effort and attention. Blair and Peters (2003) directly tested the relation between on-task behavior in the classroom and vagal withdrawal and found that preschool-aged children who demonstrated decreased vagal withdrawal during an executive functioning task were rated as more on-task by their teachers. Similarly, Calkins and colleagues (2007) reported a small but significant correlation between vagal withdrawal and mother-report on the interest/persistence subscale of the Toddler Behavior Assessment Questionnaire (Goldsmith, 1996) among a sample of 2-year old children. Although these findings indicate a relation between engagement and vagal withdrawal, the use of parent and teacher report may introduce reporter biases into the data that may be avoided by more objective laboratory assessments of engagement that include a diverse set of behavioral indicators.

The adult motivation literature provides further insight into the relation between physiological regulation and engagement. Research on Motivational Intensity Theory uses processes related to the autonomic nervous system as a way of measuring concurrent effort and engagement in adults (Silvia, Eddington, Beaty, Nusbaum, & Kwapil, 2013). Among adult populations, it is hypothesized that sympathetic activity implies motivational engagement, as it indicates active increase in arousal and effort, whereas parasympathetic activity regulates this arousal in order to control emotion and stress.

Although these studies most commonly employ measures of sympathetic activity, more recent research has also included RSA as a supplementary indicator of emotion regulation during goal-driven tasks (Kreibig, Gendolla, & Scherer, 2010; Silvia et al., 2013). Given that adults may have more diverse cognitive and behavioral mechanisms to maintain engagement that are not yet fully developed among young children, physiological processes may be particularly important for children to sustain engagement on a task.

Emotion Support and Engagement

Although these biopsychological processes are integral to the understanding of development, they do not occur within a vacuum. Rather, development is driven by both intrinsic and extrinsic factors (Nowakowski et al., 2010; Sameroff, 2010). According to the biopsychosocial perspective, the biopsychological self-system is embedded within Bronfrenbrenner's model of social ecology, which specifies that overlapping spheres of context provide the environment in which development occurs (Sameroff, 2010). Indeed, current literature on school age children and adolescents suggests that engagement is highly influenced by school (Lee & Smith, 1993/1995), teacher (Klem & Connell, 2004; Reeve, Jang, Carrell, Jeon, & Barch, 2004; Skinner, Furrer, Marchand, & Kindermann, 2008), peer (Perdue, Manzeske, & Estell, 2009), and parent factors (Bempechat & Shernoff, 2012; Grolnick & Ryan, 1989). Before children enter school, greater time may be spent within the home environment, and parenting factors may be among the most relevant and influential extrinsic predictors of engagement. Specifically, emotionally supportive parenting may influence child engagement by promoting the development of regulatory skills, a sense of autonomy, and feelings of relatedness (Grolnick & Farkas, 2002; Deci et al., 1993; Jennings & Connors, 1989; Mokrova et al., 2012; Salonen, Lepola, & Vauras, 2007; Young & Hauser-Cram, 2006).

Caregiver factors have strong implications for the development of self-regulation, particularly in regard to emotion control (Calkins & Hill, 2007; Fox & Calkins, 2003). During infancy and early childhood, children are not yet able to adequately self-regulate and must therefore rely on caregivers to help control their arousal and model effective behavioral coping strategies (Calkins & Hill, 2007). As young children develop self-regulatory mechanisms, parents must continue to scaffold this development by providing supportive caregiver-regulation. Thus, parents who are more sensitive to their children's needs and displays of distress may be better able to identify situations in which their child is capable of regulating on his own versus when help is needed. On the other hand, parents who display over-controlling behavior or exert control when it is unnecessary may inhibit the development of child self-regulation. Indeed, children experiencing parental over-control may not have the opportunities to learn behavioral regulation strategies or develop the intrinsic regulatory skills (Fox & Calkins, 2003) necessary to successfully engage (Cleary & Zimmerman, 2012; Pintrich & De Groot, 1990).

Autonomy support may also play an important role in shaping the motivational processes that promote engagement (Fredricks et al., 2004; Raftery, Grolnick, & Flamm, 2012; Reeve, 2012). According to Self-Determination Theory (Deci & Ryan, 1992), humans have a basic need to feel autonomous. Therefore, individuals are expected to be more intrinsically motivated during self-selected activities and after achievements for which they feel responsible (Deci & Ryan, 1992). As such, caregivers who support autonomous behavior and foster optimally challenging environments provide opportunities for their children to feel both agentive and efficacious. In turn, these feelings may promote ambitious goal setting behavior (Deci & Ryan, 1985), which is an indicator of cognitive engagement. Conversely, adult over-control may disturb a child's natural tendency to engage in appropriately stimulating activities, constrain a sense of autonomy and competence, and promote an external locus of causality (Deci & Ryan, 1985). For example, when parents interfere with their children's activities—perhaps by providing unnecessary rewards, punishments, criticism, or unwanted help—they may deny their children a sense of choice and undermine the intrinsic value of the intruded upon task (Deci, et al., 1993; Deci & Ryan, 1987).

Empirically, parental support for autonomy is predictive of persistence during laboratory tasks in infancy and early childhood (Frodi et al., 1985; Jennings & Connors, 1989; Deci et al., 1993) and school engagement and motivation in middle childhood (Ginsburg & Bronstein, 1993; Grolnick & Ryan, 1989; Wang, Pomerantz, & Chen, 2007). Moreover, research has established a positive relation between teacher support for autonomy and student engagement among school age children (Reeve et al., 2004; Skinner et al., 2008). Given that parents are likely a more proximal source of education for children before they enter school, these teacher findings provide further evidence that parental autonomy support may be predictive of engagement during early childhood.

Self-Determination Theory also posits that humans have a basic drive to feel related to others. As such, contexts that promote feelings of security and social relatedness will foster internal processes of interest and investment (Ryan & Deci, 2000) and encourage engagement (Fredricks et al., 2004; Reeve, 2012). Feelings of relatedness may be most directly relevant to the dimension of affective engagement, which signifies positive emotions and feelings of identification with a specific task or the environment in which that task is performed. Empirically, a stronger sense of relatedness to and belonging within a social network of parents, peers, and teachers is related to greater classroom engagement in early childhood (Birch & Ladd, 1997), middle childhood (Furrer & Skinner, 2003) and early adolescence (Goodenow, 1993). Among younger children, parental variables that promote a sense of relatedness, such as positive affect and emotional support, have been associated with greater on task behavior and other behavioral indicators of motivation and engagement (Eisenberg et al., 2003; Jennings & Connors, 1989; Mokrova et al., 2012; Salonen et al., 2007; Young & Hauser-Cram, 2006).

Studies examining parenting behaviors more generally also corroborate the positive influence of emotion support on child engagement. Parent involvement (Estell & Perdue, 2013) and the parent-child relationship quality (Perdue et al., 2009) were predictive of child engagement among school age children. Among preschoolers, emotionally supportive behaviors, such as low intrusiveness and high responsive encouragement, were specifically related to child on task behavior and behavioral self-control (Neitzel & Stright, 2003). Furthermore, among a sample of 4-year-old children, emotional support, but not cognitive support, was positively related to pre-academic skills (Leerkes, Blankson, O’Brien, Calkins, & Marcovitch, 2011) and on-task behavior

(Mokrova et al., 2012). Thus, caregiver emotional support may play a specific role in promoting behavioral engagement, especially among young children.

Altogether, current theory and empirical work suggest that parental emotional support may affect such child processes as motivation and self-regulation and in turn promote greater engagement at the cognitive, affective and behavioral levels.

Physiology and Emotion Support

Differences in caregiver emotional support may also be important for task engagement in that it may alter the relation between child physiological regulation and task engagement. Indeed, current theory suggests that the transactions between internal and environmental factors, and not just the factors themselves, are key to understanding development (Calkins, 1994; Gottlieb & Lickliter, 2007; Nowakowski et al., 2010; Sameroff, 2010). Given the proximal influence of parenting during early childhood, it is likely that caregiver behaviors interact with factors on the child level. Supporting empirical research has indeed demonstrated that parent and child characteristics interact to predict developmental outcomes (Dennis, 2006; Kochanska, Aksan, & Joy, 2007), and several studies have found interesting interactive patterns specifically between parenting and child physiology (El-Sheikh, 2001; Hastings et al., 2008b; Leary & Katz, 2004; Perry, Calkins, Nelson, Leerkes, & Marcovitch, 2012).

Thus, caregiver emotional support may moderate the influence of physiological regulation on engagement. Specifically, children with greater support may be less reliant on their ability to physiologically regulate than children with less emotional maternal support. In contexts of low emotion support, children may not develop strong behavioral regulatory skills or motivational drives and must therefore rely more heavily on their ability to physiologically regulate when engaging with a task. On the other hand, emotionally supportive parenting may help mitigate physiological risk by promoting the development of stronger behavioral regulatory skills and motivational drives within the child. These bolstered resources may in turn offset any deficit imposed by weaker physiological regulation.

Current Study

This study investigated the direct and indirect effects of both parental emotional support and physiological regulation, as they related to task engagement in 4-year old children. Relations among these variables may be particularly important to investigate at this age, as children in this transitional developmental period may begin to engage in more formal goal-driven tasks for the first time. Furthermore, given the important role engagement plays in predicting school adjustment, understanding engagement before the beginning of school may have practical implications for interventions work aimed at eliminating performance gaps before kindergarten.

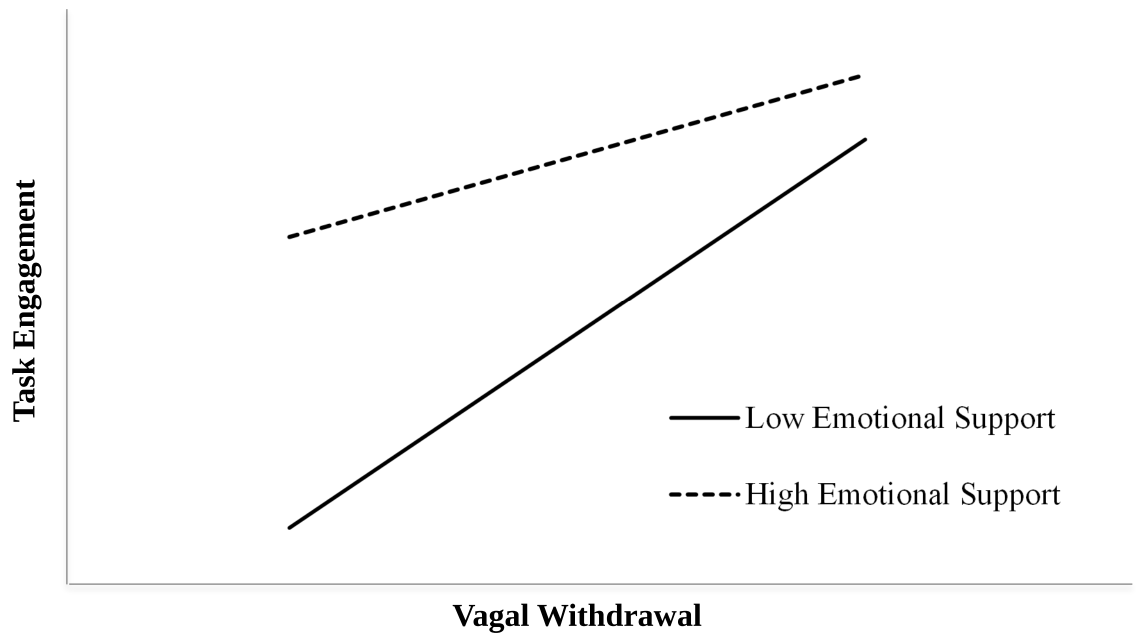
As preschool-age children may be less than reliable self-reporters and may not attend formal academically-focused preschool, the current study will measure task engagement solely through behavioral observation within the laboratory. Indeed, laboratory tasks may be uniquely useful for testing task engagement, as they eliminate reporter bias and allow direct comparison across children. Furthermore, the use of a complex coding system with multiple indicators of engagement may provide a rich portrait of engagement at this age. Although this methodology only directly measures behavioral engagement, behavioral indicators of affect, effort, and strategy use provide useful information about the underlying processes of cognitive and affective engagement and their observable manifestations. Another advantage to measuring several behavioral indicators of engagement is that a richer, more informative depiction of engagement can be drawn. By assessing behavioral indicators of strategy use and persistence during difficulty, we hoped to avoid conflating our measure of engagement with any maladaptive behavior, such as perseveration, and intended to explore qualitative differences in engagement even among children who remained on task during the entire duration of laboratory session.

Given the novelty of the current observational dimensions, no specific hypotheses about the factor structure of behavioral engagement were drawn. However, it was predicted that all dimensions of engagement would be moderately correlated and would be explained by three or fewer factors. It was deemed possible that all factors might load onto a single factor of behavioral engagement, as all indicators were measured through observed behavior. Conversely, we also considered that the scales primarily measuring affect would form its own factor specifically related to affective engagement, and that the measure of strategy use and persistence during difficulty would form its own factor specifically related to cognitive engagement. This largely exploratory factor analysis was conducted to inform future analyses using similar observational dimensions.

In accordance with the robust literature indicating that greater vagal withdrawal implies optimal regulation (Calkins, 1997; Calkins & Dedmon, 2000; Graziano & Derefinko, 2013; Porges, Doussard-Roosevelt, Portales, & Greenspan, 1996), it was predicted that children with higher levels of vagal withdrawal would be better able to physiologically regulate their attention and frustration and would thus be better able to maintain longer periods of engagement. It was also hypothesized that greater maternal emotional support would predict greater task engagement. Children with greater emotional support were expected to be more intrinsically motivated and to possess a more developed repertoire of behavioral regulatory strategies on which to rely, thus leading to greater task engagement.

Finally, it was also posited that maternal emotional support would moderate the relation between vagal withdrawal and task engagement. Greater maternal emotional support may promote the development of behavioral strategies that may allow more poorly regulated children to maintain engagement despite having fewer physiological resources to aid attention and emotional coping. In contrast, children who receive less maternal emotional support may lack these behavioral and motivational strategies that support task engagement and may thus be more reliant on their ability recruit greater physiological capital. Thus, the effect of physiological regulation on task engagement is expected to be stronger among children with lower emotional support than among children with higher emotional support (see Figure 1 for predicted results).

Figure 1. Predicted Interaction Among Emotional Support And Vagal Withdrawal In Predicting Task Engagement.



Vagal withdrawal is expected to have a larger effect on children with less emotional support than on children with greater emotional support.

CHAPTER II

METHODS

Participants

As a part of a larger longitudinal study, children and their mothers were recruited from daycares, preschools, and local centers within and around a mid-sized southeastern city of the USA. Two hundred and sixty three children joined the study at the age of 3.5 years. Of these 263 children, 244 were able to return for follow-up assessments approximately one year later. During the 4-year data collection wave, children ranged in age from 49-59 months (*M*=42.1, *SD*=2.0), were approximately split on sex (52% female), and were socioeconomically diverse (32% African American, 60% European American, 2% Hispanic, 6% other). Mothers were on average 34 years of age (*SD*=5.69). Fifty-three percent of mothers had completed a 3-year college degree or higher, 74% were married or living with a partner, and 77% worked outside of the home. Family annual income ranged from $2,400-$120,000 (*M*=$58,008, *SD*=$34,875), with an average income-to-needs ratio of 2.86 (*SD*=1.75). Mothers of the 244 participating children at the 4.5 year visit were on average older (t [259]= 2.36, p<.05), more likely to be white (□□[1, *N*=262]=5.06, p<.05), and more well educated than mothers of children who did not return for follow up analyses (t [259]= 2.46, p<.05).

Procedure

Families who wished to volunteer scheduled laboratory visits that lasted approximately 2 hours in length. During the visit, children completed several tasks with an experimenter while mothers filled out a series of questionnaires. Children were videotaped while completing most tasks, and both mother and child were videotaped during a mother-child game. Families received $60 for their time, and children were able to select a small toy to take home at the completion of the visit.

Measures

Demographics. Mothers provided information about their child's home and family environment. Demographics, such as family monthly income, number of individuals within the household, and child's race were collected. Family income-to-needs ratios were calculated by dividing the total family income by the appropriate poverty threshold, determined by the year in which the income was earned (2007) and the total number of adults and full-time children living within the household. Sex and minority status were dummy coded, with females and whites as the reference groups (0 = Female and 1 = Male; 0 = White, 1 = Non-white).

Maternal emotional support. Mother-child interaction was observed during a planning and problem-solving task, which lasted approximately 7 minutes. The mother and child pair were presented with a laminated game board, a die, a toy bear, and a set of cards depicting various chores. They were then given instructions to help the bear complete all of his chores and get to his friend's birthday party by rolling the die and moving the bear to the necessary destination (e.g,, grocery story, friend's house), depicted on the game board. The experimenter instructed the pair to complete the chores in the quickest way possible but refrained from giving any more specific instructions. The task ended when the bear reached the birthday party (i.e., the picture of the friend's house on the game board), when the mother and child stopped engaging in the task, or when the 7 minutes allotted to this task were complete. This task was designed to analyze the manner in which mothers guide their child's engagement on collaborative, goal-directed problem-solving tasks; thus, whether the dyad completed the game was not considered relevant for this task.

Maternal behavior was coded on a 5-point Likert-like scale for (1) *emotional responsiveness*, (2) *intrusiveness*, and (3) *negativity*. *Emotional responsiveness* measured sensitivity and warmth and assessed the extent to which mothers expressed enjoyment about being with the child, provided encouragement, and flexibly guided and maintained their child's focus on the current task. *Intrusiveness* assessed the lack of autonomy support through such behaviors as making decisions for the child, not allowing the child to have a turn, or provided too many directions. Finally, *negativity* gauged the amount of child-directed negativity through verbal and nonverbal cues. All three of these parenting dimensions had observed scores that ranged from 1 (low indication of behavior) to 5 (high indication of behavior). Approximately 20% of all videotapes (N=50) were coded by two coders in order to establish reliability. Inter-observer agreement was calculated by intraclass correlations, which were all high (emotional responsiveness = 0.90; intrusiveness = 0.91; negativity = 0.90). Maternal behavior was also coded for *metacognitive information* and *cognitive* information, but these dimensions were not used for current analyses.

These three dimensions of parent emotion-supporting behavior were aggregated into a single construct by averaging the scores into a single composite variable. Both intrusiveness and negativity were reversed before calculating the average. Internal consistency of the *emotion support* component was good (α = .78).

Child task engagement. Task engagement was measured during an impossible puzzle task. Children were presented with a wooden block that had a string laced through its many holes. The middle of the string was surreptitiously glued to the center hole of the toy, thus making it impossible to completely untangle the string from the toy. The experimenter instructed the child to completely untangle to string from the toy and then left the testing room. Mothers remained in the testing room with their child, but were instructed not to engage with or help their child. After 3 minutes, the experimenter returned with a visually identical toy that was not impossible and helped the child successfully untangle the string. Although there is some controversy as to whether unsolvable versus solvable tasks are best suited to measuring motivational processes in young children (Barret, MacTurk, & Morgan, 1995), impossible tasks may help eliminate the confounding effect of child cognitive competence. Specifically, unsolvable tasks should ensure that all children experience difficulty and that children do not complete the task before the allotted time has elapsed (McCall, 1995).

Children's behavior was coded on six dimensions, each assessing a different aspect of task engagement. All dimensions were rated on a Likert-like scale ranging from 1 (low/no indication of behavior) to 5 (high indication of behavior). *On-task behavior* measured maintained focus and involvement with the task and was largely based in the amount of time the child remained task-oriented. *Enthusiasm/Energy* described the extent to which a child displayed interest and eager engagement versus bored or passive activity. *Persistence* assessed continued effort and engagement even when the task became demonstrably difficult for each individual child. *Strategy use* measured how flexible children were in their problem-solving approaches (e.g., pulling the string when pushing it doesn't work, asking for help) and how well children could identify which part of the task needed greater focus effort (e.g., carefully isolating one piece of string to untangle versus pulling all strings at random). Behavioral signs of *positive* and *negative affect*, based on facial and vocal cues, were also assessed. Affect was coded on two dimensions, rather than one, to fully capture each child's affective profile. Two coders both coded approximately 10% of videos (N=25) to establish reliability. Interclass correlation coefficients ranged from 0.83 (enthusiasm/energy) to 0.95 (positive affect).

Vagal withdrawal. In order to measure child vagal tone, respiratory sinus arrhythmia (RSA) was collected during the impossible puzzle task and during a baseline task, which involved children watching a short non-arousing video. Electrocardiogram (EKG) was recorded through two disposable pediatric electrodes, placed on the child's chest and stomach, which were connected to a preamplifier that processed output through a vagal tone monitor (Series 2000 Mini0Logger, Mini Mitter Co., Inc. Bend, OR) for R-wave detection. Data files containing interbeat intervals (IBI) were edited for artifacts from movement. Forty-one data files were analyzed with MXEDIT software (Delta Biometrics, Inc, Bethesda, MD) and 156 were analyzed using Cardio Batch/Edit software (Brain-Body Center, University of Illinois at Chicago, Chicago, IL) to derive vagal tone. Vagal tone scores did not differ based on the software used for analysis. The distance between heart rate beats (IBI) was be calculated as a function of respiratory frequency (Porges, 1985) to obtain RSA every 30 seconds during baseline and every 15 seconds during tasks. Mean baseline RSA was subtracted from mean task RSA to obtain measures of RSA change for each task. Higher RSA difference scores indicate greater levels of vagal withdrawal.

Receptive Vocabulary. The Peabody Picture Vocabulary Test-III (PPVT; Dunn & Dunn, 1997), a test of receptive vocabulary, was collected for use as a potential covariate. Children are told a word and are instructed to point to the correct corresponding picture out of a display of four illustrations. Standard scores were calculated as a function of child chronological age and raw score. The possible range of scores was from 40 to 160 and observed scores ranged from 53 to 140.

Data Analysis

Data reduction and factor analysis. Given the novelty of the coding scheme used to assess task engagement, exploratory factor analysis was used to assess how best to summarize these observations for hypothesis testing. Given the proposed multidimensionality of school engagement among school age children (Fredricks et al., 2004), multiple factors may be needed to best explain these data. On the other hand, an overarching single construct of task engagement may also emerge. Iterative principle components method was used to extract factor weights and explained variance, and, given the identical scale (1 to 5) on which all behaviors were coded, a covariance matrix was used to analyze interrelations among the variables. The results of this factor analysis were used as the dependent variable(s) for all subsequent analyses.

Regression analyses. A series of regressions were conducted to analyze the possible main effects of and interaction between caregiver emotional support and physiological regulation in predicting task engagement. To control for the possible confounding effects, receptive vocabulary and demographic variables found to significantly correlate with task engagement were entered into the first step of the equation. Baseline level RSA was also entered at this initial step to control for any confounding influence of resting vagal tone. In the second step, the main effects of centered caregiver emotional support and centered vagal withdrawal were entered. The interaction term, created by multiplying centered scores of caregiver emotional support and vagal withdrawal, was entered during the third and final step of analysis. Individual variable betas and changes in explained variance at each step were analyzed.

CHAPTER III

RESULTS

Missing Data

Out of the full sample of 244 children, 196 cases were used for analyses. Task engagement data for one child was not used, due to experimenter error during task administration. Vagal tone data was not collected for 32 children: Nine children refused to wear the equipment, seven files were deemed unanalyzable, four files were lost due to experimenter or equipment error, and 12 visits were conducted off-site, where heart rate equipment was unavailable. Additionally, baseline vagal tone was missing for eight children and vagal tone during the challenge task was missing for an additional three children. Thus, change scores were unable to be calculated for these 11 children. Four outliers were also removed from analyses: One case had an extreme baseline score and three cases had extreme vagal change scores. Finally, four mothers failed to report family income; therefore, these incomes-to-needs ratios could not be calculated. All four of the children whose mothers failed to report income were also missing vagal withdrawal scores. All analyses were computed using listwise deletion of missing observations.

Descriptive Statistics

Means and standard deviations of all variables can be found in Table 1. All variables fell within the normal range of skewness and kurtosis.

Table 1. Descriptive Statistics of Study Variables

	N	Mean	SD	Skewness (SE)	Kurtosis (SE)
Task Engagement					
On-task behavior	243	3.54	1.13	-0.36 (0.16)	-0.75 (0.31)
Enthusiasm	243	2.88	0.89	-0.37 (0.16)	-0.18 (0.31)
Persistence	243	3.27	1.23	-0.21 (0.16)	-0.81 (0.31)
Strategy Use	243	3.33	1.16	-0.36 (0.16)	-0.66 (0.31)
Positive Affect	243	1.63	0.93	1.43 (0.16)	1.29 (0.31)
Negative Affect	243	2.26	1.10	0.64 (0.16)	-0.32 (0.31)
Task engagement component	243	0.00	1.00	-0.49 (0.16)	-0.56 (0.31)
Emotional Support					
Emotional responsiveness	244	3.82	0.99	-0.32 (0.16)	-0.76 (0.31)
Intrusiveness	244	2.26	1.21	0.71 (0.16)	-0.51 (0.31)
Negativity	244	1.50	0.74	1.98 (0.16)	5.50 (0.31)
Emotional support composite	244	0.02	0.83	-0.91 (0.16)	0.63 (0.31)
Physiological Regulation					
Vagal tone (baseline)	202	6.64	1.08	-0.18 (0.17)	-0.22 (0.34)
Vagal tone (task)	208	5.42	1.13	0.10 (0.17)	0.18 (0.34)
Vagal withdrawal	197	1.26	0.73	0.21 (0.17)	0.44 (0.36)
Receptive vocabulary (std score)	244	105.86	14.89	-0.35 (0.16)	0.20 (0.31)
Income-to-needs ratio	240	2.86	1.75	0.53 (0.16)	-0.44 (0.31)

Factor Analysis and Data Reduction

All six engagement dimensions were significantly correlated with one another (min $|r|$ =0.14, max $|r|$ = 0.83, $p < .05$, see Table 2). Factor analysis on these dimensions yielded a single component with an eigenvalue greater than the mean eigenvalue value (see Table 3). Although a second factor yielded an eigenvalue close to the mean eigenvalue value (M = 1.17), this factor primarily explained variation in only a single variable - negative affect. Furthermore, a scree plot (see Figure 2) corroborated the use of a single factor, given the linear formation of factors two through six and the steep increase in slope between the first and second factors. The single retained factor explained 60.10% of the variance and contrasted on-task behavior (Λ=0.88), enthusiasm (Λ=0.88), persistence (Λ=0.94), strategy use (Λ=0.85), and positive affect (Λ=0.34) with negative affect (Λ= -0.44). Thus, only one component of engagement, which will be labeled *task engagement*, was retained for future analyses. Component scores were calculated for each individual by forming a linear combination with individual scale scores and component weights.

Table 2. Correlation Matrix of Six Task Engagement Dimensions

	1	*2*	*3*	*4*	*5*
1. On task behavior	-				
2. Enthusiasm	.75**	-			
3. Persistence	.83**	.78**	-		
4. Strategy use	.63**	.71**	.70**	-	
5. Positive affect	.19**	.33**	.21**	.29**	-
6. Negative affect	-.23**	-.18**	-.41**	-.28**	-.14*

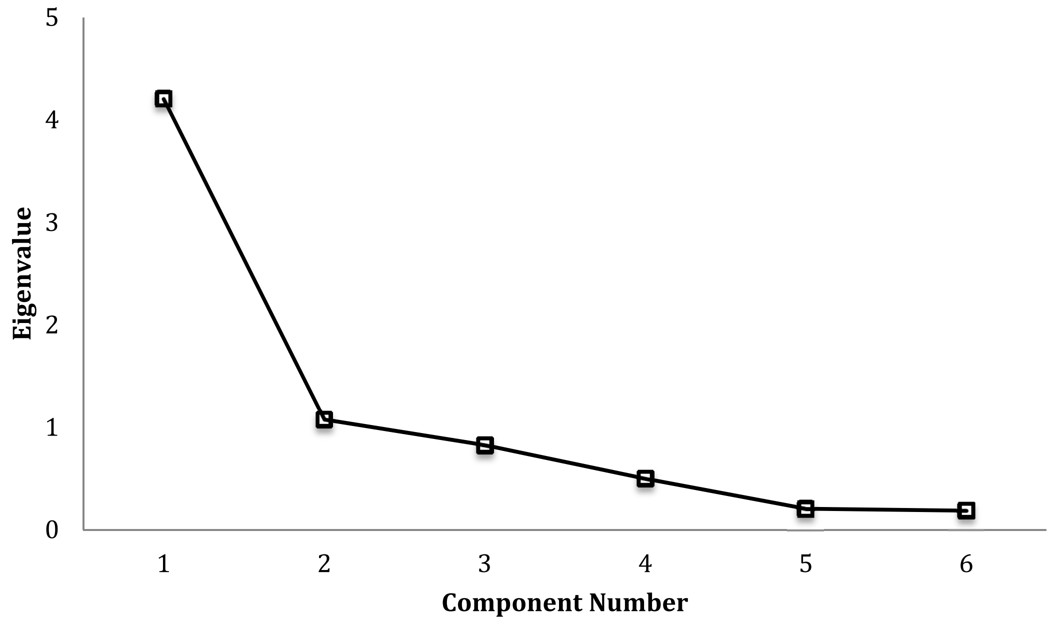
* $p < .05$. ** $p < .01$.

Table 3. Eigenvalues of Exploratory Factor Analysis Using Covariance Matrix

	Initial Eigenvalues		
Component	Total	% of Variance	Cumulative %
1	**4.21**	**60.10**	**60.10**
2	1.01	15.37	75.47
3	0.83	11.80	87.27
4	0.50	7.13	94.40
5	0.20	2.92	97.32
6	0.19	2.68	100.00

Note: Mean eigenvalue total = 1.17. Components with eigenvalue greater than mean are in boldface.

Figure 2. Scree Plot for Factor Analysis of Observed Task Engagement Variables.



Bivariate Correlations

Correlational analyses were run between task engagement and sex, race, SES, and receptive vocabulary to determine whether there was a statistical need to control for any of these variables. Task engagement was significantly positively associated with vagal withdrawal but not with caregiver emotional support (see Table 5). Task engagement was also positively correlated with receptive vocabulary (r = 0.21, $p < .01$), but not with sex, race (dichotomized white versus non-white), or SES (income to needs ratio). A follow-up ANOVA investigating the effect of race (white, black, Hispanic, biracial/other) on task engagement confirmed a lack or relation between these variable ($F_{4,240} = 1.18$, *ns*). Caregiver emotion support was not related to either baseline vagal tone or vagal withdrawal, but both caregiver emotion support and vagal withdrawal were significantly correlated with receptive vocabulary, minority status, and SES (see Table 5). Therefore, vocabulary, minority status, and SES were all retained as covariates for future analyses.

Table 4. Pearson Correlations Among Study Variables (N = 196)

	1	*2*	*3*	*4*	*5*	*6*	*7*
1. Task Engagement	-						
2. Vagal Withdrawal	.24**	-					
3. Emotional Support	.07	.05	-				
4. Baseline Vagal Tone	-.00	.38**	-.01	-			
5. Receptive Vocabulary	.17*	.18*	.31**	-.07	-		
6. Sex	-.12	-.12	.06	.09	-.15*	-	
7. Minority status	-.03	.01	-.34**	.16*	-.36**	-.01	-
8. Income to needs ratio	-.03	.11	.21**	-.04	.37**	.06	-.24**

* *p* < .05. ** *p < .01*. .

Regression Analysis

Task Engagement was regressed on child vagal withdrawal, caregiver emotional support, and their interaction term, controlling for baseline vagal tone and receptive vocabulary. The overall model was significant ($F_{1,190}$=3.49, p <.01, R^2=0.08) and indicated a main effect of physiological regulation (β = 0.35, p <.01): Children with greater vagal withdrawal exhibited greater task engagement. However, the main effect (β= -0.05, *ns*) and moderating effect (β= -0.14, *ns*) of emotional support were nonsignificant (See Table 6), suggesting that emotional support did not influence child task engagement or moderate the effect of physiological regulation on engagement.

Table 5. Multiple Regression Analysis Predicting Task Engagement from Children's Vagal Withdrawal and Caregiver Emotion Support (N=196)

	Model 1			Model 2			Model 3		
Variable	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Minority status	.04	.16	.02	.05	.16	.02	.04	.16	.02
Income to needs	-.06	.04	-.11	-.07	.04	-.12	-.07	0.4	-.12
Receptive language	.02	.01	.22**	.01	.01	.16	.01	.01	.16
Baseline vagal tone	.01	.07	.01	-.08	.07	-.00	-.09	.07	-.10
Vagal withdrawal				.34	.11	.25**	.35	.11	.26**
Emotional support				.06	.09	.05	-.05	.09	.04
VW*ES							-.14	.13	-.07
ΔR^2	.04			.05			.01		
F for change in R^2	1.99			5.45**			1.10		

* $p < .05$. ** $p < .01$, VW = Vagal Withdrawal, ES = Emotion Support

CHAPTER IV

DISCUSSION

The goal of this study was to investigate task engagement among preschool age children and to assess the biopsychosocial processes that may influence variation in engagement at this age. As engagement influences academic outcomes and school adjustment, understanding early predictors of engagement may help inform more targeted preschool interventions and programming and thus promote more adaptive developmental trajectories. Vagal withdrawal provides a useful indicator of physiological regulation and may offer a unique way of assessing internal processes of control that are not observable behaviorally. As physiological regulation helps focus attention and regulate emotion, it was hypothesized to support task engagement among young children. However, it was also predicted that the role of physiological regulation would be moderated by caregiver emotion support, as supportive parenting may help promote behavioral and motivational mechanisms by which a child may overcome physiological deficits. The results of the current study help elucidate some of the biopsychosocial correlates of engagement and suggest several new directions for future research.

This study provided needed empirical evidence for the construct of task engagement during early childhood. Although specific elements of engagement, such as on-task behavior or parent reported behavior regulation, are more commonly examined an isolated behaviors among preschool-age children, this study attempted to investigate engagement more holistically by incorporating these various indicators into the complex, multidimensional construct of task engagement. The six observed scales, indicating behavioral manifestations of behavioral, cognitive, and affective engagement, were all inter-correlated, and factor analysis suggested that their covariance was best summed by a single construct. These results suggest that cognitive, affective, and behavioral processes of engagement may be very highly intertwined among 4-year-old children. It is possible that engagement is less complex in early childhood and that engagement at these three levels has not yet differentiated. As children develop more advanced cognitive and emotion regulation, these components of engagement may become more distinct and yield a mote complex factor structure. However, these data should be interpreted with caution, as affective and cognitive indicators of engagement were measured through behavior. As such, the unobservable, internal processes of affective and cognitive engagement may not be fully represented, and the single observed factor may represent behavioral engagement only.

The current findings also supported the biopsychosocial perspective of development, as they highlight the interrelation of biological systems and behavioral processes. Specifically, this study established the association between task engagement and physiological regulation, as measured by vagal withdrawal during challenge. More physiologically regulated children were more likely to display a combination of greater on-task behavior, persistence, enthusiasm, advanced strategy use, and positive affect and less negative affect. Thus, although the effect size was small, it appears as though physiological regulation provides an important additional resource for examining individual differences among children and for understanding the internal processes that influence developmental outcomes. As physiological regulation is related to sustained attention (Suess et al., 1994) and emotion regulation (Calkins, 1997; Hastings et al., 2008a; Musser et al., 2011), children who were more physiologically regulated during our laboratory task may have been better able to biologically control their frustration and maintain their focus, and therefore more easily engage with the task.

Given the impossible nature of the engagement task in the current study, these results may further indicate that physiological regulation plays an important role in a child's ability to behaviorally persist in the face of extreme challenge. Although children may not be faced with impossible tasks in more normative environments, they will likely experience challenges far beyond their current capabilities in various contexts, including school. These results suggest that physiological regulation may be one mechanism that promotes continued engagement during these challenging events.

The main effect of physiological regulation was not moderated by parent emotion support in this study: Physiological regulation was equally predictive of engagement across parenting contexts. This null result may be partially driven by the unexpected lack of relation found between parent emotion support and child engagement in this sample. These results indicate that parent emotion support does not affect child task engagement – a finding that goes against our hypotheses and contradicts extent empirical work. The current study differed from other studies that did find a relation between emotion support and indicators of engagement in the method of measuring engagement and the task during which engagement was measured. For example, whereas this study measured engagement during an impossible task, Mokrova and colleagues (2012) measured engagement as an aggregate between time on-task during an unstructured block task and qualitative involvement during a mother-child game. Thus, it is possible that engagement during mother-child interaction may be more influenced by maternal emotional support than engagement during solitary goal-driven tasks.

It is also possible that the impossible task used by the current study was too frustrating for some children. This may be especially true for children of more emotionally responsive parents: As parents remained in the testing room with instructions not to help or engage with their children, the experience of not receiving help during a task that is evidently above their ability level may have violated certain assumptions of support and felt particularly distressing. Thus, future analyses using a more appropriate task in which the caregiver is not present may provide a better test of the relation between emotion support and the current conception of engagement.

By integrating both intrinsic and extrinsic factors into the same model and examining their interaction, this study hoped to illuminate the developmental processes that may be obscured by investigating either parenting or physiology alone. Although we failed to find an interactive effect, the examination of contextual effects remains critical for understanding development. For example, it is also possible that emotion support may moderate physiological regulation and child engagement during tasks that don't involve parents purposefully ignoring child requests for help. Thus, further research must be conducted to determine the role of parenting on task engagement.

The results of this study were limited by some methodological decisions. First, the use of an impossible task to measure engagement may not have represented ecologically valid childhood experiences and may have affected the results of our study. As suggested, the use of this task may have obscured the relation between emotional support and engagement, as parents were instructed to dismiss child calls for help. Furthermore, the impossibility of the task may have influenced observed variation of behavioral manifestation of affective and cognitive engagement. Indeed, it may be noted that the variables of positive and negative affect were not highly correlated with each other or the other engagement variables and had only modest factor loadings onto our single factor of engagement. The frustration involved with not making any incremental progress, due to the inability to solve the task, may have caused more negative affect and less positive affect to be observed than would be expected on a solvable task. Strategy use may also have been constrained by this methodological design: Once the impossible stage was reached, no new challenges could occur to generate new strategy use. A non-impossible task may therefore have yielded greater variability within these engagement indicators and have provided greater power to assess the relations between engagement and other child or contextual factors.

Additionally, there was no learning component in the current engagement task. Investigating engagement during a challenging learning context may be both more representative of normal childhood activities and may also be more relevant to future engagement in school contexts. Thus experiments using a learning-centered paradigm that provides greater opportunities for diverse strategy use should be conducted to further assess the factor structure of task engagement in early childhood and its early correlates

It is also acknowledged that parent emotional support was measured during a task in which child behavior may have influenced parenting behavior. Indeed, it is possible that a more engaged child may illicit greater responsivity and less negativity during dyadic interactions. Furthermore, this study only examined the effects of emotion support from the child's primary caregiver. Emotional support received by the secondary caregiver, in most cases the father, may have provided additional information about the emotional environment in which the child develops. Moreover, current research with school age children point to the important role of teacher support in predicting engagement (Reeve et al., 2012; Furrer & Skinner, 2003). Although many children may not yet be enrolled in a formal school program at this age, day care providers may have a unique effect on child engagement within a classroom-like setting. Thus, measuring the emotional support provided by secondary caregivers, such as fathers, day care instructors, or preschool teachers, may have further informed differences in child engagement.

Finally, the correlational design of this study prohibits any assumptions of causality. Longitudinal studies should follow-up the current analysis to help provide temporal context, which might further illuminate the developmental pattern of between physiological regulation and task engagement. Prior research does suggest that early physiology has important impacts on future behavior. Indeed, physiological regulation in infancy and toddlerhood longitudinally predicts behavior problems in early childhood (Calkins et al., 2007; Porges et al., 1996) and it has been found to longitudinally interact with parenting factors to predict negative affect, peer relations, behavior problems, academic achievement, and emotion regulation (Katz & Gottman, 1997). As physiological regulation early in development may have cascading effects on the development of higher order regulatory systems at the affective, cognitive, and behavioral levels (Calkins & Fox, 2002), it may also provide early indication of future engagement.

Despite these limitations, this study had several implications for future research. As the current findings supported a biobehavioral framework of development, they help provide support for the investigation of other biological systems, such as frontal EEG asymmetry or neural response to error, in relation to engagement. Indeed, biological systems do not operate independently of one another, and adopting a more holistic view of physiological processes may better illuminate the relations between biology and behavior. For example, measuring sympathetic activity, which may be an indicator of effort (Silvia et al., 2013), in addition to parasympathetic activity may provide an even richer depiction of the physiological mechanisms of engagement. Although the two branches of the autonomic nervous system classically are thought to operate symbiotically, their interrelation may in fact be more complex (Fox et al., 2006). Future analyses may investigate differential patterns of sympathetic and parasympathetic activation and how they relate to the development of task engagement.

In conclusion, this study examined a novel way to assess the complex construct of engagement through observational methodology and helped to establish the relation between physiological regulation and task engagement in early childhood. Intrinsic differences related to biological systems of regulation help explain variation in behavioral task engagement. As engagement is an important predictor of school adjustment and academic outcomes, this study contributes to broaden current understanding of the biopsychosocial systems that influence adaptive development.

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