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INDIVIDUAL DIFFERENCES IN YOUNG CHILDREN'S RESPONSES TO STRESS: THE ROLE OF PERCEPTION

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This work is dedicated to my parents, Vince and Laura Smith, for inspiring in me from an early age a passion for the pursuit of knowledge and a drive to make a difference in this crazy, wild, wonderful world.

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Abstract

Early life stress is associated with a host of social, emotional, cognitive, and behavioral difficulties for children later in life. These negative effects of early life stress are thought to be in part a consequence of chronic and/or extreme perceptions of stress leading to extended activation of physiological, psychological, and behavioral stress response systems, ultimately resulting in dysregulation in these systems. However, not all children who experience early life stress, even the same type of stressor, demonstrate later negative outcomes. It is important to understand the mechanisms that support individual differences in the outcomes of children exposed to early life stress in order to develop more effective targeted interventions for at-risk children and their families. The current work takes an integrative approach to addressing what factors underlie individual differences in children's responses to early life stress, examining interactions among psychophysiological functioning, environmental factors, and children's self-regulatory behaviors in the context of a preschool program targeting children exposed to early life stress. In Study 1, I demonstrate that children exhibit positive change in self-regulatory behaviors during the preschool program. Additionally, children's patterns of behavior change are influenced by whether the child is living with their biological parents and whether they complete the program. In Study 2, I find that children's parasympathetic cardiac regulation is related to their patterns of behavior change. Children with lower parasympathetic cardiac control at the start of the program initially demonstrate poorer self-regulatory behaviors but also have more pronounced positive change in these behaviors during the program. In addition, children's parasympathetic cardiac regulation increases during the program, and these increases are associated with improvements in self-regulatory behaviors. Lastly, in Study 3, I examine changes in children's behavior in response to the occurrence of a stressor (abuse, moving care, and parent arrest). I find, somewhat

surprisingly, that children's behavior improves after a parent arrest. After an occurrence of abuse, there are no immediate changes in children's behavior, but children's overall pattern of positive change in self-regulatory behaviors slows. Together this work illustrates the complex nature of interactions among children's early environment, psychophysiological functioning, and their responses to early life stress. I discuss the implications of this work for understanding children's immediate responses to stress, the influence of developmental patterns of psychophysiological change on these responses, and the role of individual differences in perceptions of environmental demands in children's responses to stress.

Chapter 1: General Overview and Introduction

Early life experiences represent an important influence on children's development, having long-lasting effects across a wide range of domains (Cicchetti, 2010; Pollak, 2005). While experience shapes individuals across the life-span (Gould, Beylin, Tanapat, Reeves, & Shors, 1999; Graham, Christian, & Kiecolt-Glaser, 2006; Lupien, McEwen, Gunnar, & Heim, 2009), early childhood is an especially key period of influence. Infants and children are dependent upon adults for basic survival needs (Adolphs, 2003), making early relationships with parent(s)/caregiver(s) integral in shaping children's cognitive and affective development. Children's perceptions of their parent's/caregiver's availability and responsiveness is the basis for the development of their representations of self and others (attachment models) which will influence how they perceive and interpret the world around them throughout their lifespan (Bowlby, 1969). Additionally, how a child perceives their early environment has long lasting biological consequences. In infancy and early childhood, there are high rates of synaptic regrowth and remodeling in the brain (Hill et al., 2010; Levitt, 2003), especially the cortex, and these processes are experience dependent, involving the strengthening of used synapses combined with the elimination of unused synapses (Andersen, 2003; M. H. Johnson, 2001). While neurogenesis and remodeling occurs throughout the lifespan (Gould et al., 1999), this process is accelerated in early childhood, making the brain, especially cortical areas involved in emotion and cognitive regulatory processes, highly susceptible throughout this period to environmental inputs (Andersen, 2003; M. H. Johnson, 2001)

Stress during this period can be especially harmful, resulting in a wide range of negative effects including the development of later psychopathology (Collishaw et al., 2007), behavior problems such as aggression, conduct disorder, and antisocial behaviors (Alink, Cicchetti, Kim,

& Rogosch, 2012; Jaffee et al., 2009), and difficulties with emotion recognition and representations (Curtis & Cicchetti, 2013; Pollak & Kistler, 2002). These effects are thought to be a result of chronic perceptions of threat in the environment leading to extended autonomic and neuroendocrine stress responses (McEwen, 2004; McEwen, 2007) eventually resulting in dysregulation of these physiological stress response systems (Lupien et al., 2009) and abnormal development of higher level cortical areas such as the prefrontal cortex (Belsky & De Haan, 2011). Additionally, there is some evidence that the effects of stress in early childhood are not easily recoverable or countered-acted. For example, in rodents, stress during the first three weeks of life, such as maternal deprivation or repeated maternal separation, leads to alterations in emotional and spatial memory which are associated with reductions in hippocampal neurogenesis (Ivy et al., 2010; Lucassen et al., 2013; Walker et al., 2004). While inhibition of neurogenesis in the hippocampus by stress in adulthood is often reversible, the changes observed after postnatal stress are long lasting and have implications for emotional and cognitive functioning into adulthood (Korosi et al., 2012; Lucassen et al., 2013). In humans, children exposed to severe neglect and deprivation through institutionalization early in life demonstrate behavioral difficulties and alterations in emotion processing that persist into adolescence even after adoption or placement in foster care (Bick, Luyster, Fox, Zeanah, & Nelson, 2017; Burkholder, Koss, Hostinar, Johnson, & Gunnar, 2016; Humphreys et al., 2018).

However, while stress in early childhood is associated with a wide range of negative effects later in life, not all children who experience early life stress develop these negative outcomes (McCrory, De Brito, & Viding, 2010; Watts-English, Fortson, Gibler, Hooper, & De Bellis, 2006), even those exposed to the same type of stressor (i.e. sexual abuse). These children demonstrate a continuum of outcomes ranging from the negative outcomes outlined above to children who demonstrate little, if any, disruption in psychological functioning and behavior. Historically, this variance has been viewed as noise, rather than meaningful differences (Lazarus, 1993; Masten, Cutuli, Herbers, & Reed, 2009). However, recently there has been a focus on developing a better understanding of the factors that contribute to this observed variation. Indeed it appears that individual variation in neurobiological factors, such as genes (Rutter, 2012; Sturge-Apple, Cicchetti, Davies, & Suor, 2012) and physiological functioning (Blair, Berry, Mills-Koonce, & Granger, 2013), along with variation in family processes and environmental factors such as parental warmth and sensitivity and positive relationships with parents or other adults (Chen, Miller, Kobor, & Cole, 2011; Cicchetti, 2010; Masten, 2011), may play a critical role in observed individual differences in children's responses to early life stress. Additionally, individual differences in how children perceive a stressor likely has a large influence on the variance observed in these children's outcomes. While often neglected within the early life stress literature which focuses on utilizing "objective measures" (Scott, McLaughlin, Smith, & Ellis, 2012), perception has been established in the adult and non-human animal literature to be a primary influence on individual differences in responses to stress (Bollini, Walker, Hamann, & Kestler, 2004; Mormede, Dantzer, Michaud, Kelley, & Le Moal, 1988). It is an individual's perception of an event as a stressor that leads to neurobiological, psychological, and behavioral stress responses motivated at addressing the potential stressor (Juster, McEwen, & Lupien, 2010; McEwen, 2000; McEwen, 1998). Indeed, an individual's perception of an experience can continue to generate stress responses even after the initial stressor is removed (McEwen, 2001). Incorporating an understanding of the importance of these perceptual factors can aid in better understanding what leads to individual differences in children's responses to early life stress, ultimately providing greater insight into what factors protect against early life stress, which children and families might be most vulnerable to early life stress, as well as aiding in the development of more effective, targeted interventions for these at risk children and families.

1.1 What is Early Life Stress?

Throughout this paper, I use early life stress to refer to chronic and/or extreme stress experienced early in childhood, including, but not limited to, maltreatment, neglect, poverty, decreased access to educational resources, and an unstable family environment (Danese, Pariante, Caspi, Taylor, & Poulton, 2007; Pollak, 2005). Stress itself is a somewhat difficult term to define, used in a variety of contexts with multiple different meanings (McEwen & Wingfield, 2010). However, the framework that has demonstrated the most utility in terms of understanding the psychophysiological effects of stress is that which describes stress as the psychological and physiological responses elicited when an individual perceives an event as a potential stressor (McEwen, 2016; McEwen & Wingfield, 2010; Sapolsky, 2004). While stress is often considered to be negative, in most circumstances, it actually serves a beneficial function of motivating individuals to respond to potential threats or challenges in the environment (McEwen, 2000). Indeed, allostasis refers to the body's adaptive response to stress, through physiological, psychological, and behavioral changes, aimed at maintaining physiological and social stability through change in response to perceived environmental demands (McEwen, 2000). As already emphasized, it is the brain's perception of an experience as stressful that initiates the physiological and behavioral responses leading to adaptation and allostasis (McEwen, 2001, 2012).

While acute stress responses may serve a beneficial function, chronic, extended stress is thought to result in dysregulation of physiological stress response systems, including alterations in hypothalamic-pituitary-adrenal (HPA) axis (Miller, Chen, & Zhou, 2007) and autonomic nervous system (ANS) functioning (Norman, Hawkley, Cole, Berntson, & Cacioppo, 2011), immune dysregulation (Glaser & Kiecolt-glaser, 2005; Kinsey, Prendergast, & Nelson, 2003), and structural alterations in the brain (McEwen, 2000). Chronic stress early in life can be especially impactful, given the brain is still developing and highly plastic, with perceptions of stress leading to changes in physiological stress response system functioning that then influence how individuals perceive and respond to later stress, facilitating a cycle of dysregulation (De Kloet, Sibug, Helmerhorst, & Schmidt, 2005).

1.2 The Effects of Early Life Stress

1.2.1 Early Life Stress and Behavior, Affect, and Cognition

Early life stress can result in negative behavioral effects that persist into adolescence and adulthood. For example, early maltreatment is associated with increased levels of both internalizing and externalizing behaviors in children (Dykman et al., 1997; Essex et al., 2013; Keiley, Howe, Dodge, Bates, & Petti, 2001). Additionally, repeated maltreatment, measured by child protective services reports, is associated with more rapid increases in internalizing and externalizing behaviors in children from the ages of 4 – 12 years (Li & Godinet, 2014). Children who experience severe neglect while in an orphanage, often referred to as institutional deprivation, demonstrate a wide range of behavioral problems including inattention/overactivity, increased prevalence of conduct issues and disorder, and increased externalizing and internalizing behaviors (O’Connor & Rutter, 2000; Sonuga-Barke, Schlotz, & Kreppner, 2010; Stevens et al., 2008). Maltreatment is also associated with increased aggressive behavior in childhood (Alink et al., 2012; Cyr, Pasalich, McMahon, & Spieker, 2014; Shackman & Pollak, 2014) and increased criminal behaviors in adulthood (Cuadra, Jaffe, Thomas, & DiLillo, 2014).

Many of these disruptions in behavior are thought to be a result of altered cognitive processes involved in self-regulation and inhibitory control. As mentioned above, institutional deprivation early in life is associated with increased inattention and overactivity which in turn relates to an increased prevalence of conduct problems (Stevens et al., 2008). Institutional care is also linked to decreased inhibitory control, with inhibitory control mediating the relationship between disinhinbited social behavior and length of time in institutional care (Bruce, Tarullo, & Gunnar, 2009). Additionally, children who have experienced maltreatment demonstrate decreased emotion regulation which is associated with increased externalizing symptomatology (Kim & Cicchetti, 2010), increased risk of bullying others, as well as increased likelihood of also being bullied by peers (Shields & Cicchetti, 2001).

The disruption of affective processes is another pathway through which early life stress is thought to influence behavior. Affective processes refer to a broad set of psychological states encompassing changes in visceral states and behavioral motivations based on individuals' perceptions of environmental demands, and these processes provide the underlying structure for emotion (Craig, 2003; Critchley & Harrison, 2013). They allow individuals to interpret, effectively interact with, and respond to the environment around them (McNaughton & Corr, 2009). This means affective processes influence a wide range of domains, including social interaction and behavior, and cognitive processes such as learning, decision making, and attention (Stanley, Ferneyhough, & Phelps, 2009). Anxiety provides a good example of this, as it is common to most, if not all mammals, and plays the important role of indicating the presence of a potential threat within an individual's environment (Barlow, 2000). Anxiety is a future-oriented affective state characterized by anticipation and apprehension of potential threats, and produces a number of physiological changes that support motivated defensive behaviors aimed at threat detection, including increased vigilance and risk assessment via modulation of attentional systems, increased muscle tension, and increased defensive quiescence (stretched attend posture) (Eldar, Yankelevitch Roni, Lamy, & Bar-Haim, 2010; McNaughton & Corr, 2004; Rhudy & Meagher, 2000).

In social species, affective processes play an important role in motivating the social behaviors supporting social connection. Specific emotional expressions often operate to induce affective states in the perceiver, supporting a motivated response towards the other person (Decety & Lamm, 2009; Lemerise & Arsenio, 2000; McNaughton & Corr, 2009). The perceiver's interpretation of another's expression will influence their own behavioral responses and how they then engage with the person (van Kleef, 2009). These expressions and responses are especially tightly linked in infancy and early childhood, where emotional expression is linked to basic survival functions, such as feeding, cleaning, and comfort (Adolphs, 2003; van Kleef, 2009). Indeed, crying in infancy plays an important communicative role, signaling a need for care and protection, and eliciting care-taking and protective behaviors from the caregiver (Acebo & Thoman, 1995; Doi & Shinohara, 2012; Hahn-Holbrook, Holbrook, & Haselton, 2011). Additionally, infants as young as 3- and 4-months demonstrate the ability to discriminate between different emotions, measured via looking times and evoked response potentials (Hoehl & Striano, 2010; Montague & Walker-Andrews, 2001), and there is some evidence infants are especially sensitive to maternal expressions of emotions (Minagawa-Kawai et al., 2009). Key in children's affective development is their relationship with their parent(s)/caregiver(s) (Fearon, Bakermans-Kranenburg, van IJzendoorn, Lapsley, & Roisman, 2010). As mentioned previously, these early relationships shape the development of children's attachment models, with infants developing an internalized representation of self and others based on their perception of their parent's/caregiver's availability and responsiveness. This representation forms the basis for the development of later relationships (Bowlby, 1969; Cassidy & Shaver, 2002).

Early life stress often disrupts this early relationship, either directly through abuse or maltreatment of the child by the parent or caregiver (Levine, 2005), or indirectly through external stressors that act on both the parent and child, changing parent directed behavior towards the child (Farmer & Lee, 2011). This disruption is associated with the development of anxious/ambivalent or avoidant attachment styles, which are related to internalizing/externalizing behaviors (Fearon et al., 2010; Madigan, Atkinson, Laurin, & Benoit, 2013), development of later psychopathologies, including depression and anxiety (Sroufe, Carlson, Levy, & Egeland, 1999), difficulties forming healthy relationships later in life (Simpson, 1990), deficits in empathy (Britton & Fuendeling, 2005; Decety & Meyer, 2008), as well as difficulties academically (Bergin & Bergin, 2009).

Additionally, disruption of this early parent child relationship, can lead to altered affective representations that then change how the child interacts with their environment in the future. Children who experience physical abuse are better at recognizing anger from less information (Pollak & Sinha, 2002), and are more likely to categorize faces on a continuum from fear to anger as angry (Pollak & Kistler, 2002). This suggests that children who are in an environment where the ability to detect an angry emotional expression has consequences for their own physical safety and survival may be more prone to categorizing others' emotional expressions as angry. This bias could lead to potentially inappropriate behavioral responses to other individuals around them, possibly through increased aggression or withdrawal in social situations and hypervigilance or misinterpretation of threat cues in other individuals. Overall this literature suggests that early life stress has a wide range of effects across affect and cognition, and these lead to the development of maladaptive and disruptive behaviors through childhood, adolescence, and adulthood.

1.2.2 Early Life Stress and the Autonomic Nervous System

These negative effects of early life stress on behavior, cognitive, and affective processing are thought to be linked to chronic perceptions of the environment as threatening leading to dysregulation of primary biological stress response systems as a result of extended exposure to autonomic and neuroendocrine stress responses (Juster et al., 2011; Lupien et al., 2009). The brain responds to perceived stress in a coordinated and systematic manner, producing a range of effects “designed” to facilitate an adaptive response to the stressor. A key system in this response is the autonomic nervous system (ANS) (Berntson & Cacioppo, 2004; Garfinkel & Critchley, 2016; Thayer & Lane, 2009). The ANS consists of a complex network of peripheral nerves and ganglia associated with regulatory systems of the brain and spinal cord which serve to control smooth muscles and glands of the viscera (Berntson, 2000). The ANS is organized into two branches, the sympathetic branch and the parasympathetic branch, and was originally hypothesized by Walter Cannon to primarily function to maintain homeostasis, or the stability of the internal fluid matrix (Cannon, 1929). More recently, the ANS has been implicated in a wide range of cognitive and affective responses, including having a key role in facilitating psychological and behavioral responses to stress (Berntson & Cacioppo, 2004; McEwen, 2000).

The sympathetic and parasympathetic nervous system work in concert to respond to external and internal threats to physiological stability (Berntson, 2000; McEwen, 2004; Norman, Devries, Hawkley, Cacioppo, & Berntson, 2012). The sympathetic nervous system (SNS) originates in the intermediolateral cell column of the thoracic and lumbar divisions of the spinal cord, and spinal sympathetic motor neurons give rise to preganglionic efferents. These efferents exit the spinal cord in the ventral roots where they enter an interconnected set of sympathetic chain ganglia which lie along each side of the spinal cord. From there, preganglionic fibers either ascend or descend before terminating on sympathetic ganglion cells which give rise to postganglionic axons that project to visceral organs. The primary neurotransmitter of the sympathetic preganglionic synapse is acetylcholine (ACh) while sympathetic postganglionic synapses employ norepinephrine (NE) (Berntson, 2000). In contrast, the parasympathetic nervous system (PNS) originates in the intermediolateral column of the sacral spinal cord and in numerous brainstem nuclei including the nucleus ambiguus, dorsal motor nucleus of the vagus, and salivatory nuclei. Unlike the sympathetic nervous system, the peripheral ganglia are not collected into ganglionic chains, but are located in or near the visceral organs innervated, leading to more localized action. ACh is the primary neurotransmitter employed at both preganglionic and postganglionic parasympathetic synapses (Berntson, 2000). The two autonomic branches receive inputs from an interconnected network of higher level brain regions including the prefrontal, cingulate, and insula cortices along with the hypothalamus and amygdala, often referred to as the Central Autonomic Network (CAN) (Thayer & Lane, 2000), which receives and integrates visceral, humoral, and environmental information and coordinates autonomic, neuroendocrine, psychological, and behavioral responses to perceived environmental challenges (Thayer & Lane, 2000, 2009).

Classically, the ANS is thought to respond in a reciprocal manner to threat or stress with sympathetic activity increasing as parasympathetic activity decreases (parasympathetic withdrawal) (Cannon, 1929). This promotes the release of catecholamines, including norepinephrine, serotonin, and dopamine, which elicit physiological changes throughout the periphery that prepare the body for physical activity, including increases in heart rate, blood pressure, metabolic rate, and alertness (Watts-English et al., 2006). Norepinephrine also interacts with the HPA axis and glucocorticoids resulting in the two systems working together to coordinate motivated responses to a perceived stressor (Dunn, Swiergiel, & Palamarchouk, 2004; Watts-English et al., 2006). This response to stress is typically adaptive, with appropriate autonomic responses being important in the production of coordinated motivated behaviors aimed at addressing potential threats and playing a key role in the animal's health and survival (McEwen, 2001; Sapolsky, 2004). Additionally, the ANS also interacts with and coordinates responses of other important stress response systems, including the immune system and the HPA axis, through effects exerted both centrally and peripherally (McEwen, 1998; Padgett & Glaser, 2003). It is important to note, that recent work has demonstrated ANS responses to stress, especially social stressors, is not as straightforward as sympathetic activation coupled with parasympathetic deactivation. Indeed, these systems can show a wide range of differential activation/deactivation patterns in response to stress, including parasympathetic and sympathetic co-activation or co-deactivation (Berntson & Cacioppo, 2004), likely mediated by differences in how individuals are perceiving the stressor.

Chronic stress results in dysregulation of the ANS in both animal and human models (McEwen & Seeman, 1999), and chronic stress early in life can result in differing trajectories of development of the ANS systems (Gunnar, Frenn, Wewerka, & Van Ryzin, 2009). Indeed, there is evidence that children and adults exposed to stress early in life demonstrate altered patterns of ANS reactivity, thought to be indicative of a potential hypervigilance to threat (Ladd, Owens, & Nemeroff, 1996; Sánchez, Ladd, & Plotsky, 2001). For example, children who have experienced physical abuse demonstrate greater heart rate (dually influenced by the SNS and PNS) deceleration to viewing an unresolved silent angry interaction compared to non-abused controls

(Pollak, Vardi, Bechner, & Curtin, 2005). Women with a history of sexual and/or physical abuse in childhood with concurrent depression demonstrate higher mean heart rate in response to stress (Heim et al., 2000). However, other work finds no differences in heart rate reactivity to a stressor in early adolescent females who experienced maltreatment (MacMillan et al., 2009). These differences in findings could be due to variance in the type of maltreatment, the age of participants, and the presence or absence of comorbid psychopathologies. However, they may also be due to a lack of sensitivity in the measure being used. Because heart rate is influenced by both branches of the autonomic system, it alone is unable to inform researchers of much more than general changes in physiological arousal (Berntson & Cacioppo, 2004). Disentangling differences in the sympathetic and parasympathetic resting levels and reactivity in individuals exposed to early life stress can help further our understanding of how these systems react to chronic early life stress as well as the role they play in the disruption of behavior and psychological processes later in life. Additionally, resting ANS activity, especially that of the PNS, is thought to play an important role in individuals' sensitivity to threat and self-regulatory processes (Lane et al., 2009; Porges, 2007; Thayer & Lane, 2009). Given children who experience early life stress demonstrate both heightened sensitivity to threat (Pollak & Sinha, 2002) and problems with self-regulation (Collishaw et al., 2007; Kim & Cicchetti, 2010; Maughan, Cicchetti, Toth, & Rogosch, 2007), understanding the effects of early life stress on the PNS is important to furthering our understanding of the mechanisms linking early life stress to later behavior, emotional, and cognitive difficulties.

There is some recent work that attempts to disentangle the influence of early life stress on the two systems. Gunnar and colleagues (2009) find that children adopted from institutional care at 12 months or older demonstrate increased resting sympathetic activity compared to non-adopted children, but no differences in either sympathetic or parasympathetic reactivity to stress and resting parasympathetic activity. Additionally, infants raised in orphanages where they are exposed to extreme neglect demonstrate increased resting sympathetic activity after adoption compared to non-adopted controls, maintain those differences over the first 16 months of life, and demonstrate a pattern of a steeper trajectory of change in sympathetic activity over this time period (Esposito, Koss, Donzella, & Gunnar, 2016). These increased levels of sympathetic activity immediately after adoption were also positively correlated with children's problem behaviors 32 months later (Esposito et al., 2016). However, this literature is still in its infancy, and there is little known about normal developmental trajectories of autonomic reactivity in humans, how early exposure to stress influences the PNS and SNS, how this contributes to how these systems then respond to stressors later in life, and the implications disruptions in these systems have for the development of disruptive behaviors and emotional processes.

1.2.3 Individual Differences in Responses to Early Life Stress

The prevalence of early life stress within our society makes it important to understand the mechanisms linking early life stress to negative behavioral, emotional, and cognitive outcomes along with physiological dysregulation. Over 3-million children in the United States alone are exposed to abuse or maltreatment each year (US Department of Health & Human Services Administration for Children and Families Administration on Children Youth and Families Children's Bureau, 2018), and this includes only a few subtypes of early life stress and only those children who are referred to child protective services (CPS). Importantly, there is a wide range of variability in children's outcomes to early life stress, even among those who experience similar types of early life stress (Belsky, Bakermans-Kranenburg, & van Ijzendoorn, 2007; Heim & Nemeroff, 2002). Historically, as mentioned above, these individual differences have been neglected in the literature, but recently there has been a push to investigate the factors contributing to them (Ellis, Bianchi, Griskevicius, & Frankenhuis, 2017; Masten, 2011). Understanding the factors that influence individual differences in children's outcomes to early life stress is critical in identifying protective factors that can be the target of early intervention for at risk children and families.

Individual differences are key when thinking about resilience to early life stress, or the tendency to adaptively cope with that stress (i.e. exhibit motivated responses aimed at addressing the perceived stressor, but then rapidly recovering to baseline) (Karatsoreos & McEwen, 2011). When discussing resilience in children exposed to early life stress it is important to keep in mind that many of children's observed outcomes may actually represent adaptive approaches to coping with their environment (Ellis et al., 2017). The observed increased sensitivity to expressions of anger in children who experience physical abuse (discussed above) (Pollak & Sinha, 2002; Pollak & Tolley-Schell, 2003; Shackman & Pollak, 2005) likely represents an adaptive strategy aimed at quickly detecting danger in an environment where there is consistent exposure to unpredictable expressions of anger. However, these strategies become problematic for children once they must interact within a broader social context (Ellis et al., 2017; Ellis & Boyce, 2008).

Taking a nuanced approach to understanding the mechanisms contributing to individual differences can help us better understand what might promote resilience in children exposed to early life stress. Factors thought to be associated with resilience include genetic variation, variation in physiological reactivity, and a wide range of psychological factors (Masten, 2011; Rutter, 2012). One prevalent theory in the resilience literature is the idea of stress inoculation, or that exposure to stressors can have a buffering effect on both physiological and behavioral responses to future stressors (Rutter, 2012). However, while there is good support for this within the non-human animal literature (Lyons, Parker, & Schatzberg, 2010), the research in humans is less clear (Rutter, 2012). One possibility is that stress inoculation is specific to repeated acute stress resulting in more adaptive coping to future stressors, while chronic stress results in dysregulation and maladaptive responses in stress response systems (Lyons, Parker, Katz, & Schatzberg, 2009). Again, non-human animal work appears to support this (Dhabhar & McEwen, 1997; McEwen, 2004), but in humans it is harder to distinguish between what constitutes chronic vs acute stress given ethical barriers to manipulating exposing human subjects to one versus the other, and the incredibly wide range of differences across individuals in what is perceived as a stressor. This indicates that resilience is more complex than a strengthening of stress response systems from mere exposure to stress, suggesting a need for a better understanding of how individuals respond differently to different types of stress, and how these varying types of stress influence individuals' later stress responses.

The ANS has been implicated as potential moderator of individual differences in children's responses to early life stress. PNS activity is associated with individual differences in a wide range of emotional and self-regulatory processes, including sensitivity to threat, social engagement, inhibitory control, and emotion regulation, with higher levels of PNS activity at the level of the heart being linked to decreased sensitivity to threat and greater regulatory behavior (Porges, 2007; Thayer & Lane, 2009). The vagus nerve, involved in parasympathetic control of peripheral organs including the heart, both receives information about the external environment from the brain and sends information regarding the internal environment back to the brain, making it an important bidirectional pathway of communication between the brain and periphery (Garfinkel et al., 2013; Mayer, 2011), and key in facilitating motivational responses to the both the internal and external environment (Berntson, 2000; Berntson & Cacioppo, 2004; Porges, 2007; Thayer & Lane, 2009). Additionally, there is good evidence that vagal activity is linked to brain activity in areas such as the medial prefrontal cortex (mPFC) and amygdala during engagement in emotional and regulatory processes, suggesting it may index activity in the central neural systems involved in these processes (Lane et al., 2009; Thayer, Ahs, Fredrikson, Sollers III, & Wager, 2012; Thayer & Lane, 2009). Because of this, it is likely parasympathetic regulation at the level of the heart is linked to how children perceive and respond to early life stress and their environment.

Indeed, there is some evidence that children with higher levels of parasympathetic regulation are buffered against some of the negative effects of early life stress (Blair et al., 2013; Katz, 2007; Katz & Gottman, 1995). For example, children in a more chaotic home environment demonstrate increased cortisol responses to a laboratory stressor (evidence of hyper-responsive to stress), but this relationship only holds for children with low levels of parasympathetic regulation (Blair et al., 2013). In adolescents with a history of childhood trauma, resting parasympathetic activity moderated the relationship between childhood stress and youth reported internalizing problems, with there being a significant relationship between childhood stress and internalizing problems but only for adolescents with low resting parasympathetic activity (Mclaughlin, Alves, & Sheridan, 2014). Additionally, resting parasympathetic regulation buffers against the negative effects of marital conflict on children, with children with low resting parasympathetic activity demonstrating a positive relationship between marital conflict and anxiety while those with high resting parasympathetic activity do not demonstrate such a relationship (El-Sheikh, Harger, & Whitson, 2001). Given low resting parasympathetic activity has been associated with increased sensitivity to threat (Thayer, Ahs, Fredrikson, Sollers, & Wager, 2012; Thayer & Lane, 2009), it is possible this buffering effect is due to children with higher resting parasympathetic activity perceiving these situations as less stressful or threatening than children with low resting parasympathetic activity, and therefore do not have a neurophysiological or behavioral stress response to that situation. However, while parasympathetic activity appears to have a buffering effect on responses to early life stress, the mechanisms through which it acts are still not clear, and there is a need for a better understanding of the mechanisms themselves and how they might be utilized in designing protective interventions for at-risk children.

There have been several psychological factors identified as important to buffering against the negative effects of early life stress, including parental care and sensitivity, quality of peer and other social relationships, and personality style (Collishaw et al., 2007; Masten, 2011; Rutter, 2012). However, often neglected within the early life stress literature is the role perception plays in responses to stress. In the early childhood literature, there is a focus on utilizing "objective measures" of early stress experiences – i.e. substantiated child protective services reports – rather than retrospective and self-report measures (Hardt & Rutter, 2004; Scott et al., 2012). In contrast, within the adult, adolescent, and non-human animal literature, individual differences in how people perceive their environment have been demonstrated to be incredibly important in affective processes and motivated responses. Perceived control and predictability are two of the most important factors which influence human and non-human animals' responses to a stressor (Mormede et al., 1988). In humans, perceptions of control have been demonstrated to decrease perceived pain intensity of an electrical shock (Muller, 2012) and alter cortisol responses to an aversive noise (Bollini et al., 2004). Perceived social status predicts current health status and changes in health status (Adler, Epel, Castellazzo, & Ickovics, 2000; Singh-Manoux, Marmot, & Adler, 2005) and anxiety, stress, and cardiovascular risk (Ghaed & Gallo, 2007) above and beyond “objective” social status. Models of allostasis, referred to earlier, provide a good conceptualization of the importance perception plays in individuals’ experiences of stressors, with an individual’s perception of an experience as stressful being what initiates the physiological and behavioral responses leading to adaptation and allostasis (McEwen, 2001, 2012).

Together this suggests that it is important to not only investigate childhood stress using “objective” measures of stress but also investigate children’s perceptions of stress in order to better understand individual differences in children’s responses to stress. It is likely, based off the previously described literature, that these perceptions are key in influencing individual differences observed in children’s responses to stress. Indeed, perceptions of parental care have been identified as a potential factor contributing to resilience (Collishaw et al., 2007; Masten, 2011). Additionally, perceived loneliness and retrospectively reported childhood abuse interact to predict health outcomes with children with high loneliness and high perceptions of childhood abuse having the highest cardiovascular risk (Norman, Hawkley, Ball, Berntson, & Cacioppo, 2013). Better understanding the role of both children’s and parents’ perceptions in the context of early stress, in combination with more “objective” measures of stress, is incredibly important to try and understand individual differences in how children respond to stress and how we might best help them. Indeed, changing perceptions, in concert with altering the environment itself, may actually be the most effective intervention for children within difficult home environments.

1.3 The Current Work

The aim of the current work is to examine children’s psychological, physiological, and behavioral responses to early life stress and what factors influence individual differences in these responses, with the goal of identifying protective factors for children in high risk environments to better understand which children/families might be most susceptible to specific types of intervention. This work consists of three studies conducted in collaboration with the Building Block's Preschool Program at Child and Parent Services (CAPS) in Elkhart, IN, a program that targets children who have experienced and/or are at risk of experiencing early life stress. These studies aim to address the following questions:

Study 1: How do children's self-regulatory behaviors change over the course of the preschool program, and what factors influence those patterns of change, with a specific focus on how the introduction of a stable environment (i.e. the classroom) affects patterns of change and are those patterns more pronounced for children who are in less stable home environments?

Study 2: Do individual differences in patterns of tonic parasympathetic cardiac functioning influence children's self-regulatory behaviors during the preschool program, does parasympathetic cardiac functioning change over the course of the program, and how do any observed changes in parasympathetic cardiac functioning relate to children's behavior in the classroom?

Study 3: How do children's self-regulatory behaviors change after the occurrence of a significant stressor (i.e. parent arrest), and does children's parasympathetic functioning predict this change?

Chapter 2: Overview of General Methods Common Across Studies

2.1 Sample Description

For all studies, participants included 150 parents and children ages 3 to 8 years (108 male; M = 59.59 months, SD = 10.24 months) who participated in the Building Blocks' Laboratory Preschool Program at Child and Parent Services (CAPS) in Elkhart, IN, a program which targets children who have experienced some form of early life stress and their families, between 2006 – 2016. Of these children 46.7% (70) were Caucasian, 31.3% (47) African American, 4.7% (7) Hispanic, and 17.3% (26) Multi-Racial. 24.0% of these children were living out of home (i.e. in foster care, adopted, or living with grandparents). On average, children were in the program for 6.28 months (SD = 3.80 months). This work was approved by both the CAPS' Building Blocks' Preschool Program and the University of Chicago's Institutional Review Board. All parents provided consent for use of their child's data.

2.2 Description of Program

The CAPS' Building Blocks' Preschool Program is a 10-month-long program (academic school year) for preschoolers and kindergarteners who have experienced some form or have been identified as at-risk of exposure to chronic and or extreme early life stress, such as abuse or maltreatment, parental financial instability, etc. Potential students are referred to Building Blocks by the Elkhart public school systems, child protective services, and other child service agencies (mental health, social work, etc) throughout the Elkhart County area. Building Blocks' interviews each prospective child and family and assesses risk prior to enrollment. Children are primarily admitted on a first come first serve basis from the referrals, with the preschool aiming to be a last course of intervention – i.e. if families have not pursued alternative options for intervention/aid the preschool will refer them to those prior to allowing a child admission. The program emphasizes a high teacher to child ratio (approximately one teacher for every 3 children) and uses an individual based approach. This involves teachers spending time one-on-one working with children to support children's use of self-regulatory techniques, including emotion recognition (i.e. teaching the child to identify their own and others emotions), appropriate emotion expression techniques (i.e. children are giving strategies through which they can express their emotions such as "stomping out their mad" instead of screaming, hitting, scratching etc), and appropriate peer interaction and play (i.e. teachers work with children to prevent hitting, scratching, biting and other forms of violent behavior in peer interactions), as well as typical academic skills including reading, writing, and math.

The Building Blocks Program utilizes a holistic approach to aiding enrolled children in that the program works with both children and families. All caregivers (parents or guardians) of children enrolled in the preschool program are required to complete parenting classes, either through classes offered at CAPS or other community classes, as well as weekly in-home visits, provided by preschool staff. In these visits, the home visitor works with parents to help implement effective parenting strategies and techniques in the home, including discouraging the use of corporal punishment, teaching parents to implement and follow through with logical consequences using techniques such as time outs rather than spanking to discipline their children, and helping parents encourage similar forms of appropriate emotion expression (i.e. "stomping out their mad" or "shaking out their sad") as those used in the classroom in their children at home. Additionally, the home visitor acts to provide an additional source of support for these struggling families. Building Blocks documents each home visit and any other contact with the family (phone calls, test message etc) including summaries of conversations with the parents, notes of child behavior and child directed parent behaviors, and the occurrence of any significant stressors or changes in the home. Building Blocks also documents daily classroom behavior and events (time outs, how often children hit, bit or scratched other children etc) for each child. Together this results in a wealth of data that can be used to examine individual variation in these children's behavioral patterns.

2.3 Data

All measures were collected by the preschool in four formats: 1) Documentation of the home, family environment, and family's/child's past history during intake interviews of children and families admitted to the program; 2) Documentation of each child's behavior in the classroom by the teachers throughout the child's time in the program; 3) Collection of physiological data (for a subset of children) daily in the classroom through the use of ambulatory physiological monitors; and 4) Documentation of the home environment including any significant stressful events that occur within the family during the child's time in the preschool program.

Intake Interviews: Prior to children entering the program, the school performs a structured intake interview with parents/guardians, in which they ask questions about the child's home environment (e.g. how many people are currently living in the home), family structure (single parent or two parent), care source (biological parents, foster care, adoptive parents), the child and parents' previous experiences with abuse, and past stressors experienced within the family. Additionally, during this interviews the staff document why the family has been referred to the program and the source of referral (e.g. child protective services (CPS), elementary school).

Daily Classroom Behavior: While children are enrolled in the program, the school collects a plethora of information on children's daily behavior. For each child, teachers' compile a short daily summary of the child's behavior while in the classroom. Additionally, teachers document the number of time outs (when a child has to be physically restrained for their own and/or the class' safety) each child has every day. Time outs are used when children are used to encourage appropriate emotion expression and classroom behavior (i.e. not hitting, scratching or biting others in the classroom, sitting still and quietly during those activities that involve listening, etc). The occurrence of a time out is indicative of a child struggling with self-regulation within the classroom context.

Teachers' also provide ratings of children's ability to cope with disappointment or change, express anger appropriately, and control impulses on a Likert scale from 0 – 4, with higher numbers indicating better functioning (ratings monthly prior to 2014, daily after 2014, see Appendix D for items). These ratings are based on children's ability to express themselves using appropriate strategies encouraged by the preschool rather than expressing themselves through hitting, biting, screaming, withdrawal from group activities, etc. Additionally, the preschool keeps records of attendance information, medical history, transitions in and out different care sources (foster or biological parent), any child protective services reports filed, and documents every communication with each child's caregivers and/or extended family.

Physiological data: Indices of children's physiological functioning were collected daily from children starting in 2014. An electrocardiogram was collected with the Zephyr Bioharness 2.0 ambulatory device, which consists of a band with two electrodes that is worn around the chest such that the electrodes are placed on the left and right side of the chest, crossing the heart. Children wore the Zephyr Bioharness 2.0 daily while they were in the classroom. Respiratory sinus arrhythmia (RSA) was derived from the electrocardiogram as a measure of parasympathetic cardiac control using prespecified procedures (Berntson et al., 1997) (Processing of this data will be discussed in more detail in Chapter 4).

Home Visits: During the child's enrollment in the program, parents'/guardians' are also required to have weekly home visits provided by the school, during which information about the parents'/guardians' behavior toward the child, child's behavior at home, the current home environment, any significant changes or adverse events (e.g. removal from home, parent has new partner in house, parent arrest, abuse report filed) was collected and documented.

2.2.1 Primary Outcomes of Interest

For all studies presented, outcome measures of interest will be teacher documentation of children's self-regulatory behaviors in the classroom. Teachers' ratings of children's ability to cope well with change, effectively express anger, and control impulses were summed to form a composite score of children's self-regulatory behavior within the classroom. Additionally, I also coded the daily classroom documentation for the number of times a child was placed in time out each day as a behavioral index of self-regulation.

2.2.2 Primary Predictors of Interest

Environmental Instability: Primary predictors of interest consist of data coded and compiled from the intake interview, daily written documentation, and documentation of home visits by the home visitor. Indices of household instability/risk were coded from the intake interview and include: 1) The total number of people currently living in the home (both adults and children); 2) Child care source (who the child is living with: i.e. biological parents, adoptive parents, foster parents, or extended family); 3) Family configuration (i.e. the child lives in a single parent or two parent household); 4) A lifetime stressors checklist where caregivers are presented with a list of potential family stressors and asked to indicated which have occurred in the family in the child's lifetime (Appendix E); 5) Parent/guardian reported past abuse of the child ("Has the child experienced or witnessed abuse?").

These variables were extracted and coded to examine potential environmental influences on child behavior and behavior changes during the program. Additionally, school documentation of number of child protective services (CPS) reports filed during the program and whether or not the child completed the program were included as potential moderators of individual differences in children's behavior trajectories (teacher ratings of self-regulatory behavior, average number of safe holds, average number of time outs) while in the program. I also included the amount of months a child attended the program as a predictor to try and disentangle any effects of completing the program from amount of time in the program. Importantly, children's completion of the program is not necessarily associated with completing a full academic year in the program. Children who successfully transition from Building Blocks into either another preschool classroom or Kindergarten are coded as completing the program. This means that completion of the program does not necessarily mean the child has been in the program for a longer time, although the two are significantly correlated ($r = 0.31$, $p < 0.001$) (for information on specific coding of these variables see Chapter 3).

Physiological functioning: To examine changes in psychophysiological functioning over the course of the program and the relationship between psychophysiological functioning and children's behavior in the program as well as in response to adverse events, cardiovascular measures of parasympathetic autonomic nervous system activity (RSA) were collected daily from each child in the classroom using an electrocardiogram starting in 2014 (discussed in detail in Chapter 4).

Stressful Life Events: In order to examine children's responses to stress, all documentation collected by the preschool (intake interviews, classroom documentation, and documentation of home visits) were coded using pre-identified search terms to identify three types of stressful life events that may have occurred during a child's time in the program: 1) parent arrest, 2) moving in or out of foster care/guardianship; 3) experience of abuse (discussed in detail in Chapter 5).

2.4 Statistical Analyses: General Approach

To assess changes in children's self-regulatory processes during their time in the preschool program, I utilized hierarchical linear modeling (HLM) techniques, a complex form of ordinary least square (OLS) regression which fits a linear function to the observed data while accounting for variation across individuals to estimate the population level rate of change based on the observed data set (Raudenbush & Bryk, 2002; Singer & Willett, 2003). These models are preferable over a repeated measures analysis of variance approach as longitudinal data are inherently nested with time grouped within subject (each individual has a series of outcomes for each time point), and HLM accounts for potential variation in observed outcomes across individuals. Additionally, HLM can handle missing values without imputation (i.e. replacing missing values with substituted values based on distribution of data set) (Raudenbush & Bryk, 2002; Singer & Willett, 2003). All models were run using the nlme package for R, developed for building hierarchical linear models, with full maximum likelihood estimation (method of computing estimates of population parameters that jointly maximize the likelihood of observing a particular sample of data; for more explanation see Singer & Willett, 2003) in R v3.2.3.

Chapter 3: Study 1 - Relationship Between Environmental Stability and Children's Household

3.1 Introduction

Early life stress is associated with a wide range of negative outcomes, including increased aggressive behaviors, changes in emotion recognition and representation processes, and the development of psychopathology (for review see Lupien, McEwen, Gunnar, & Heim, 2009; Pechtel & Pizzagalli, 2011). Prevalent among these are disruptions in children's self-regulatory behaviors, which I broadly conceptualize as an inability to inhibit or modify behaviors based on contextual demands (Johansson, Marciszko, Gredebäck, Nyström, & Bohlin, 2015; Weiner, Gedhof, & Gestsdottir, 2015). For example, children exposed to early life stress demonstrate increased externalizing behaviors (Barch, Belden, Tillman, Whalen, & Luby, 2017; Heleniak, McLaughlin, Ormel, & Riese, 2016), conduct problems (Docherty, Kubik, Herrera, & Boxer, 2018; Jaffee et al., 2009), and anti-social behaviors (Alink et al., 2012; Shaw & Gilliam, 2000). However, not all children who experience early life stress demonstrate problems with self-regulation (McCrory et al., 2010; Watts-English et al., 2006). Understanding what factors contribute to individual differences in children's responses to early life stress can aid in creating programs supporting the development of self-regulatory behaviors among children in high risk environments. This is additionally important, as research is only beginning to illuminate what factors contribute to this variability in efficacy of programs aimed at aiding and supporting self-regulatory processes (Belsky & Van Ijzendoorn, 2014). Attempts at better understanding what psychological and contextual factors modulate children's responses to their environment can help develop targeted programs that better aid different sub-populations of children.

As described in Chapter 1, early life stress, specifically chronic or extreme stress, is linked with a host of problem behaviors in children that carry through into adulthood (Shonkoff & Garner, 2012). For example, early life stress, in the form of maltreatment, has been associated with difficulties in emotion regulation which in turn predict increased internalizing behaviors (Kim-Spoon, Cicchetti, & Rogosch, 2013) and increased negative affect and aggressive behaviors (Shackman & Pollak, 2014). Children who experience neglect, another form of chronic, extreme stress, early in childhood have poorer classroom behaviors (Manly, Lynch, Oshri, Herzog, & Wortel, 2013). In adolescents, experiences of chronic stress early in life have been associated with increased risky health behaviors (Roberts, English, Thompson, & White, 2017), as well as criminal behavior and delinquency in both adolescence and adulthood (Duin, van et al., 2017; Malvaso, Delfabbro, & Day, 2017).

Given the influence of early life stress across a range of self-regulatory behaviors, a number of programs aimed at addressing these issues in children have been developed (Bor, Sanders, & Markie-Dadds, 2002; Hsueh, Lowenstein, Morris, Mattera, & Bangser, 2014). While program efficacy is mixed, many of these programs do appear to be effective at improving children's self-regulatory behaviors, at least in the short term (Domitrovich, Cortes, & Greenberg, 2007; Fisher, Gunnar, Chamberlain, & Reid, 2000; Nix, Bierman, Domitrovich, & Gill, 2013). However, research has only recently begun to explore factors contributing to variation in children's responses to programs aimed at supporting self-regulatory behaviors (Bakermans-Kranenburg, Van IJzendoorn, Pijlman, Mesman, & Juffer, 2008). Investigating what influences individual differences in response to positive environments can help elucidate for which individuals within populations exposed to early life stress a specific type of program may be most effective.

One potential factor impacting children's responses to programs aimed at supporting self-regulatory behaviors is the stability of a child's home environment. As discussed in Chapter 1, an individual's perceived control and perceived predictability of their environment plays an important role in individual variation in stress responses (Mormede et al., 1988). Inconsistency in stability within the home for children at-risk for early life stress is likely to result in perceptions of a lack of predictability and controllability (Mccoy & Raver, 2014). Indeed, lack of stability in the home appears to moderate some of the negative outcomes associated with experiences of early life stress (Berry et al., 2016; Masten et al., 2009). Children exposed to maltreatment as well as greater instability in out of home placements demonstrate an increased risk for criminality as adults (DeGue & Widom, 2009). Children living in poverty, another form of chronic extreme stress, with increased family instability demonstrate decreased effortful control, a type of self-regulatory behavior (Sturge-Apple, Davies, Cicchetti, Hentges, & Coe, 2017). Examining multiple environmental factors associated with environmental stability in tandem is one potential avenue through which to explore individual differences in children's responses to programs aimed at supporting self-regulatory behaviors in at risk children.

The current study aims to examine changes in children's self-regulatory behaviors during the Building Block's preschool program and environmental factors which may moderate these changes. Building's Block's Preschool program is especially conducive to studying patterns of changes in children given the high frequency, detailed information collected on children's classroom behavior, home environments, and experiences with stress. This allows for not only a fine grained analysis of change in children's self-regulatory behaviors over time in the program, but also an in depth examination of how environmental factors and stress exposure influence those patterns of change.

3.2 Methods

3.2.1 Participants

Participants included 138 children 3 to 8 years (M = 59.15 months, SD = 10.37 months; 101 Male) of the 150 children who participated in the Building Blocks' Laboratory Preschool Program at Child and Parent Services (CAPS) in Elkhart, IN. Participants included children who participated in the program between 2006 – 2015. Of these children 46.8% (65) were Caucasian, 30.2% (42) African American – Black, 5.0% (7) Hispanic, and 16.5% (23) Multi-Racial. 24.6% of these children were no longer living with their biological parents (i.e. in foster care or placed in guardianship). On average, children were in the program for 6.42 months (SD = 3.84 months). This study was approved by both the CAPS' Building Blocks' Preschool Program and the University of Chicago's Institutional Review Board. All parents provided written consent for use of their child's data.

3.2.2 Study Measures

All data was extracted and analyzed from information documented by the staff at Building Blocks. The current study focuses on two main aspects of these data: 1) Measures of environmental instability coded from school documentation of the child's home and family environment and past history of stress and abuse; and 2) Measures of children's self-regulatory behaviors taken from teacher documentation of child's behavior in the classroom.

Child Self-Regulatory Behaviors: The sum score of teachers' monthly ratings of children's self-regulatory behavior (copes well with change, effectively expresses anger, controls impulses) were used to assess changes in children's behavior during the program. Additionally, I also examined changes in number of time outs children had. Total number of time outs was summed for each month and then divided by the number of days in the month to create an average monthly score of time outs for each child.

Environmental Instability: As predictors, I included those measures outlined in Chapter 2, Section 2.2.2: Environmental Instability. These included caregiver report of whether or not the child has experienced abuse (yes or no), the number of people currently living in the home (both adults and children), child care source (who the child is living with: i.e. biological parents, adoptive parents, foster parents, or extended family), family configuration (the child lives in a single parent or two parent household), the lifetime stressors checklist completed by caregivers, number of CPS reports filed during the program, whether the child completed the program, and the number of months a child was in the program. These variables were extracted and coded to examine potential environmental influences on child behavior and behavior changes during the program.

For analyses, the number of people living in the home was calculated as a sum of adults and children in the household. Parent configuration was coded as a bivariate categorical variable of single parent or two parent household. Whether a child was living with their biological parents was coded as a bivariate categorical variable of living with biological parents or in an alternative care situation, which included living with adoptive parents, foster parents, or in guardianship. The majority of children not living with their biological parents were in foster care (67.6%) which is why I did not attempt to examine specific effects of type of care outside of biological vs non-biological parents. Changes in children's care source are tracked over the course of the program (i.e. moving in or out foster care). However, the current analyses focus on children's care source at the start of the program (see Chapter 5 for relationships between children's changes in care source and self-regulatory behaviors). As is typical when assessing lifetime stressors (Felitti et al., 1998; Sarason, Johnson, Siegel, 1978), child's exposure to prior stress was calculated as a sum score of the number of stressors in the family a caregiver marked on the lifetime stressors checklist. Abuse of child was coded as bivariate categorical variable (abuse/no abuse). CPS reports were coded as a sum score of number of reports filed by teachers or school staff while the child was in the program. Just because a report was filed did not mean CPS opened an investigation. However, the fact that teachers and/or home visitors felt an observed event met their criteria for filing a report reflects that staff perceived instability and a potential threat for children in the home. Completion of the program was coded as a bivariate categorical variable of "child completed the program" or "child did not complete the program." Again, due to the fact that children who transition successfully from the preschool program to another classroom count as completing the program, these effects are somewhat separable form those of time in the program. However, to examine if effects of completion of the program differ from total time in the program, the total amount of months a child spent in the program was calculated and included as a predictor in analyses.

3.2.3 Statistical Analyses

I utilized hierarchical linear growth models (as described in Chapter 2, Section 2.4) to examine changes in children's self-regulatory behaviors during the program and the influence of environmental stability on any observed patterns of change. Inspection of individual subject level trajectories indicated that a linear growth model was most appropriate for the data set. Time was treated as random and nested within subject. The composite teacher rating score each month and average number of time outs each month, were included as outcome variables to examine change in children's self-regulatory behavior over the course of the program. An initial model, including only time in the program as a predictor was run to examine general patterns of growth for each outcome measure based on recommendations from Singer & Willett, 2003. Environmental predictors were then incorporated in a stepwise manner into the models as fixed predictors at the subject level to examine influences of these factors on children's self-regulatory behaviors and changes in these behaviors over time. These models were then compared using Log Likelihood (LL) and Akaike Information Criterion (AIC) statistics to determine which model best fit the data (Singer & Willett, 2003), and only results of the best fit model are reported. To control for any potential effects of age or gender, both of which are have previously been associated with differences in self-regulatory behaviors (Carlson & Wang, 2007; Kochanska, Coy, & Murray, 2001), these were also included in all models as fixed covariates. To better understand and interpret any significant interactions observed, simple slopes were computed following recommendations by Preacher, Curran, & Bauer, 2006.

3.3 Results

Overall, children's self-regulatory behaviors significantly improved over the course of the program, with there being a significant positive effect of time in program on children's behavior rating ($\beta = 0.34$, $SE = 0.03$, $p < 0.001$; $r2 = 0.19$; Table 1; Figure 1). This effect remained significant after controlling for gender and age (Table 1). While there was a significant effect of gender on self-regulatory behavior ($\beta = 1.26$, $SE = 0.36$, $p < 0.001$), with females having better behaviors than males, there were no effects of age ($\beta = -0.01$, $SE = 0.02$, $p = 0.42$). Additionally, incorporating gender improved the model fit ($p < 0.001$) but including age did not ($p > 0.05$).

There were no significant effects of time in program on average number of time outs ($\beta = 0.01$, $SE = 0.01$ $p = 0.09$; $r2 = 0.005$) (Table 1; Figure 1). After including gender and age, there was a significant effect of gender on time outs ($\beta = -0.36$, $SE = 0.20$ $p < 0.001$; Table 1) such that females had fewer time outs each month than months. There were no effects of age on time outs (β = -0.003, SE = 0.005, $p = 0.57$; Table 1). Including gender improved model fit ($p < 0.05$), but including age did not ($p > 0.10$).

Effects of home environment on teacher rated self-regulatory behavior: Across model iterations, the most consistent predictors of teacher ratings of behavior were living with biological parent(s) and child completing the program. The model which best fit the data (accounted for the most variance in the data) (AIC = 2733.05, LL = -1350.53, r2 = 0.24) included these two predictors, along with total number of months in program and gender, as well as an interaction between gender and completion of the program (see Table 2). The main effect of time described in the above section on children's teacher rated behavior remained significant in the best fit model (β = 0.37, SE = 0.04, $p < 0.001$), with children's teacher rated behaviors improving over time in the program. Interestingly, there was also a main effect of children living with their biological parent(s) (β = 1.12, SE = 0.37, $p < 0.01$), with children living with their biological parents at the start the program having significantly lower teacher ratings of behavior their first month in the program compared to children not living with their biological parent(s) (Figure 2).

There were significant interactions of fixed predictors completion of program (β = 0.20, SE = 0.06, $p < 0.01$) and total number of months in the program (β = -0.03, SE = 0.01, $p < 0.001$) with the random predictor of time in program (Figure 3). Comparisons of the simple slopes (Preacher et al., 2006) for completion of the program reveals that, while children who complete and do not complete the program both demonstrate significant positive change over time ($p < 0.001$), the slope for children who do not complete the program is smaller (β = 0.27) than those who do complete the program (β = 0.47). This suggests that children who complete the program demonstrate greater improvement than those who do not. Total number of months in program (fixed) demonstrated the opposite pattern. For total number of months in the program, I examined simple slopes for children who were in the program for a greater number of months compared to a fewer number of months (based on recommendations by Aiken & West, 1991 simple slopes were calculated at ± 1 standard deviation). Again, all children demonstrated significant positive change ($p < 0.001$), but children who were in the program longer (more months; $\beta = 0.23$) demonstrated a smaller positive slope of change than children who were in the program for a shorter amount of time (fewer months; $\beta = 0.48$). None of the other variables demonstrate significant interactions with time, and including interactions between predictor variables did not significantly improve the model fit ($p > 0.10$).

Gender demonstrated a positive effect similar to that observed in previous studies ($\beta = 1.01$, SE = 0.35, $p < 0.01$), with females starting the program with increased teacher ratings of self-regulatory behaviors compared to males, but gender did not significantly interact with time ($\beta = 0.04$, SE = 0.07, $p = 0.59$). However, gender did interact with completion of the program and time in program ($\beta = -0.39$, SE = 0.14, $p < 0.01$) (Figure 4). I computed simple slopes for female compared to male students and found that while all individuals demonstrate improvement over the program (for simple slopes see Table 3), males who do not complete the program demonstrate less change over time (Table 3). Including this interaction improved model fit ($p < 0.05$). There were no significant main effects or interaction effects of number of people living in the household, but including this term improved model fit ($p < 0.05$, Table 2).

Effects of home environment on time outs: As with teacher rated self-regulatory behaviors, the best fit model (AIC = 658.67, LL = -309.34, $r2 = 0.19$) for average number of time outs included living with biological parent(s), completion of the program, and gender, as well as number of CPS reports while in program and number of people living in the house. It also included an interaction of gender and completion of the program and an interaction of living with biological parent(s) and completion of the program (see Table 4). As with the unconditional model, there were no significant effects of time in program on average monthly time outs (β = 0.01, SE = 0.01, $p = 0.40$). There was a significant main effect of living with biological parent(s) (β = -0.21, SE = 0.10, $p < 0.05$) such that children living with their biological parent(s) had significantly more time outs during their first month in the program (Figure 5) compared to children in alternative care. Additionally, there was a significant interaction effect of living with biological parent(s) and time in program (β = 0.06, SE = 0.02, $p < 0.01$) (Figure 5). Examining the simple slopes of children living with biological parents compared to alternative care suggested that children living with their biological parents demonstrated no change in time outs during the program (β = -0.01, $p = 0.43$), while children living in alternative care demonstrated significant increases in time outs over time in the program (β = 0.05, $p < 0.001$). In contrast, children not living with their biological parent(s) demonstrated a significant increase in average monthly time outs during the program (β = 0.05, $p < 0.001$). Number of CPS reports while in the program significantly predicted average time outs in the first month of the program (β = 0.20, SE = 0.06, $p < 0.01$), such that children who had more CPS reports filed during the program had more time outs their first month in the program (Figure 6).

There was also a significant interaction effect of living with biological parent(s) and completion of the program (β = -0.51, SE = 0.02, $p < 0.05$) (Figure 7). Comparing simple slopes indicated that the difference in average time outs in the first month of the program between children living with their biological parent(s) and children in alternative care was only significant for children who completed the program (Completed: β = -0.47, $p < 0.001$; Did not complete: β =

0.04, $p = 0.72$). Again there was a significant interaction of completion of the program, gender, and time in program ($\beta = 0.10$, $SE = 0.04$, $p < 0.01$) (Figure 8). Using simple slopes comparisons, males who completed the program demonstrated no significant change in average monthly time outs ($\beta = -0.02$, $p = 0.29$) while males who did not complete the program demonstrated increases ($\beta = 0.04$, $p < 0.05$). In contrast, there were no significant changes in average time outs over time in the program for females regardless of whether or not they completed the program (Completed: $\beta = 0.02$, $p = 0.10$; Did not complete: $\beta = -0.02$, $p = 0.14$). Including number of people in the household improved model fit ($p < 0.05$), but exhibited no significant effect on behavior (see Table 4). Including number of months a child was in the program, to determine whether effects of completing program were due to time spent in program, did not improve model fit ($p > 0.10$), change any of the observed effects, or have any significant effects on average monthly time outs.

3.4 Discussion

The goal of this study was to identify environmental factors that contribute to individual differences in patterns of behavior change in a population of children exposed to early life stress in response to a preschool program aimed at supporting self-regulation in high-risk children. Importantly, this study found that on average children responded positively to the preschool program. Additionally, whether or not children were living with their biological parent(s) along with whether they completed the program predicted both children's initial teacher rated self-regulatory behaviors, average monthly time outs, and changes in these measures over the course of the program, suggesting that these factors may affect intervention efficacy within the context of populations at risk for early life stress.

Somewhat unexpectedly, I found that populations traditionally be considered as at greater risk for poorer behaviors (children who were not living with their biological parent(s) – primarily in foster care or guardianship placement) demonstrated better behaviors in their first month in the program, as assessed both through teacher ratings and time outs, than those living with their biological parent(s). However, despite having more time outs initially, children living with their biological parent(s) demonstrated stability in number of time outs during the program, while children living in alternative care demonstrated increases, ending the program with more time outs than children living with their biological parent(s). Additionally, while not significant, a somewhat similar pattern was evident for teacher rated self-regulatory behaviors, with children living with their biological parent(s) demonstrating a steeper slope of positive change in these ratings. While initially somewhat surprising, one potential possible explanation for these findings is that children who have been removed from their biological parent(s) care have greater experience with change and disruption and are better able to adjust to beginning the preschool program. For many children, starting the preschool program is likely perceived as an unpredictable and uncontrollable event, and therefore represents a stressor. For children in already extreme uncontrollable and unpredictable environments, this change may be perceived as less stressful.

Additionally, the literature on the relationship between placement in foster care and self-regulatory behaviors is mixed, with some work finding a positive effect and some finding a negative effect. Indeed it appears the relationship between foster care placement and children's self-regulatory behavior is influenced by factors such as number of care placements and perceptions of and attachment to foster parents (Cooley, Wojciak, Farineau, & Mullis, 2015; McLaughlin, Zeanah, Fox, & Nelson, 2012; Newton, Litrownik, & Landsverk, 2000; Villodas, Litrownik, Newton, & Davis, 2016). It is likely that differences in children's perceptions of their caregiver may be influencing the observed effects. It is also possible that given the children enrolled in the preschool program are already a high risk population, children no longer living with their biological parent(s) may be in relatively more stable environments, and this is why they demonstrate better behaviors. However, this does not explain the increase in the number of time outs observed in children no longer living with their biological parents. Of course, it is also possible that, as teachers are not blind to children's home situations, there is an initial grace period in which teachers are less likely to place these children in time outs. However, if teacher bias towards children living in alternative care was driven the observed effects I would expect to see the same pattern in teacher rated self-regulatory behaviors, which I do not. Importantly, number of CPS reports filed for children during their time in the program, an alternative marker of risk for families and likely associated with a higher risk of being moved out of home, did positively predict children's average number of time outs in the first month of the program. Examining the amount of time a child has been out of home as well as the variability in their placement structure (i.e. how often do they move foster homes) could help provide insight into what may be driving these findings. It is important future research examine what factors about these households or children may be contributing to the observed differences.

Successful completion of the program was also related to children's patterns of behavior change, measured both through teacher ratings and time outs. Children who completed the program demonstrated greater positive change in behaviors over the course of the program, indicating that it is these children who benefitted most from the program. Interestingly, this does not seem to be driven by the amount of time a child spent in the program. In fact, number of months a child was in the program had the opposite effect on teacher ratings of behaviors.

Children who were in the program longer demonstrated, while still positive, decreased improvement in behaviors during the program. For time outs, number of months a child spent in the program had no effect. Importantly, children's completion of the program is not tied to length in the program – children can complete the program prior to the end of the academic year through a successful transition facilitated by the preschool staff into another Kindergarten or preschool classroom. The results suggest that children who successfully complete the program, independent of number of months in the program, reap the most benefits behaviorally. Speaking to this, there was an interesting interaction of completion of the program and living with biological parent(s), such that the differences in number of time outs during children's first month in the program between children living with their biological parent(s) and children not living with their biological parent(s) was only significant for those who did not complete the program.

It is the case that completing the program, regardless of the total amount of time spent in the program, is likely linked to teacher perceptions of children's behaviors. If a child completes the program through a successful transition into another classroom, this indicates the teachers perceive the child's behaviors to be at a level appropriate for this transition. Additionally, it is possible that children with overall poorer self-regulatory behaviors struggle to complete the program. However, children are never removed from the program due to their classroom behaviors. A child not completing the program is a result of either excessive absences, parent non-compliance with program requirements (either they do not complete the required parenting classes or refuse to participate in regular home visits), or a child moving out of the transportation area and parents being unable to provide transportation. This means that a child not completing the program indicates non-compliance with program guidelines and lack of participation in the program (i.e. absences) while completion represents compliance and participation. Therefore, the results provide support that children of families who participate and comply with the program's holistic requirements are those that are most benefitted by the program itself.

There are several limitations of this study that should be mentioned. This work had no control group against which to compare the program meaning the observed behavior changes could be due to external factors or normal patterns of developmental change. However, the primary goal of this study was not to assess program efficacy, but rather within individual differences in behavior change, taking a holistic approach to what environmental factors may contribute to it. Additionally, the fact that this study had access to a large range of environmental variables and behavior ratings were collected at high frequencies over the time period assessed provides us with a unique context within which to examine the questions of interest. It is also the case that completion of the program was related to greater improvement in children's behavior, despite these children not starting the program with better behaviors, suggesting that positive behavior change is driven by participation in the program. Additionally, these effects held after controlling for age which indicates they are not a result of age related developmental change.

Lastly, the study is limited by its reliance on teacher interpretations of children's behavior change. I did utilize both teacher reported behaviors in combination with counts of time outs, which are indicative of problematic classroom behaviors. However, time outs are still implemented by the teacher and subject to teacher perception, meaning the observed effect could be driven by teachers being less likely to put children in time out after more time interacting with them. However, this is a limitation with many studies examining environmental influences on children's self-regulatory behaviors, as they often rely on parent or teacher reported child behaviors (Cheng et al., 2007; Kaaresen et al., 2008; Sanders, Kirby, Tellegen, & Day, 2014).

Regardless, the comparable relationships between predictors and patterns of behavioral change I find across time outs and teacher ratings suggest the observed effects represent meaningful relationships.

It is important to note that while I am characterizing the observed behaviors under the umbrella of self-regulation, it is not necessarily the case that these behaviors are motivated by a lack of what would classically be considered as self-regulation. Rather, they could represent the manifestation of behavioral strategies these children have found to be successful in navigating their current home environment (Ellis et al., 2017; Pollak, 2008). However, these strategies become problematic once children start navigating the broader social world (Blair & Raver, 2012), which often coincides with the start of school, making it important to understand individual differences in children's responses to programs aimed at supporting more effective strategies.

Overall this study suggests that there are important individual differences in how children exposed to early life stress respond to intervention. It points to complex interactions between children's home environment, implementation of a more positive and stable environment, and changes in behavior. Future work should focus on the mechanisms driving these complex relationships. Better understanding these differences in children's patterns of behavioral change can help researchers and clinicians better target interventions at specific subpopulations of at-risk families and children.

3.5 Appendix A: Chapter 3 Tables and Figures

Table 1: Effects of time in program on teacher rated self-regulatory behaviors and time outs

Model	**Fixed Effect**	**β (SE)**	**df**	**β (SE)**	**df**
Teacher Rated Self-Regulatory Behaviors	Intercept	5.09*** (0.16)	779	5.15*** (0.16)	733
	Time	0.34*** (0.03)	779	0.34*** (0.03)	733
	Gender	-	-	1.26*** (0.36)	132
	Age	-	-	-0.01 (0.02)	132
	Time*Gender	-	-	-0.004 (0.08)	733
	Time*Age	-	-	0.006 (0.004)	733

Table 1, continued

Time Outs	Intercept	0.50*** (0.04)	743	0.49*** (0.04)	696
	Time	0.01 (0.01)	743	0.02 (0.01) †	696
	Gender	-	-	-0.36*** (0.10)	128
	Age	-	-	-0.003 (0.005)	128
	Time*Gender	-	-	0.02 (0.02)	696
	Time*Age	-	-	0.002 (0.001)	696
	Random Effects	**Variance**		**Variance**	

Table 1, continued

Teacher Rated Self-Regulatory Behaviors	Intercept	3.25	2.94
	Time	0.09	0.09
Time Outs	Intercept	0.19	0.17
	Time	0.003	0.002
Model Fit Statistics			
Teacher Rated Self-Regulatory Behaviors	AIC	3076.54	2897.66
	Log Likelihood	-1532.27	-1438.83
	r^2	0.19	0.19
Time Outs	AIC	1004.54	957.01
	Log Likelihood	-496.27	-468.51
	r^2	0.005	0.07

Note. $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\dagger}p < 0.10$

Table 2: Effects of environmental variables on children's teacher rated self-regulatory behaviors

Fixed Effect	**β (SE)**	**df**
Intercept	5.21*** (0.16)	694
Time	0.37*** (0.04)	694
Living with biological parent(s)	1.12** (0.37)	122
Completion of program	0.07 (0.33)	122
Months in program	-0.02 (0.04)	122
Gender	1.01** (0.35)	122
Completion of program*Gender	1.15† (0.69)	122
Living with biological parent(s)*Time	-0.11 (0.07)	694
Completion of program*Time	0.20** (0.06)	694

Table 2, continued

Months in program*Time	-0.03*** (0.01)	694
Gender*Time	0.04 (0.07)	694
Time*Completion of program*Gender	-0.39** (0.14)	694
Random Effects	**Variance**	
Intercept	2.64	
Time	0.06	
Model Fit Statistics		
AIC	2733.05	
Log Likelihood	-1350.53	
r^2	0.24	

Note. Results represent the best fit model based on stepwise incorporation of environmental predictors into model. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.10

Table 3: Simple slopes for completion of the program, gender, and time interaction for teacher rated self-regulatory behaviors

Slope	**β**
Female, Completed program	0.36***
Female, Did not complete program	0.43***
Male, Completed program	0.51***
Male, Did not complete program	0.20***

Note. ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, $^{\dagger}p < 0.10$

Table 4: Effects of environmental variables on children's average time outs

Fixed Effect	**β (SE)**	**df**
Intercept	0.50*** (0.04)	538
Time	0.01 (0.01)	538
Number of people in house	-0.06† (0.03)	94
Number of CPS reports	0.20** (0.06)	94
Living with biological parent(s)	-0.21* (0.10)	94
Completion of program	0.15† 0.09	94
Gender	-0.22* (0.22)	94
Completion of program*Gender	0.05 0.18	94
Living with biological parent(s)*Completion of program	-0.51* (0.20)	94

Table 4, continued

Number of people in house*Time	-0.0002 (0.006)	538
Number of CPS reports*Time	-0.01 (0.01)	538
Living with biological parent(s)*Time	0.06** (0.02)	538
Completion of program*Gender*Time	0.10** (0.04)	538
Living with biological parent(s)*Completion of program*Time	0.02 (0.04)	538
Random Effects	**Variance**	
Intercept	0.12	
Time	0.002	
Model Fit Statistics		
AIC	658.67	
Log Likelihood	-309.34	
r^2	0.19	

Note. Results represent best fit model based on stepwise incorporation of environmental predictors into model. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.1

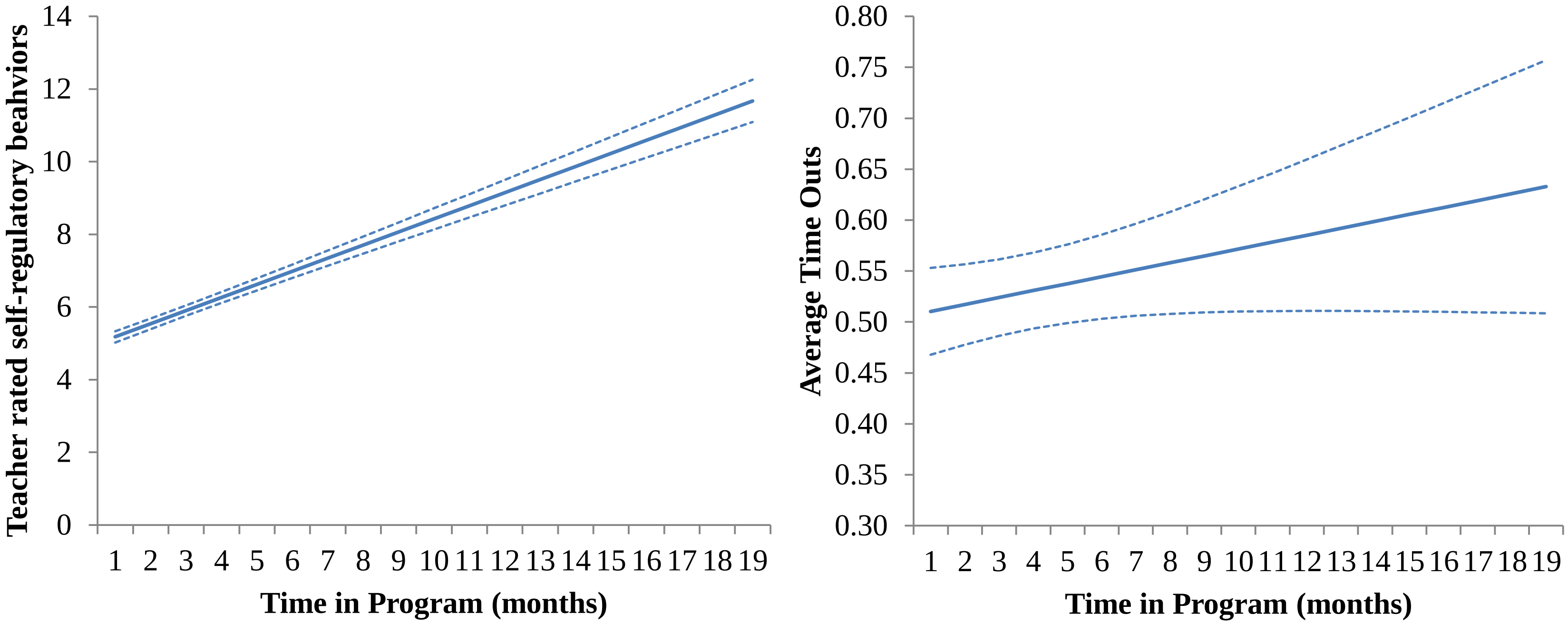

Figure 1: Relationship between time in program and teacher rated self-regulatory behaviors and average time outs.

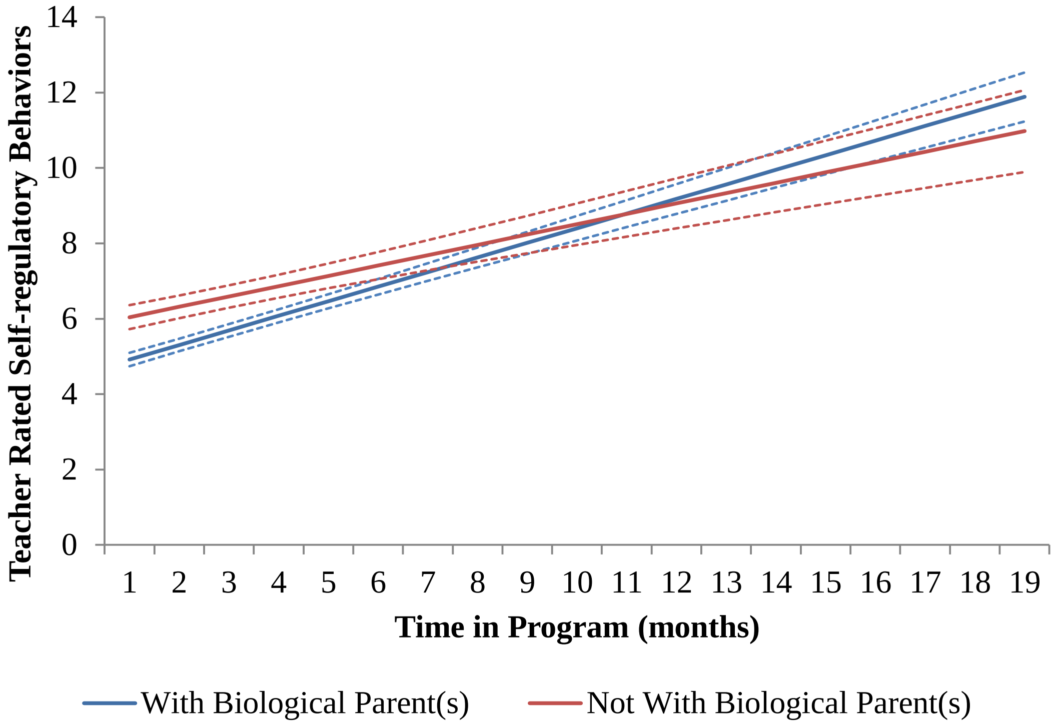

Figure 2: Relationship between living with biological parents and children's teacher rated self-regulatory behaviors.

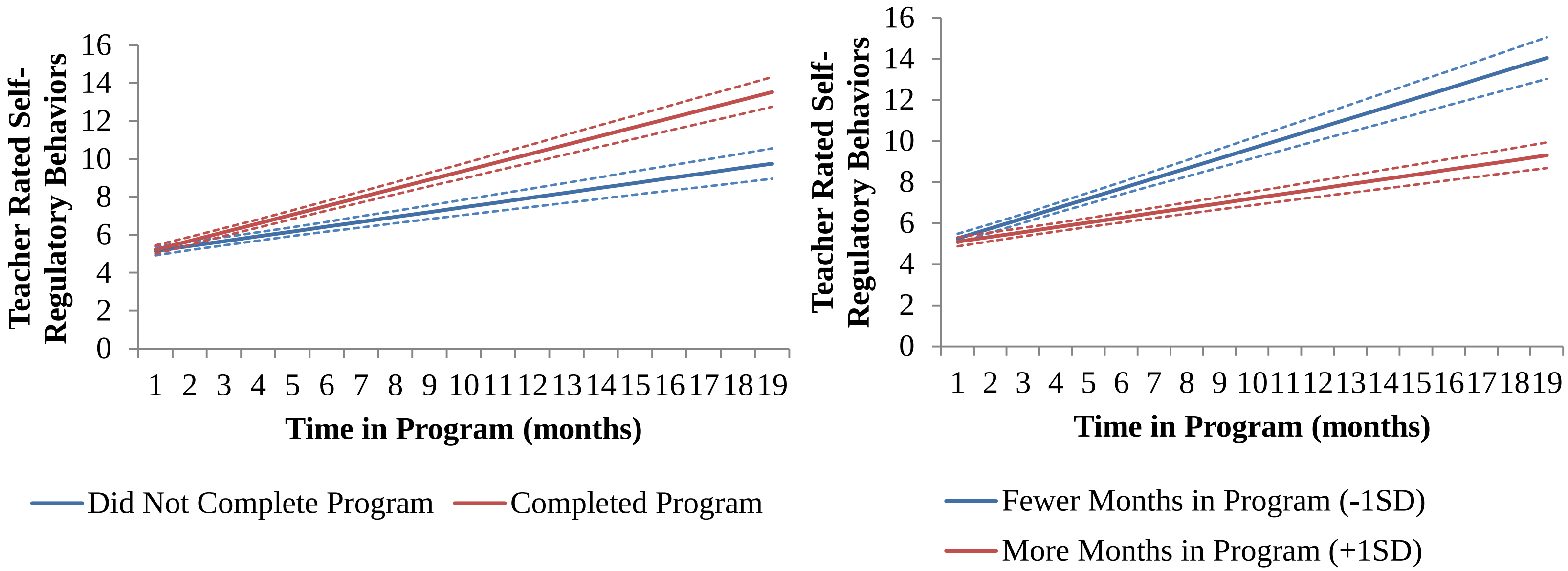

Figure 3: Relationship between completion of program and children's teacher rated self-regulatory behaviors and months in program and children's teacher rated self-regulatory behaviors

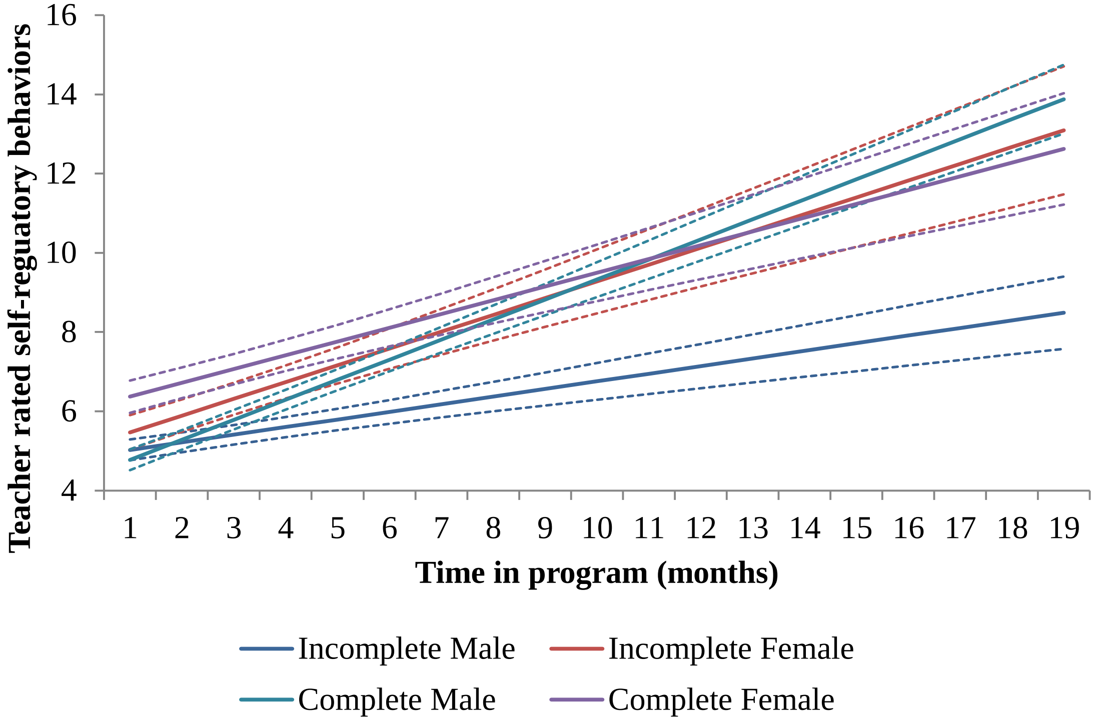

Figure 4: Relationship between completion of the program, gender, and time in program on children's teacher rated self-regulatory behaviors

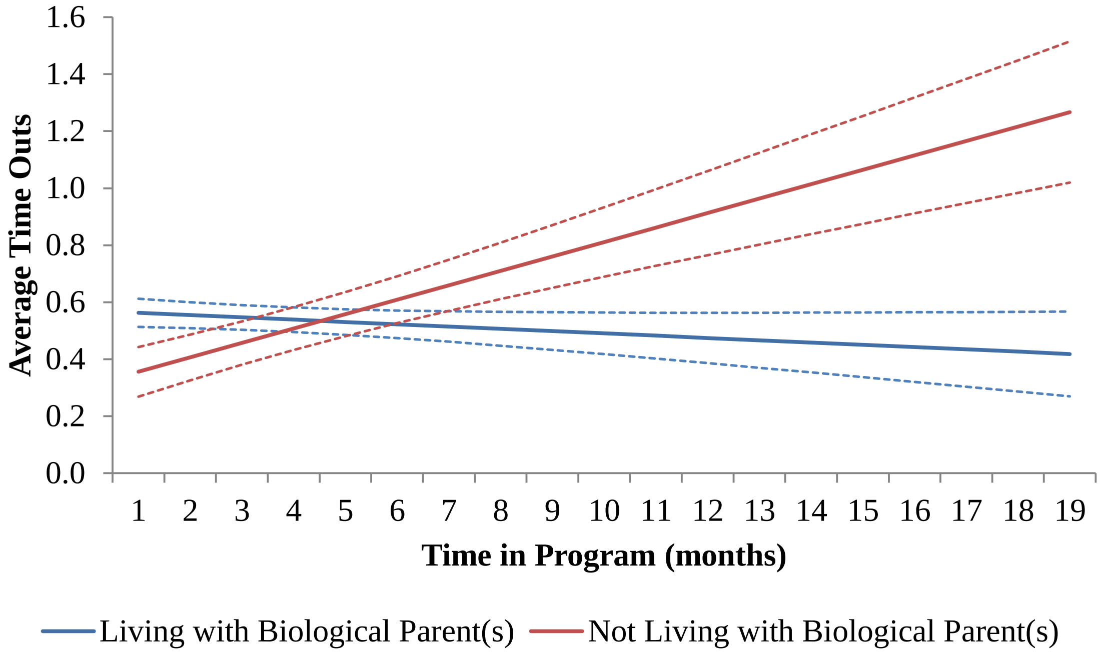

Figure 5: Relationship between living with biological parents and children's average number of time outs

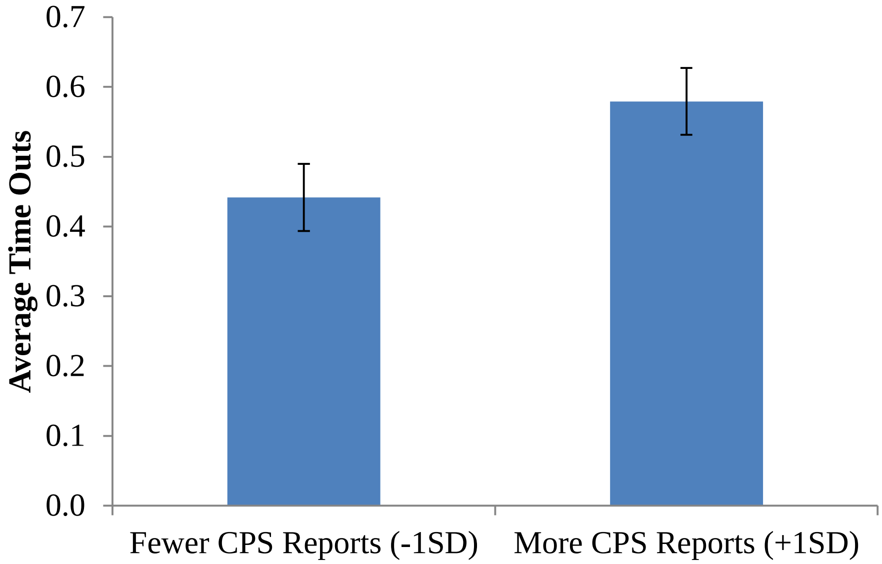

Figure 6: Relationship between CPS reports and children's average number of time outs

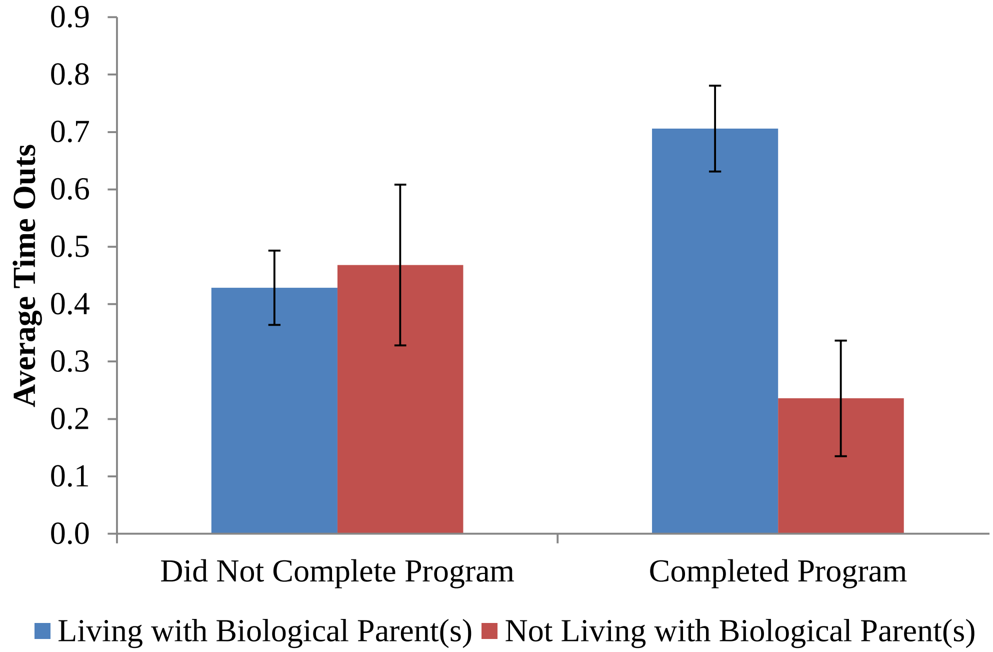

Figure 7: Relationship between completion of the program, living with biological parents, and children's average number of time outs

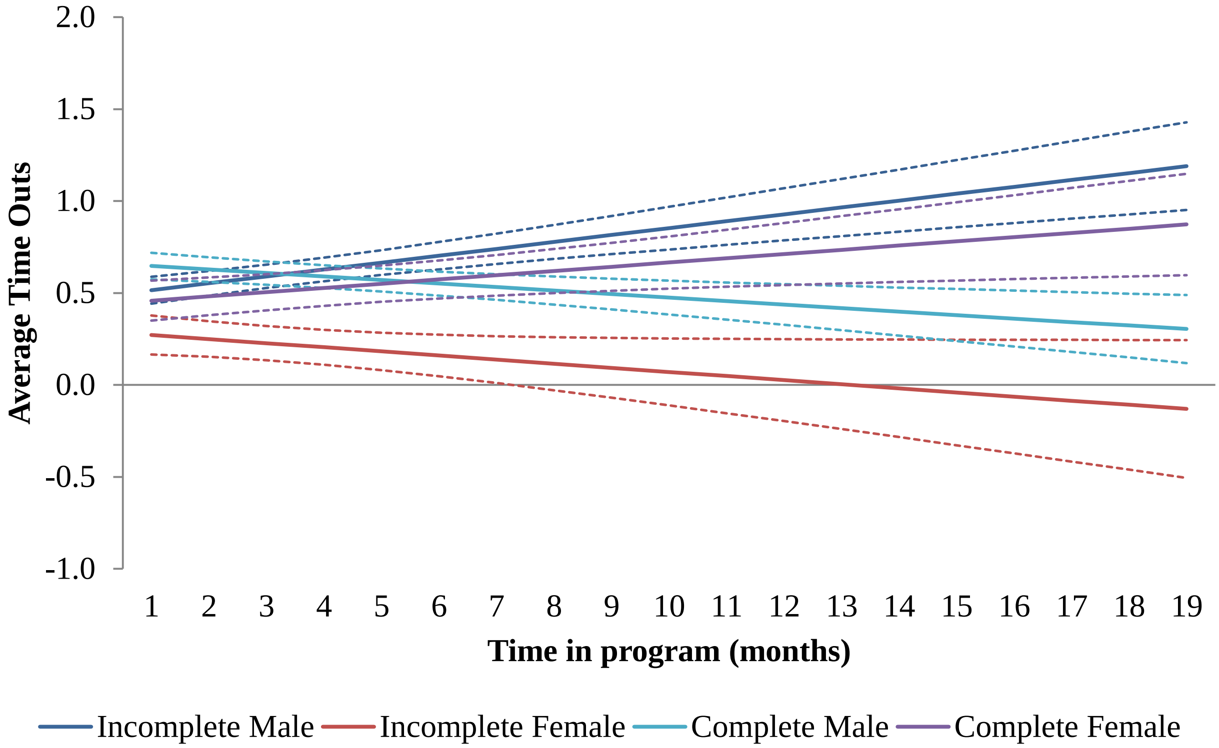

Figure 8: Relationship between completion of the program, gender, time in program and children's average number of time outs

Chapter 4: Study 2 - Physiological Functioning and Children's Self-Regulatory Behaviors

4.1 Introduction

The previous study explored changes in preschoolers' self-regulatory behaviors over time in the Building Block's Preschool Program and the environmental factors which influence individual differences in children's patterns of change. The current study aims to expand this work, examining the relationship between physiological functioning, specifically parasympathetic autonomic cardiac functioning, and children's patterns of self-regulatory behavior change during the preschool program. Early life stress has been linked to altered physiological functioning across a range of stress response systems, including the hypothalamic pituitary axis and immune functioning (Fagundes, Glaser, & Kiecolt-Glaser, 2013; Koss & Gunnar, 2017; Lupien et al., 2009). However, relatively little of this work has focused on the autonomic nervous system (El-Sheikh & Erath, 2011; Koss & Gunnar, 2017), despite it being one of the primary stress response systems (Berntson & Cacioppo, 2004; McEwen, 2017). The current work aims to elucidate some of these relationships between early life stress, autonomic cardiac functioning, and children's behavior in a sample where measures of both autonomic cardiac regulation and behavior are sampled at high frequencies over time.

The majority of work that has examined the relationship between autonomic regulation and early life stress focuses on its utility as a predictor of risk (El-Sheikh & Erath, 2011; Koss & Gunnar, 2017) – i.e. do children with specific patterns of autonomic regulation demonstrate exacerbated or dampened responses to stress? Indeed, there is good evidence suggesting that certain patterns of autonomic regulation, particularly that of the parasympathetic nervous system, buffer individuals against some of the negative effects of early life stress. This is especially true in regards to relationships between early life stress and problems with self-regulatory behaviors (Beauchaine, 2001; El-Sheikh, Arsiwalla, Hinnant, & Erath, 2011). For example, increased parent reported marital conflict, a form of chronic/extreme stress, is associated with greater prevalence of behavior problems in children. However, this relationship is moderated by children's basal parasympathetic cardiac regulation, with high parasympathetic regulation ameliorating the negative effects of marital conflict on behavior problems (El-Sheikh et al., 2010, 2001; Katz & Gottman, 1995). Additionally, having high parasympathetic cardiac regulation is associated with fewer aggressive behaviors in infants exposed to high levels of prenatal stress (Suurland, van der Heijden, Huijbregts, van Goozen, & Swaab, 2017) and buffers against the effects of early life stress on internalizing symptoms in adolescents (McLaughlin, Rith-Najarian, Dirks, & Sheridan, 2015).

This research suggests that basal parasympathetic cardiac regulation may be an indicator of individual differences in children's responses to early life stress. Additionally, this work parallels well with the extensive adult literature demonstrating that basal parasympathetic cardiac control is a stable indicator of individual differences in risk for psychopathology, emotion and cognitive regulatory processes, and sensitivity to threat in the environment (Kemp, Koenig, & Thayer, 2017; Thayer & Lane, 2000, 2009). In adults, these relationships are thought to be a result of basal parasympathetic cardiac control indexing activity centrally in what has been referred to as the Central Autonomic Network (CAN), which consists of cortical and subcortical circuits that interact to control psychophysiological responses to environmental change, including potential stressors (Kemp et al., 2017). However, many of the cortical structures of the CAN, including the prefrontal cortex, cingulate cortex and amygdala, are still experiencing rapid growth and development during infancy and early childhood (Hill et al., 2010; Levitt, 2003), which is accompanied by increased cortical control over the brainstem regions responsible for parasympathetic innervation of the heart (Porges, 2001). This suggests that the relationship between the CAN and parasympathetic cardiac control is likely not as stable in children as what has been observed in adults (Beauchaine, 2001; Porges, 2001, 2015), making it important to investigate how children's parasympathetic cardiac functioning changes over time and in response to their environment, as well as how any observed changes relate to changes in self-regulation. Indeed, the little research examining changes in parasympathetic cardiac control early in development does suggest that there are increases in parasympathetic control of the heart during infancy and early development (Alkon, Boyce, Davis, & Eskenazi, 2011; Esposito et al., 2016; Jewell, Suk, & Luecken, 2017; M. Johnson et al., 2017), that likely parallel increases in children's self-regulatory abilities during that time period (Kochanska et al., 2001; Kopp, 1982). However, there is little work systematically examining changes in these systems, how they relate to children's affective, cognitive, and behavioral processes, and how these developmental patterns may be influenced by children's environment.

This lack of understanding regarding the developmental trajectories and implications of these trajectories for children's psychosocial functioning is problematic given that much of the research examining the relationships between early life stress and negative affective and cognitive outcomes relies on the hypothesis that early life stress alters the development of stress response systems, including the autonomic nervous system, and leads to dysregulated responses to future stressors (Koss & Gunnar, 2017; Lupien et al., 2009; Porges, 2015). However, this hypothesis primarily is dependent on research from cross-sectional work between populations of children, adolescents, or adults who previously experienced a form of early life stress and children, adolescents, or adults who did not, finding alterations in individuals exposed to early life stress physiological reactivity to laboratory stressors (Giuliano, Roos, Farrar, & Skowron, 2018; Koss & Gunnar, 2017; Lunkenheimer, Busuito, Brown, & Skowron, 2018; Quas et al., 2014). There is a dearth of work systematically examining these changes and their implications for the development of these systems early in development (Alkon et al., 2011; Esposito et al., 2016; Jewell et al., 2017). While the available cross sectional work provides important insight into the effects of early life stress on stress responses systems, its mixed findings related to alterations in different physiological stress response systems, especially those related to parasympathetic nervous systems, makes this literature difficult to interpret. Better understanding both normative and developmental patterns of these systems along with developmental patterns in children exposed to early life stress can aid in illuminating the specific nature of these alterations in parasympathetic cardiac regulation and the mechanisms through which these alterations occur. Building Blocks Preschool provides a unique context in which to examine how children's environments shape physiological development and the implications of any observed changes in physiological functioning for children's behavior.

The current study aims to examine parasympathetic cardiac regulation in children exposed to early life stress and the relationship between parasympathetic cardiac regulation and children's responses to the preschool program. Additionally, this study attempts to understand whether there are changes in parasympathetic cardiac functioning over the course of the program and if those changes are related to changes in children's self-regulatory behaviors. To do this, children's parasympathetic cardiac regulation during their first month in the preschool and each following month was examined in relationship to children's changes in behavior, assessed using teacher ratings and time outs, during the program.

4.2 Methods

4.2.1 Participants

Participants were a subset of 38 children (3 – 7 years; 30 male) of the 150 children who participated in the Building Blocks' Laboratory Preschool Program (see Chapter 2, section 2.2). These children attended the preschool between the years of 2014 and 2017, during which physiological measures were collected daily in the classroom along with the other forms of data collected by the preschool. Of these children, 44.7% (17) were Caucasian, 39.5% (15) African American, 2.6% (1) Hispanic, and 10.5% (4) multi-racial. 10.5% of these children were no longer living with their biological parents, and on average children were in the program for 6.18 months (SD = 2.67).

4.2.2 Study Measures

Child Self-Regulatory Behaviors: As with Study 1 (see Chapter 3, Section 3.2.2), the primary outcome measures of interest came from teacher documentation of children's behavior in the classroom. However, starting in 2014 teachers began completing the standardized behavior ratings (for expressing anger appropriately, controlling impulses, and coping well with disappointment and change) on a daily basis rather than monthly (Appendix D). For the current study, these daily ratings were utilized as outcome measures for all analyses, along with daily number of time outs.

Physiological Data: An electrocardiogram (ECG) was collected daily from children during their regular classroom activities using the Zephyr Bioharness 2.0 ambulatory device, which consists of a band with two electrodes that is worn around the chest such that the electrodes are placed on the left and right side of the chest, crossing the heart. MindWare software (MindWare Technologies LTD, Gahanna, OH) was used to derive high frequency heart rate variability (HF-HRV), also known as respiratory sinus arrhythmia (RSA), from the ECG using spectral analysis of the interbeat interval series using prespecified procedures (Berntson et al., 1997). RSA has been demonstrated to index parasympathetic cardiac control (Berntson et al., 1997). The interbeat interval series was time sampled at 4 Hz (with interpolation) to yield an equal interval time series. This time series was detrended (second-order polynomial), end tapered, and submitted to a fast Fourier transformation. HF-HRV spectral power was then integrated over the respiratory frequency band (0.27-0.70 HZ), and RSA is represented as the natural log of the heart period variance in the respiratory band (in ms2). Appropriate respiratory frequency band values (0.27 – 0.70 HZ) were determined based on MindWare's recommendations for children ages 3 – 6 years ("KB0015 Changing respiratory band settings within the HRV application," 2016). To assess general parasympathetic cardiac functioning, RSA data was coded for 10 minutes from one day each month during the child's time in the program.

4.2.3 Statistical Analyses

As in Study 1 (Chapter 3, Section 3.2.3), hierarchical linear growth models were run with time nested within subject and the composite teacher rating score, and time out average as outcome variables to examine change in children's self-regulatory behavior over the course of the program. Additionally, to examine changes in autonomic regulation of the heart, HLM models were run assessing changes in RSA during the program.

To examine the relationship between autonomic cardiac functioning and children's self-regulatory behavior a series of HLM models were run assessing two primary questions. First, as previous work has primarily treated parasympathetic functioning as a stable predictor of individual differences in behavioral responses to adversity, the relationship between children's physiological functioning at the start of the program and behavior change during the program was explored, where the coded data for RSA from the child's first month in the program was incorporated as a time-invariant predictor of children's behavior. Second, as I had multiple measures of children's parasympathetic cardiac functioning over time, the relationship between any observed changes in children's physiological functioning and behavior during the program was examined by incorporating RSA from each month in the program as a time-varying predictor of self-regulatory behaviors. For the second model, self-regulatory behaviors were averaged over the month following the day with available coded physiological data. To further examine these relationships, models were run using behavior ratings the day immediately following that with coded physiological data as the outcomes, and models using data the day prior as a predictor of changes in physiological functioning. To better understand and interpret any significant interactions observed, simple slopes were computed following recommendations by Preacher, Curran, & Bauer, 2006.

4.3 Results

4.3.1 Change in Self-Regulatory Behaviors and Physiological Functioning During the Preschool Program

As in Study 1, this subsample of children demonstrated significant change in behaviors over the course of the program, with self-regulatory behaviors improving over the course of the program ($\beta = 0.03$, SE = 0.005, $p < 0.001$) (Table 5; Figure 9). Including age and gender did not change this effect, although there was a significant main effect of gender on teacher rated self-regulatory behavior ($\beta = 2.39$, SE = 0.89, $p < 0.05$), with females demonstrating higher ratings compared to males (Table 5). There were no significant effects of time on children's daily time outs ($\beta = -0.001$, SE = 0.002, $p = 0.77$) (Table 5; Figure 9). Observed effects for time outs did not change when controlling for age and gender, and there were no significant effects of age or gender (Table 5).

Additionally, children demonstrated significant changes in RSA over the course of the program ($\beta = 0.08$, SE = 0.04, $p < 0.05$), with RSA improving over time in the program (Table 6; Figure 10). While incorporating gender as a covariate did not change the effects of time in program on RSA ($\beta = 0.08$, SE = 0.04, $p < 0.05$), including age resulted in the effect no longer being significant, albeit trending ($\beta = 0.07$, SE = 0.04, $p = 0.09$). This effect remained trending when controlling for both gender and age ($\beta = 0.07$, SE = 0.04, $p = 0.09$), and there were no significant effects of either gender or age on changes in RSA during the program (Table 6).

4.3.2 Effects of Physiological Functioning in the First Month of the Program on Self-Regulatory Behaviors

Teacher Ratings of Self-Regulatory Behaviors: For full results from models examining the effects of children's initial RSA (first month in the program) on teacher rated self-regulatory behaviors see Table 7. The effect of time in program on children's teacher rated self-regulatory behavior remained significant after incorporating children's initial RSA (first month in the program) into the model ($\beta = 0.08$, SE = 0.02, $p < 0.001$). Children's initial RSA demonstrated a significant main effect on children's self-regulatory behaviors ($\beta = 0.73$, SE = 0.26, $p < 0.01$) such that children with higher RSA in their first month of the program started had higher teacher rated self-regulatory behaviors in their first month of the program (Figure 11). Additionally, initial RSA significantly interacted with time to predict children's self-regulatory behaviors ($\beta = -0.01$, SE = 0.004, $p < 0.05$). To examine this interaction, I ran a simple slopes analysis using procedures outlined by Preacher et al., 2006 looking at slopes for initial RSA one standard deviation above and the below the mean (based on recommendations by Aiken & West, 1991).

Children with RSA one standard deviation below the mean (lower initial RSA) demonstrated a significant increase in self-regulatory behaviors over time ($\beta = 0.04$, $p < 0.001$) while those with RSA one standard deviation above the mean (higher initial RSA) did not ($\beta = 0.01$, $p = 0.31$; Figure 11). This suggests that while children with lower RSA in their first month of the program start the program with poorer behaviors than children with higher RSA, these children also demonstrate the most improvement in self-regulatory behaviors over the course of the program. Including gender and age did not change these effects (Table 7), although there was a significant effect of gender ($\beta = 2.19$, SE = 0.77, $p < 0.01$) on composite behavior teacher ratings such that females had higher ratings than males.

Time Outs: For full results from models examining the effects of children's initial RSA (first month in the program) on number of time outs see Table 7. The effect of time in program on number of time outs remained non-significant across all models. There were no significant effects of baseline RSA on children's time outs during the program (Figure 11). Incorporating gender and age did not change any effects, and there were no significant effects of gender and age (Table 7).

4.3.3 Relationship Between Changes in Physiological Functioning and Changes in Behavior (self-regulatory behavior scores averaged for month)

Teacher Ratings of Self-Regulatory Behaviors: For full results from models examining the effects of children's change in RSA on teacher rated self-regulatory behaviors see Table 8. Incorporating RSA as a time-varying predictor of children's self-regulatory behaviors averaged over the course of the month following the date with coded physiological data resulted in a significant main effect of RSA ($\beta = 0.31$, SE = 0.12, $p < 0.01$), such that increases in RSA are associated with significant improvements in behavior (Figure 12). This is important given RSA itself increases over time in the program. The effect of time in program on teacher rated self-regulatory behavior remained significant ($\beta = 0.65$, $SE = 0.14$, $p < 0.001$). Additionally, there was a significant interaction effect of RSA with time ($\beta = -0.08$, $SE = 0.03$, $p < 0.01$), in a similar direction to that observed with children's initial RSA. This effect suggests that children with initially low RSA demonstrate the most pronounced increases in teacher ratings of behavior over time. However, as RSA increases, this relationship starts to decline (Figure 13). Including gender and age did not change any of these effects, although there was still a significant main effect of gender such that females had higher teacher ratings of behavior than males ($\beta = 2.08$, $SE = 0.82$, $p < 0.05$).

To further assess the strength of the relationship between change in RSA and teacher rated self-regulatory behaviors, analyses were run using only behavior ratings the day immediately following that of coded physiological data. These models demonstrated the same effects as those using average behavior ratings (Table 9). Additionally, to assess the directionality of these effects, models were run using behavior the day prior to the day with coded physiological data as a predictor of changes in RSA. In these models, behavior was not a significant predictor of observed changes in RSA (Table 10) suggesting that changes in RSA predict improvement in self-regulatory behaviors, not vice versa.

Time Outs: There were no significant effects of changes in RSA on time outs (Table 8). Incorporating age and gender did not change these effects, and there were no significant effects of either age or gender (Table 8). However, the directionality of the effects of time outs (Table 8) followed the same pattern as that of teacher rated self-regulatory behaviors in that children demonstrated a pattern of decreases in time outs over the program, and that was more pronounced for children with low RSA (Figures 12 and 13).

4.4 Discussion

The current study expanded on Study 1, finding that not only do children's behaviors improve over the course of the Building Blocks' preschool program, but these improvements are predicted by children's parasympathetic cardiac functioning. Additionally, this study found that children's parasympathetic nervous system functioning increases during children's time in the program and these increases are associated with improvements in self-regulatory behaviors. This suggests that parasympathetic functioning is malleable to change early in development and these changes likely index changes in higher level inhibitory circuits that have important implications for children's behavior. Additionally, it points to potentially important developmental changes in the autonomic nervous system early in life which have implications not only for children's behavior but also for how early life stress may influence this system.

To date, the majority of the literature examining the relationship between autonomic functioning and early life stress, has tended to view parasympathetic indices as a stable measure of individual differences in autonomic functioning linked to individual differences in susceptibility to psychopathology and maladaptive behaviors (El-Sheikh & Erath, 2011; Koss & Gunnar, 2017). Indeed, within this literature, there is good evidence that resting cardiac parasympathetic activity buffers against some of the negative consequences of early life stress (El-Sheikh & Erath, 2011; Katz & Gottman, 1995; Mclaughlin et al., 2014). The current study supports this literature, finding that children who have lower RSA when they start the program have poorer initial behaviors. However, this difference in self-regulatory behavior is not maintained over the course of the program, and children with lower initial RSA demonstrate the greatest improvement over the course of the program. This is especially interesting given the observed changes in parasympathetic cardiac functioning during the program. Children on average demonstrate increases in parasympathetic cardiac control during the program, which appear to be at least partially independent from age related changes in parasympathetic cardiac control. These changes in RSA are in turn related to improvements in self-regulatory behaviors. Early perceptions of safety and social connection are thought to facilitate the engagement of the higher level cortical structures involved in the CAN, dampening defense systems and engaging parasympathetic control of the heart (Porges, 2015). Children exposed to early life stress, which is often accompanied by high levels of threat and few indicators of safety, may not experience this dampening of defensive systems and engagement of higher level inhibitory circuits accompanied by engagement of parasympathetic cardiac control (Porges, 2015). It is possible that the introduction of the safe, predictable and reliable environment provided by the preschool and staff aids in ameliorating some of these effects, engaging systems supporting positive social behaviors and in turn promoting increased parasympathetic cardiac control.

Of course, it could be that in the current study, the observed changes in parasympathetic cardiac regulation are age related rather than a result of the program itself. Indeed, after controlling for age the effect of time in program on RSA is only marginal. However, there are also no direct effects of age on RSA changes. Additionally, age does not account for the relationship between increases in RSA and improvements in self-regulatory behaviors which suggests the observed effects are not driven by age related developmental change in the parasympathetic nervous system. However, regardless of whether these changes are age or program related, they represent an interesting initial step in understanding the development of the parasympathetic nervous system and how changes in this system relate to changes in children’s behavior. Understanding the normative developmental patterns of the autonomic nervous system, and how these patterns changes in the context of early life stress, can help further illuminate the mechanisms underlying the link between early life stress and later negative outcomes.

As with Study 1, it is of course possible that, due to the nature of the measures utilized, some of the changes found in children's self-regulatory behaviors index changes in teacher perceptions rather than children's actual behavior. However, again this is a problem with any study that relies on observer report of child behavior. Additionally, the patterns of change are similar overall for both teacher rated behaviors and time outs, even though they are not significant for time outs, suggesting that the observed effects are not solely driven by teacher biases towards positive change.

In sum, this study provides important insight into the relationship between parasympathetic cardiac regulation and self-regulatory behaviors in children exposed to early life stress. It suggests that parasympathetic cardiac regulation is not stable in early childhood, and indeed may be susceptible to environmentally driven change. Together this provides several important avenues for research moving forward, suggesting a need for more work on not only the developmental patterns in parasympathetic cardiac regulation over time, but also how these patterns are influenced by the child's environment and experience with stress as well as how they then relate to children's development and self-regulatory behaviors.

4.5 Appendix B: Chapter 4 Tables and Figures

Table 5: Model results for the relationship between time in program and children's behavior

		Model A		**Model B**	
Outcome	**Fixed Effect**	**β (SE)**	**df**	**β (SE)**	**df**
Teacher Ratings Self-regulatory Behaviors	Intercept	8.11*** (0.40)	1989	8.09*** (0.36)	1987
	Time	0.03*** (0.005)	1989	0.03*** (0.01)	1987
	Age	-	-	-0.0003 (0.05)	35
	Gender	-	-	2.39* (0.89)	35
	Age*Time	-	-	0.001 (0.001)	1987

Table 5, continued

	Gender*Time	-	-	-0.01 (0.01)	1987
Time Outs	Intercept	0.90*** (0.13)	2544	0.91*** (0.13)	2542
	Time	-0.001 (0.002)	2544	-0.001 (0.31)	35
	Age	-	-	0.01 (0.02)	35
	Gender	-	-	-0.41 (0.31)	35
	Age*Time	-	-	-0.0004 (0.0003)	2542
	Gender*Time	-	-	-0.01 (0.01)	2542

Table 5, continued

	Random Effects	**Variance**	**Variance**
Teacher Ratings Self-regulatory Behaviors	Intercept	5.73	4.77
	Time	0.001	0.001
Time Outs	Intercept	0.58	0.56
	Time	0.0001	0.0001
Model Fit Statistics			
Teacher Ratings Self-Regulatory Behaviors	AIC	7961.67	7959.94
	Log Likelihood	-3974.84	-3969.97
	r^2	0.09	0.18
Time Outs	AIC	7463.28	7464.35
	Log Likelihood	-3725.64	-3722.17
	r^2	0.0004	0.07

Table 5, continued

Note. Model A – model including only time in program as a predictor of children’s behaviors. Model B – model controlling for gender and age. ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, $^{\dagger}p < 0.10$

Table 6: Model results for changes in children's RSA during the preschool program

	Model A		Model B	
Fixed Effect	**β (SE)**	**df**	**β (SE)**	**df**
Intercept	4.22*** (0.19)	134	4.24*** (0.19)	132
Time	0.08* (0.04)	134	0.07† (0.04)	132
Age	-	-	-0.02 (0.02)	31
Gender	-	-	-0.29 (0.45)	31
Age*Time	-	-	-0.001 (0.005)	132
Gender*Time	-	-	0.07 (0.10)	132

Table 6, continued

Random Effects	**Variance**	**Variance**
Intercept	0.54	0.51
Time	0.00003	3.69e-10
Model Fit Statistics		
AIC	573.46	579.60
Log Likelihood	-280.73	-279.80
r^2	0.02	0.04

Note. Model A – model including only time in program as a predictor of children's behaviors. Model B – model controlling for gender and age. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.10

Table 7: Model results for the relationship between children's initial RSA (first month in the program) and children's behaviors

		Model A		**Model B**	
Outcome	**Fixed Effect**	**β (SE)**	**df**	**β (SE)**	**df**
Teacher Rated Self-regulatory behavior	Intercept	5.24*** (1.20)	1797	5.02*** (1.09)	1795
	Time	0.08*** (0.02)	1797	0.08*** (0.02)	1795
	Initial RSA	0.73** (0.26)	32	0.80** (0.24)	30
	Time*Initial RSA	-0.01* (0.004)	1797	-0.01** (0.004)	1795
	Gender	-	-	2.19** (0.77)	30
	Age	-	-	-0.02 (0.04)	30

Table 7, continued

	Time*Gender	-	-	-0.01 (0.01)	1795
	Time*Age	-	-	0.001 (0.001)	1795
Time Outs	Intercept	1.31** (0.46)	2342	1.35*** (0.45)	2340
	Time	0.005 (0.01)	2342	0.01 (0.01)	2340
	Initial RSA	-0.09 (0.10)	32	-0.10 (0.10)	30
	Time*Initial RSA	-0.001 (0.002)	2342	-0.002 (0.002)	2340
	Gender	-	-	-0.48 (0.32)	30

Table 7, continued

	Age	-	-	0.01 (0.02)	30
	Time*Gender	-	-	-0.01 (0.005)	2340
	Time*Age	-	-	-0.0003 (0.0003)	2340
	Random Effects	**Variance**		**Variance**	
Teacher Rated Self-regulatory Behaviors	Intercept	4.27		3.36	
	Time	0.001		0.001	
Time Outs	Intercept	0.60		0.55	
	Time	0.0001		0.0001	

Table 7, continued

Model Fit Statistics			
Teacher Rated Self-regulatory Behaviors	AIC	7174.40	7172.80
	Log Likelihood	-3579.20	-3574.39
	r^2	0.14	0.23
Time Outs	AIC	6830.91	6832.27
	Log Likelihood	-3407.46	-3404.13
	r^2	0.03	0.09

Note: Model A – model including only time in program as a predictor of children's behaviors. Model B – model controlling for gender and age. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.10

Table 8: Model results for relationship between changes in RSA and children's behavior during the preschool program

		Model A		Model B	
Outcome	**Fixed Effect**	**β (SE)**	**df**	**β (SE)**	**df**
Teacher Rated Self-regulatory behavior	Intercept	7.19*** (0.63)	132	7.05*** (0.61)	130
	Time	0.65*** (0.14)	132	0.67*** (0.14)	130
	RSA	0.31** (0.12)	132	0.33** (0.12)	130
	Time* RSA	-0.08** (0.03)	132	-0.09** (0.03)	130
	Gender	-	-	2.08* (0.82)	31
	Age	-	-	-0.03 (0.04)	31

Table 8, continued

	Time*Gender	-	-	-0.03 (0.17)	130
	Time*Age	-	-	0.004 (0.01)	130
Time Outs	Intercept	1.15*** (0.28)	133	1.18*** (0.28)	131
	Time	-0.03 (0.07)	133	-0.03 (0.07)	131
	RSA	-0.06 (0.06)	133	-0.07 (0.06)	131
	Time*RSA	0.01 (0.01)	133	0.01 (0.01)	131
	Gender	-	-	-0.53 (0.33)	31

Table 8, continued

	Age	-	-	0.01 (0.02)	31
	Time*Gender	-	-	-0.07 (0.09)	31
	Time*Age	-	-	0.003 (0.01)	31
	Random Effects	**Variance**		**Variance**	
Teacher Rated Self-regulatory Behaviors	Intercept	4.21		3.37	
	Time	0.07		0.08	
Time Outs	Intercept	0.57		0.52	
	Time	0.03		0.02	

Table 8, continued

Model Fit Statistics			
Teacher Rated Self-regulatory Behaviors	AIC	593.92	593.08
	Log Likelihood	-288.96	-284.54
	r^2	0.11	0.27
Time Outs	AIC	355.56	358.06
	Log Likelihood	-169.78	-167.03
	r^2	0.003	0.13

Note: Model A – model including only time in program as a predictor of children's behaviors. Model B – model controlling for gender and age. ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, $^{\dagger}p < 0.10$

Table 9: Models of relationship between RSA and teacher ratings of self-regulatory behaviors the day immediately following coded RSA time point

Fixed Effect	**β (SE)**	**df**
Intercept	5.70*** (0.92)	122
Time	0.80*** (0.22)	122
RSA	0.60** (0.19)	122
Time* RSA	-0.11** (0.04)	122
Random Effects	**Variance**	
Intercept	3.99	
Time	0.01	
Model Fit Statistics		
AIC	692.76	
Log Likelihood	-338.38	
r^2	0.12	

Note. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.10

Table 10: Relationship between behavior (teacher ratings) day prior to RSA time point and RSA

Fixed Effect	**β (SE)**	**df**
Intercept	3.44*** (0.61)	126
Time	0.21 (0.21)	126
Teacher Ratings	0.09 (0.06)	126
Time* Teacher Ratings	-0.02 (0.02)	126
Random Effects	**Variance**	
Intercept	0.36	
Time	0.00004	
Model Fit Statistics		
AIC	555.37	
Log Likelihood	-269.69	
r^2	0.03	

Note. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.10

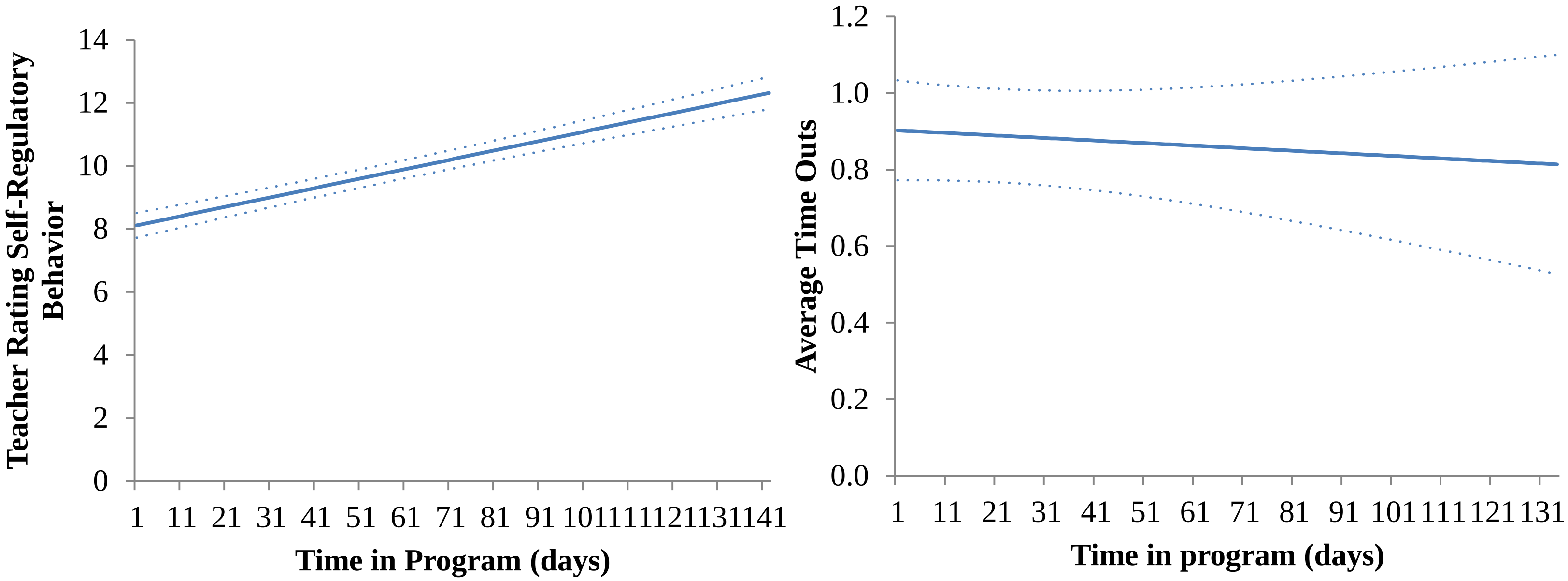

Figure 9: Relationship between time in program and children's teacher rated self-regulatory behaviors and time outs

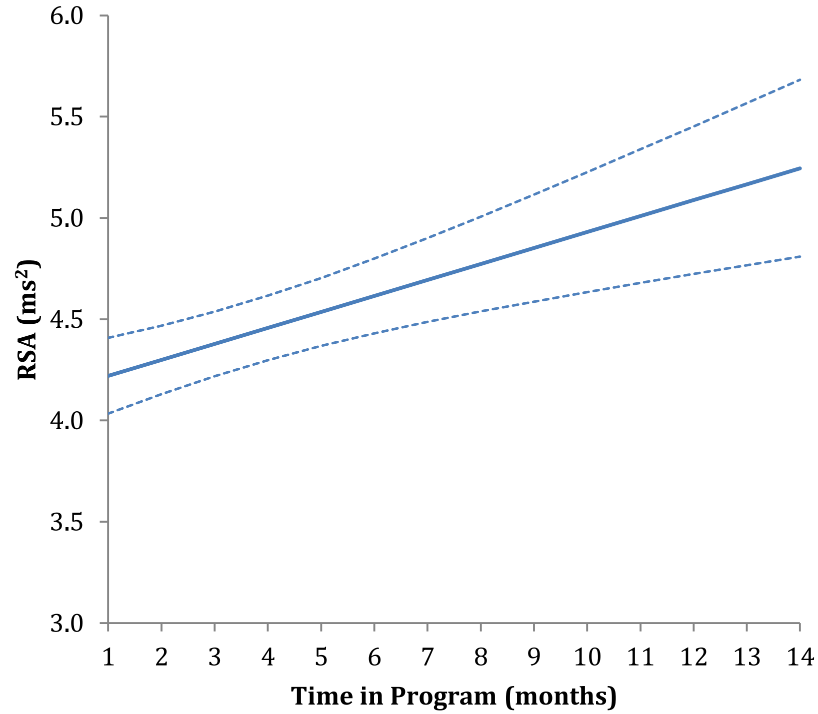

Figure 10: Relationship between time in program and changes in RSA

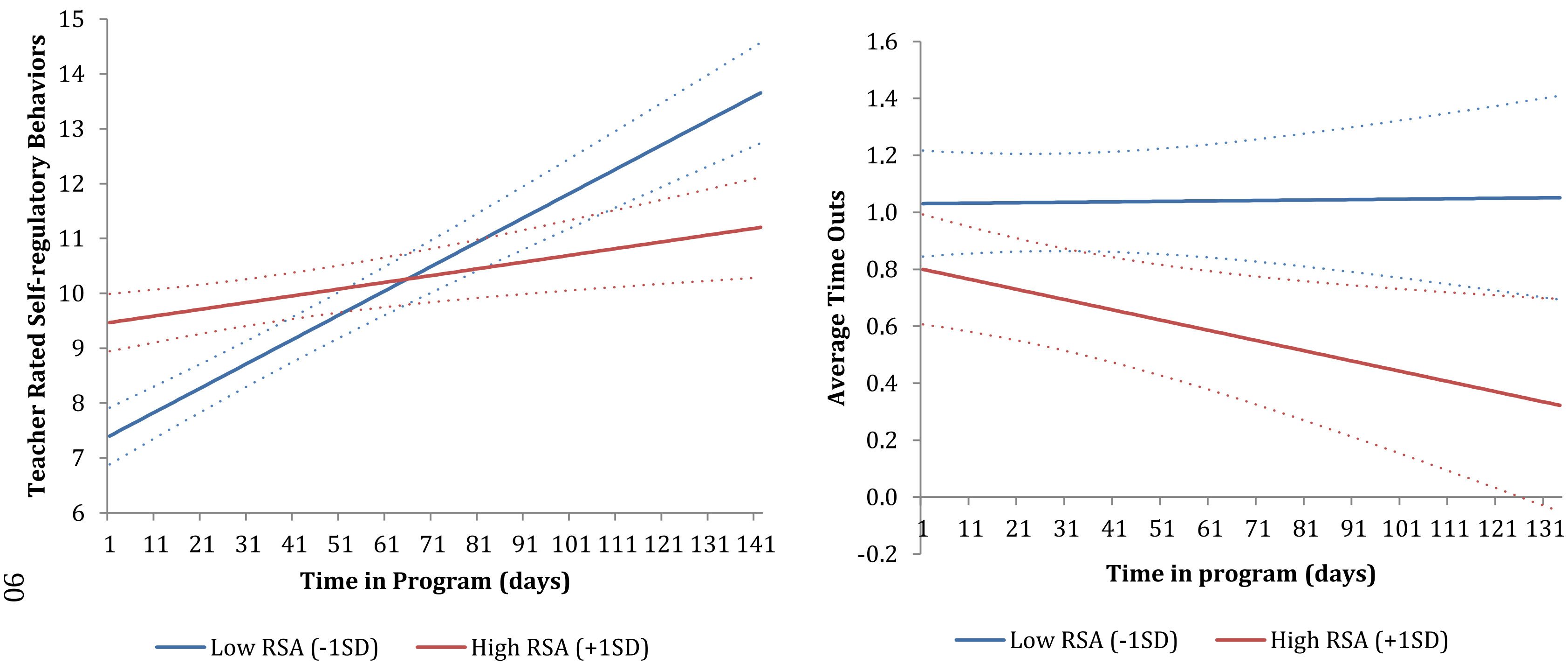

Figure 11: Relationship between initial RSA (first month in the program) and children's teacher rated self-regulatory behaviors and time outs

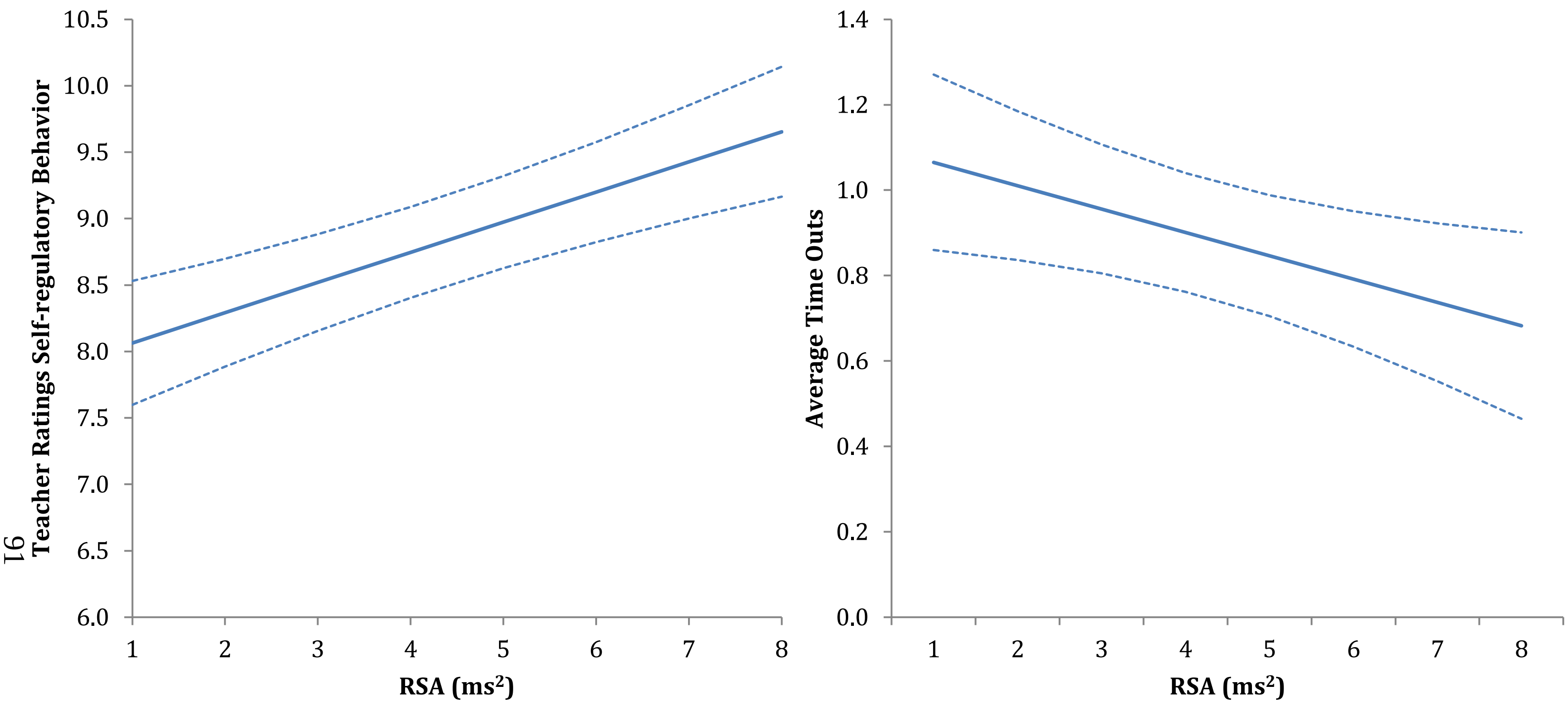

Figure 12: Relationship between changes in RSA and children's teacher rated self-regulatory behaviors and time outs

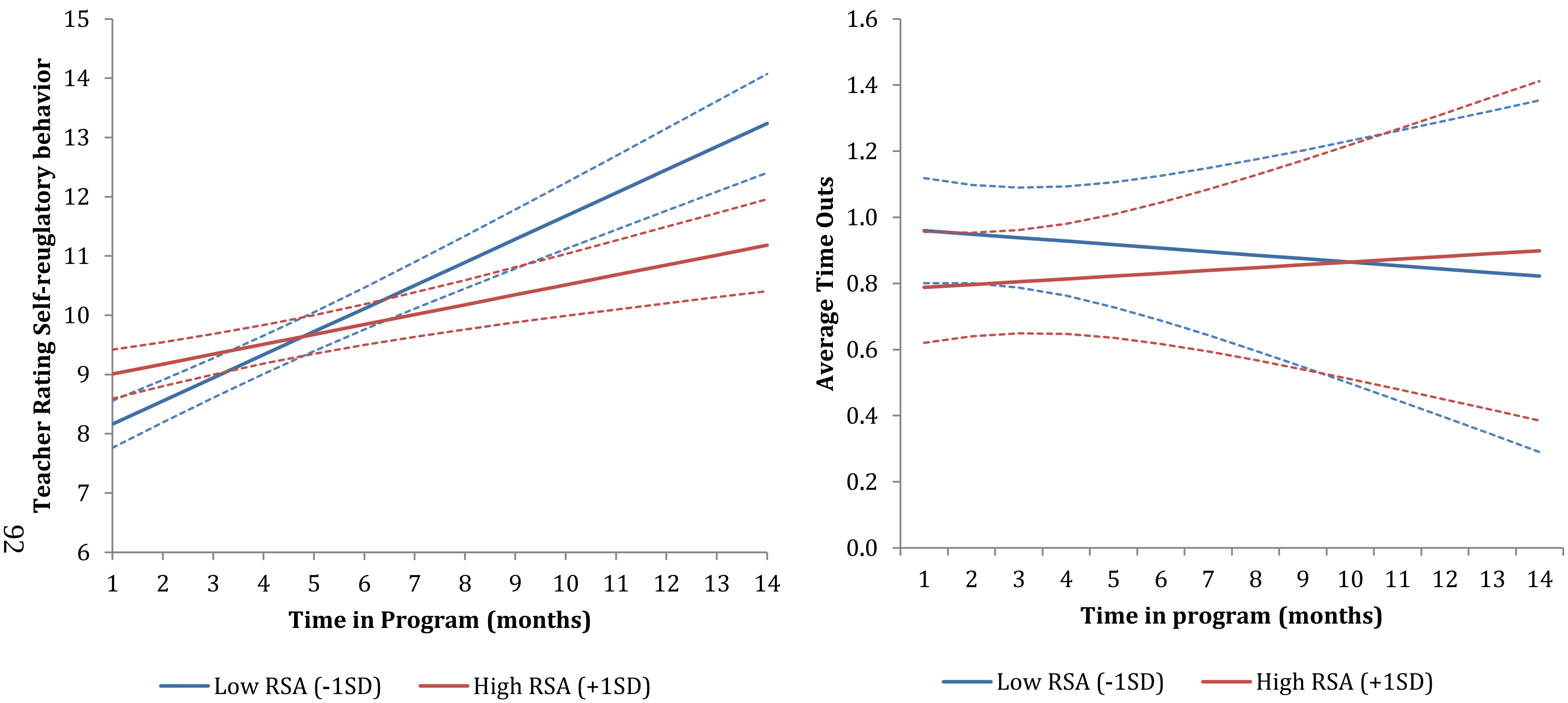

Figure 13: Relationships between changes in RSA, time in program, and children's teacher rated self-regulatory behaviors and time outs

Chapter 5: Study 3 – Significant Adverse Events and Children's Self-Regulatory Behaviors

5.1 Introduction

Studies 1 and 2 demonstrated interactions between environmental factors, physiological functioning, specifically autonomic parasympathetic cardiac functioning, and patterns of behavioral change in children exposed to early life stress. The current study aims to extend this work, assessing changes in children's behavior in response to the occurrence of a severe and/or extreme stressor while in the program. Specifically this work will focus on changes in children's self-regulatory behaviors after having a parent arrested, experience of abuse, or moving care source (i.e. moving in or out of foster care or guardianship).

Research aimed at understanding children's responses to early life stress, relies primarily on identifying a population exposed to early life stress, assessing their behavioral, psychological, and physiological functioning post stressor, sometimes years after the occurrence of the stressor, and comparing them to a comparable population not exposed to early life stress (Cicchetti, 2016; Koss & Gunnar, 2017; Pollak, 2005). This is due to the inherent difficulties associated with collecting detailed family and child data on populations longitudinally. The existing cross-sectional work provides valuable insight into how children respond to stress and the effects of stress on psychophysiological processes (Cicchetti, 2016; Koss & Gunnar, 2017; Pollak, 2005). However, the quantity and frequency of data collected in the context of the Building Block's preschool program on both the child's psychophysiological functioning in the classroom and changes within the home environment provides a unique context in which changes in children's patterns of physiological and behavioral responses immediately after the occurrence of a stressor can be examined longitudinally.

The current work focused on three types of extreme stressors: parent arrest, experience of abuse, and moving care (in or out of foster care). These three stressors were chosen as they represent extreme stress associated with increased instability and lack of predictability for these children and have been the target of extensive previous research. Parent arrest, child abuse, and experiences with foster care have all been associated with a wide range of negative outcomes for children, including increases in aggressive behaviors, increased risk for psychopathology, problems with emotion regulation, and poorer cognitive functioning (Cicchetti, 2016; Dallaire & Wilson, 2010; Dallaire, Zeman, & Thrash, 2015; Lupien et al., 2009; Newton et al., 2000; Pechtel & Pizzagalli, 2011). Children who experience abuse early in childhood are more likely to demonstrate both internalizing and externalizing symptomatology (Barch et al., 2017; Kuhlman, Geiss, Vargas, & Lopez-Duran, 2017), exhibit increased conduct problems (Docherty et al., 2018; Jaffee et al., 2009), demonstrate disrupted emotion recognition and representation (Pollak, Cicchetti, Hornung, & Reed, 2000; Pollak & Kistler, 2002), and more likely to develop psychopathology as adults and adolescents (Collishaw et al., 2007). Parent history of incarceration has also been associated with increased externalizing and internalizing behaviors (Dallaire & Wilson, 2010; Dallaire et al., 2015), increased antisocial behaviors (Murray & Farrington, 2005), and increased risk for depression (Wilbur et al., 2007), although there is some evidence that these effects driven by situational and parental factors associated with parent incarceration rather than the occurrence of incarceration itself (Kinner, Alati, Najman, & Williams, 2007). Foster care placement has been associated with problematic behaviors in children, especially in cases where children experience multiple placements (Newton et al., 2000; Rubin, O'Reilly, Luan, & Localio, 2007a). However, the effects of foster care can also be beneficial for children who are living in particularly severe environments of abuse or neglect (Fisher, Van Ryzin, & Gunnar, 2011; Smyke, Zeanah, Fox, Nelson, & Guthrie, 2010), and the beneficial effects of foster care appear to be increased in situations of high quality care or when children perceive their relationship with their foster caregiver more positively (Cooley et al., 2015; McLaughlin et al., 2012).

In light of this literature, I expect that children who experience a parent arrest or incident of abuse will demonstrate decreases in self-regulatory behaviors after the event. Given the mixed literature on the effects of foster care and moving care source, I had no specific predictions about children's responses to this stressor. Additionally, I explored whether children's parasympathetic autonomic cardiac function is associated with any observed changes in their self-regulatory behaviors in response to these three types of stressors.

5.2. Methods

5.2.1 Participants

Participants for this study consisted of the full sample of 150 children who had been through the preschool program since 2006 (see Chapter 2, Section 2.1). For analyses examining the role of parasympathetic cardiac functioning in predicting behavioral change after a significant adverse event, the subsample from Study 2 (see Chapter 4, Section 4.2.1) was used.

5.2.2 Study Measures

Child Self-Regulatory Behaviors: Primary outcome measures were the same as those utilized in Studies 1 and 2. For analyses involving the larger sample, monthly teacher ratings were utilized (See Chapter 3, Section 3.2.2). For analyses incorporating physiological data, the daily teacher ratings were used and averaged over the course of the month following the coded RSA time point (See Chapter 4, Section 4.2.2).

Stressful Life Events: To examine children's responses to the occurrence of a significant stressor, three types of stressors were extracted and coded from the information collected during home visits and the daily classroom documentation: 1) Parent arrest; 3) Occurrence of abuse or maltreatment; 3) Child moved from home (either due to parent abandonment or CPS removal).

To extract information about parent arrest, parents'/guardians' arrest histories were taken from the Elkhart County Publically Available arrest records (http://www.elkhartcountysheriff.com). These records were then coded for when they occurred (prior to child's lifetime, during child's lifetime but prior to attending the preschool program, and while the child is in the program). For those events that occurred while the child was in the program, the date associated with the arrest was documented in order to examine children's behavior and physiological functioning during the month prior to and following the arrest. Due to a change in the Elkhart County's website for obtaining publically available arrest records, arrest data was only available for a subset of 111 children (see Table 11 for demographics), and this subset did not include any of the children with physiological data.

Occurrence of abuse and child moving from home were coded from the teacher and home visit documentation using pre-identified search terms to search each child's file and identify when and what event occurred (see Appendix F for search terms). This search process consisted of two steps: 1) All documentation was searched using the specified terms; 2) Once any occurrence of the specified terms had been identified, I read the surrounding material to determine whether the occurrence met criteria for inclusion. Events were coded as abuse if they were described (by either child, parent, or teacher) as physical violence towards the child (physical abuse), sexually inappropriate child directed behavior (sexual abuse), or mentions of physical or emotional altercations among family members or individuals living in the household (domestic violence). Events that elicited a child protective services (CPS) report from either the preschool, other providers (i.e. mental health services involved in the family, elementary school staff), or parents were also coded as events of abuse.

For events to be coded as moving care, the identified term needed to be associated with a child moving either out of the biological parent(s) home into foster care or guardianship, from one foster home into another, from foster care/guardianship back in with biological parent(s), a transition from foster care to adoption, or from one biological parent's house to the others.

Physiological Data: RSA was derived and coded according to the specifications in Study 2 (Chapter 4.3.3, Physiological Data).

5.2.3 Statistical Analyses

As in Study 1 (Chapter 3, Section 3.2.3) and Study 2 (Chapter 4, Section 4.2.3), hierarchical linear growth models were run with time nested within subject and the composite teacher rating score and number of time outs as outcome variables to examine change in children's self-regulatory behavior over the course of the program. For each significant adverse event, the event occurrence was incorporated as a time-varying predictor to examine changes in behavior after the occurrence of the event. Exposure to each type of stressor was incorporated in a stepwise manner into the models as time-varying fixed predictors to examine influences of these factors on children's self-regulatory behaviors and changes in these behaviors over time. I report both model effects for stressors included independently within the models and the model which best fit the data. These models were then compared using Log Likelihood (LL) and Akaike Information Criterion (AIC) statistics to determine which model best fit the data. Models for each stressor as an independent predictor are reported along with the best fit model with stressors incorporated together as predictors.

A subset of analyses was performed examining interactions between stressor occurrence and parasympathetic cardiac function. These analyses were only performed for potential experiences of abuse as parent arrest data was not available for the subset of children with RSA data (see Study 2, Chapter 3.2.1) and only a small number of this subset of children moved care during their time in the program (n = 2). RSA was treated as in Study 2 (Chapter 4, Section 4.2.3), where RSA from children's first month in the program was examined as a time invariant predictor to explore any potential interactions of children's initial RSA in predicting abuse. RSA each month was then examined as a time varying predictor along with abuse to assess any interactions between change in RSA and occurrence of abuse. For changes in RSA, as abuse occurrence and the date for which RSA was coded were not necessarily the same date, daily teacher ratings and time outs were averaged differently from those models in Study 2. If abuse occurred during a month between days with coded RSA, behaviors were averaged from the day following the day with coded RSA to the date of occurrence of abuse. Otherwise, behaviors were averaged in a similar manner to Study 2.

Lastly, I examined RSA as an outcome to assess changes in parasympathetic cardiac regulation after an occurrence of abuse. For these models, RSA was included as the outcome variable and abuse occurrence as a time varying predictor. To control for any potential effects of age or gender, these were also included in all models. To better understand and interpret any significant interactions observed, simple slopes were computed following recommendations by Preacher, Curran, & Bauer, 2006.

5.3 Results

5.3.1 The Relationship Between Occurrence of a Stressor and Changes in Behavior

Parent Arrest

Teacher Ratings of Self-Regulatory Behaviors: The effect of time in program on children's self-regulatory behaviors remained significant after including parent arrest as a predictor ($\beta = 0.30$, SE = 0.37, $p < 0.001$; Table 12). There is a significant main effect of parent arrest on behavior ($\beta = 0.52$, SE = 0.23, $p < 0.05$), with children's behavior improving after a parent arrest (Figure 14). There are no significant interactions of parent arrest and time in program ($\beta = -0.01$, SE = 0.09, $p = 0.94$; Table 11), but including the interaction results in the main effect no longer being significant ($\beta = 0.54$, SE = 0.38, $p = 0.15$; Table 12). However, the model without the interaction is a better fit than the model with the interaction (Table 12), suggesting that the observed main effect of parent arrest on children's behaviors is meaningful. These results did not change after the inclusion of age and gender (Table 12), although there was a significant effect of gender on children's teacher rated behaviors such that females demonstrated higher teacher rated self-regulatory behaviors ($\beta = 1.01$, SE = 0.38, $p < 0.01$).

Time Outs: There were no significant effects of time in program on time outs after including parent arrests in the model ($\beta = 0.003$, SE = 0.01, $p = 0.08$; Table 12). There was no significant main effect of parent arrest on time outs ($\beta = -0.07$, SE = 0.13, $p = 0.06$; Table 12) or significant interaction between parent arrest and time in program. ($\beta = 0.02$, SE = 0.03, $p = 0.49$; Table 12). These effects did not change after including age and gender in the model (Table 12), although there was a significant effect of gender on time outs such that females demonstrated fewer time outs ($\beta = -0.35$, SE = 0.11 $p < 0.01$).

Abuse

Teacher Rated Self-Regulatory Behaviors: Again, there is a significant effect of time in program on children's self-regulatory behaviors ($\beta = 0.36$, SE = 0.03, $p < 0.001$), such that there are increases in children's teacher rated self-regulatory behaviors during the program. There is no significant main effect of abuse on behavior ($\beta = 0.21$, SE = 0.16, $p = 0.20$). However, there is a significant interaction of abuse occurrence with time ($\beta = -0.09$, SE = 0.03, $p < 0.01$), and the model including the interaction was a better fit than the model without (Table 12). Examining the simple slopes for occurrence of abuse (1) or no occurrence of abuse (0) indicated that after the occurrence of abuse individuals' improvement during the program slows (Prior to abuse: $\beta = 0.36$, $p < 0.001$; After abuse: $\beta = 0.27$, $p < 0.001$; Figure 15). Including age and gender did not change these effects, although there was a significant main effect of gender ($\beta = 1.18$, SE = 0.34, $p < 0.001$), such that females demonstrated increased teacher rated behaviors (Table 12).

Time Outs: There were no main effects of time in program on time outs after including abuse in the model ($\beta = 0.01$, SE = 0.01, $p = 0.09$; Table 12), although it was trending. However, after including both a main effect of abuse and interaction of abuse with time this effect was significant ($\beta = 0.02$, SE = 0.01, $p < 0.05$; Table 12). There was no significant main effect ($\beta = 0.09$, SE = 0.06, $p = 0.13$) or interaction with time in program of abuse on children's number of time outs ($\beta = -0.02$, SE = 0.01, $p = 0.13$) (Table 12). Additionally, models including abuse as a predictor were not a better fit than without ($p > 0.10$). Including age and gender did not change these effects, although there was a significant main effect of gender ($\beta = -0.33$, SE = 0.09, $p < 0.001$) such that females had fewer time outs than males (Table 12).

Move Care

Teacher Rated Self-Regulatory Behavior: There remained a significant effect of time in program on children's self-regulatory behavior after including moving care source ($\beta = 0.34$, $SE = 0.03$, $p < 0.001$), such that teacher ratings of children's behavior increased during the program (Table 12). However, there were no significant main ($\beta = -0.14$, $SE = 0.35$, $p = 0.70$) or interaction effects ($\beta = -0.03$, $SE = 0.08$, $p = 0.72$) for moving care source on children's behavior and including moving care source did not improve the model fit ($p > 0.10$; Table 12). Including age and gender did not change these effects (Table 12), although there was a significant effect of gender on teacher rated behaviors such that females had higher teacher rated behaviors ($\beta = 1.19$, $SE = 0.34$, $p < 0.001$).

Time Outs: There was no significant effect of time in the program on number of time outs, after incorporating moving care source as a predictor (Table 12). Additionally, there were no significant main ($\beta = 0.07$, $SE = 0.13$, $p = 0.61$) or interaction effects ($\beta = 0.005$, $SE = 0.03$, $p = 0.88$) of moving care source on children's time outs and including moving care source did not improve model fit ($p > 0.10$; Table 12). Including age and gender did not change these effects (Table 12), although there was a significant effect of gender on teacher rated behaviors such that females had fewer time outs ($\beta = -0.34$, $SE = 0.09$, $p < 0.001$).

Interactions Between Stressors

Teacher Rated Self-Regulatory Behaviors: The best fit model for the data (AIC = 2273.81, LL = -1125.90, $r2 = 0.22$) included parent arrest, abuse, and an interaction of abuse with time, along with gender (Table 13). The pattern of results for each type of stressor resembled those observed when they were included separately as individual predictors (Table 13). There was a significant main effect of parent arrest on children's teacher rated self-regulatory behaviors (β = 0.48, SE = 0.22, $p < 0.05$), with children's behavior improving after a parent arrest. There was no significant main effect of abuse on behavior (β = 0.21, SE = 0.20, p = 0.33), but there was a significant interaction of abuse with time (β = -0.11, SE = 0.04, $p < 0.01$), such that after the occurrence of abuse individuals' improvement during the program slows. There was a main effect of gender on teacher rated behaviors, such that females had higher teacher ratings (β = 1.08, SE = 0.37, $p < 0.01$). Including age did not improve the model fit ($p > 0.05$) and had no significant effects on teacher rated self-regulatory behaviors (β = -0.01, SE = 0.02, p = 0.53).

Time Outs: The best fit model for time outs included only gender (AIC = 992.85, LL = -488.42, r2 = 0.07; Table 13). There was a significant main effect of gender on time outs (β = -0.32, SE = 0.09, $p < 0.001$), such that females had fewer time outs. Including parent arrest, abuse, and moving care did not improve model fit ($p > 0.10$). Including age did not improve model fit ($p > 0.10$) and demonstrated no significant effects on time outs (β = -0.002, SE = 0.005, p = 0.71).

5.3.2 The Relationship Between Physiological Functioning, Abuse Occurrence, and Self-Regulatory Behaviors

Interactions Between RSA in First month of the Program and Occurrence of Abuse

Teacher Rated Self-Regulatory Behaviors: There were no significant interaction effects between initial RSA (first month of program) and abuse occurrence in relation to children's self-regulatory behaviors (Table 14). The observed effects of initial RSA on self-regulatory behaviors found in Study 2 (Chapter 4.3.2) remained significant after incorporating abuse (Table 14). The interaction between time in the program and abuse was not significant, but was trending (β = -0.08, SE = 0.05, p = 0.09). The model incorporating both initial RSA and abuse was a better fit than the model with only initial RSA or only abuse ($p < 0.05$). Including age and gender did not change these effects (Table 14), although as with previous models there was a significant effect of gender on teacher rated behaviors such that females had higher teacher ratings of self-regulatory behaviors ($\beta = 2.20$, $SE = 0.77$, $p < 0.01$).

Time Outs: There were no significant interaction effects between initial RSA (first month of program) and abuse occurrence in relation to number of time outs (Table 14). Additionally, including initial RSA and abuse occurrence did not improve model fit. Including age and gender did not change these effects and there were no significant effects of age or gender on time outs (Table 14).

Interactions Between Change in RSA and Occurrence of Abuse

Teacher Rated Self-Regulatory Behaviors: There were no significant interaction effects between or main effects of RSA and abuse occurrence in relation to children's teacher rated self-regulatory behaviors (Table 15). Additionally, including RSA and abuse occurrence in these models did not improve the models ($p > 0.10$). It is important to note that as these models are only looking at average teacher ratings between coded RSA date and incident of abuse, this means some of the variability in teacher ratings is lost which could contribute to the different effect observed here. Including age and gender did not change these effects although there was a consistent effect of gender across models on teacher rated behaviors such that females had higher teacher rated self-regulatory behaviors (Table 15).

Time Outs: There were no significant interaction effects between or main effects of RSA and abuse occurrence in relation to children's average number of time outs (Table 15). Additionally, including RSA and abuse occurrence in these models did not improve the models ($p > 0.10$). As with teacher self-regulatory behaviors, because these models are only looking at average teacher ratings between coded RSA date and incident of abuse, this means some of the variability in teacher ratings is lost. Including age and gender did not change any of these effects, and there were no main effects of age and gender on time outs (Table 15).

5.3.3 The Relationship Between Abuse Occurrence and Changes in Physiological Functioning

There were no significant main or interaction effects of abuse occurrence on changes in RSA (Table 16). Time remained a significant predictor of RSA, with time in the program being associated with increases in RSA ($\beta = 0.08$, $SE = 0.03$, $p < 0.05$), in the model including only time and a main effect of abuse. However, including an interaction between abuse and time in program, the main effect of time in program was no longer significant ($\beta = 0.03$, $SE = 0.05$, $p = 0.44$). That said the models including abuse occurrence were not a better fit than those without ($p > 0.10$), suggesting that the effect of time in program on RSA is meaningful. Including age and gender did not change these effects and there were no effects of age or gender on RSA (Table 16).

5.4 Discussion

The current study took advantage of the high frequency data collection, in both the classroom and home, possible at the Building Blocks Preschool Program to examine how children respond to the occurrence of a stressor and whether these responses are influenced by children’s parasympathetic cardiac functioning. These are questions that have been difficult to previously address given researchers typically identify early life stress populations post stressor (Cicchetti, 2016; Koss & Gunnar, 2017; Pollak, 2005). This study found changes in children’s behavior after having a parent arrested and after an occurrence of abuse. Having a parent arrested while in the program was associated with improvement in children’s self-regulatory behaviors post parent arrest. Additionally, experiencing abuse (child or teacher perceived) was associated with a decline in positive changes in children's self-regulatory behaviors during the program following the incident of abuse. This study found no changes in children's behavior after moving care source.

The finding that parent arrest is associated with improvements in behavior is somewhat surprising and contrary to initial hypotheses. However, it is possible that the arrest of a parent is associated with an alleviation of a source of stress within the home, which could contribute to the observed improvement in behaviors. Indeed previous work has found that negative outcomes observed in children whose parents have a history of incarceration is not driven by the incidence(s) of incarceration, but rather situational factors including SES, maternal mental health, parenting style, and family context (Kinner et al., 2007). Parent arrest may, at least temporarily, change some of those situational factors positively resulting in the positive behavior changes observed in children post parent arrest. Of course, it is also the case that some of the observed changes could be driven by bias in teacher ratings, as teachers are typically aware of the situation at home, and may give children a grace period following a parent arrest. These questions should be further explored using multiple sources of reports to assess children's behavior changes.

It is interesting that experiences of abuse, while not associated with an immediate effect on children's behavior, instead influence patterns of behavior change after the occurrence of the event. The slowing of positive change in behaviors suggests that abuse experiences do have a long-term negative impact for children, changing the way they respond to positive environments. Additionally, this finding indicates the utility of exploring longitudinal patterns of change in terms of understanding children's responses to abuse. It is important to note that incidents of abuse were coded not from substantiated or unsubstantiated CPS cases, as is typical within the literature (Hardt & Rutter, 2004; Jaffee, 2017), but rather teacher and child reports of child directed behavior. However, as discussed in Chapter 1, the focus on using CPS or other agency validated measures of abuse occurrence is problematic as it does not account for the child's own perception of their environment. The current classification method takes this perception into account as the fact that a child or parent is mentioning an event indicates it was meaningful to the family. Of course, because of this reliance on child, parent, and teacher reported event, there are likely incidences that go unreported. However, underreporting is a problem with any form of measurement utilized to identify occurrences of abuse, as identification of an event is dependent on an individuals' (either the child, parent, other family members or community members) reporting the incident in the first place (Bass, Shields, & Behrman, 2004; Dubowitz et al., 2001; Scott et al., 2012).

The lack of effects for moving care source could be driven by these events being fairly common occurrences for children who experience these events. Children who were moving care source had often experienced similar moves prior to starting the program. It is likely that these children perceive these events as normative and therefore do not experience them as stressful. It is also the case that the change itself may not be associated with immediate effects on behavior, but overall total number of moves may relate to long term negative effects on behaviors as demonstrated in previous research (Newton et al., 2000; Rubin, O'Reilly, Luan, & Localio, 2007b). Additionally, given the effects of foster care on children's outcomes have been demonstrated to be moderated by perceptions of relationships with caregiver (Cooley et al., 2015; McLaughlin et al., 2012), it is also possible that the majority of changes in placement for these children were associated with perceptions of increased parental warmth and support by the child. These are questions that can and should be explored further in the context of the current data set, as well as through asking children themselves how they perceive these events.

I found no relationships between changes in parasympathetic cardiac regulation, children's self-regulatory behaviors, and experience of a stressor. However, this is likely limited due to the coding scheme for the data. Parasympathetic cardiac functioning was coded for only one day each month and then children's self-regulatory behaviors were averaged between the date with RSA coded and the date of occurrence of a stressor for months where a stressor occurred. This approach results in a loss of variability in the data, and future work should examine parasympathetic cardiac control immediately prior to and after the stressor to better explore how parasympathetic cardiac functioning may relate to children's behavioral responses to early life stress.

This study provides some of the first insight into behavioral change in children after extreme stress and how these responses are influenced by children's parasympathetic cardiac functioning. Future work should continue to explore these relationships as well as the mechanisms which might contribute to the observed changes. To this end research should aim to assess children's perceptions of the event along with the event itself which could help illuminate some of the observed effects. Understanding the complex interactions between environment, physiology, and perception in predicting children's behavioral responses to stress can help illuminate the mechanisms through which stress exerts effects in early childhood as well as the types of interventions that may be most effective for at-risk children and families.

5.5 Appendix C: Chapter 5 Table and Figures

Table 11: Demographics for subsample with data on parent arrest

	Mean (SD)
Age (in months)	58.64 mo (10.79)
Months in program	6.35 (0.71)
	Total Number (%)
Gender	
Male	77 (69.4)
Female	34 (30.6)
Race	
Caucasian	52 (46.8)
African American	32 (28.8)
Hispanic	6 (5.4)
Multi-Racial	21 (18.9)
Not living with biological parents	32 (28.8)

Table 12: Model effects for stressors as independent predictors

			Model A		Model B		Model C		Model D	
Stressor	**Outcome**	**Fixed Effects**	**β (SE)**	**df**	**β (SE)**	**df**	**β (SE)**	**df**	**β (SE)**	**df**
Parent Arrest	Teacher Rated Self-Regulatory Behaviors	Intercept	5.40*** (0.18)	585	5.40*** (0.18)	584	5.35*** (0.17)	583	5.35*** (0.17)	582
		Time	0.30*** (0.04)	585	0.31*** (0.04)	584	0.31*** (0.04)	583	0.32*** (0.04)	582
		Parent Arrest	0.52* (0.23)	585	0.54 (0.38)	584	0.51* (0.23)	583	0.55 (0.38)	582
		Time*Parent Arrest	-	-	-0.01 (0.09)	584	-	-	-0.01 (0.09)	582
		Gender	-	-	-	-	1.01** (0.38)	105	1.01** (0.38)	105
		Age	-	-	-	-	-0.01 (0.02)	105	-0.01 (0.02)	105

Table 12, continued

		Time*Gender	-	-	-	-	0.04 (0.09)	583	0.04 (0.08)	582
		Time*Age	-	-	-	-	0.01 (0.004)	583	0.01 (0.004)	582
	Time Outs	Intercept	0.50*** (0.05)	564	0.50*** (0.05)	563	0.50*** (0.05)	562	0.51*** (0.05)	561
		Time	0.003 (0.01)	564	0.002 (0.01)	563	0.01 (0.01)	562	0.01 (0.01)	561
		Parent Arrest	0.002 (0.08)	564	-0.07 (0.13)	564	0.01 (0.08)	562	-0.04 (0.13)	561
		Time*Parent Arrest	-	-	0.02 (0.03)	564	-	-	0.01 (0.03)	561
		Gender	-	-	-	-	-0.36** (0.11)	101	-0.35** (0.11)	101

Table 12, continued

		Age	-	-	-	-	-0.002 (0.01)	101	-0.002 (0.01)	101
		Time*Gender	-	-	-	-	0.03 (0.02)	562	0.03 (0.02)	561
		Time*Age	-	-	-	-	0.001 (0.001)	562	0.001 (0.001)	561
Abuse	Teacher Rated Self-Regulatory Behaviors	Intercept	5.12*** (0.16)	778	5.06*** (0.16)	777	5.10*** (0.15)	776	5.04*** (0.15)	775
		Time	0.34*** (0.03)	778	0.36*** (0.03)	777	0.35*** (0.03)	776	0.37*** (0.03)	775
		Abuse	-0.15 (0.10)	778	0.21 (0.16)	777	-0.15 (0.10)	776	0.21 (0.16)	775
		Time*Abuse	-	-	-0.09** (0.03)	777	-	-	-0.09** (0.03)	775

Table 12, continued

		Gender	-	-	-	-	1.18*** (0.34)	143	1.18*** (0.34)	143
		Age	-	-	-	-	-0.02 (0.02)	143	-0.02 (0.02)	143
		Time*Gender	-	-	-	-	0.01 (0.08)	776	0.01 (0.08)	775
		Time*Age	-	-	-	-	0.01 (0.004)	776	0.01 (0.004)	775
	Time Outs	Intercept	0.49*** (0.04)	742	0.48*** (0.04)	741	0.49*** (0.04)	740	0.48*** (0.04)	739
		Time	0.01† (0.01)	742	0.02* (0.01)	741	0.02* (0.01)	740	0.02* (0.01)	739
		Abuse	0.02 (0.04)	742	0.09 (0.06)	741	0.02 (0.04)	740	0.09 (0.06)	739

Table 12, continued

		Time*Abuse	-	-	-0.02 (0.01)	741	-	-	-0.02 (0.01)	739
		Gender	-	-	-	-	-0.33*** (0.09)	140	-0.33*** (0.09)	140
		Age	-	-	-	-	-0.002 (0.005)	140	-0.002 (0.005)	140
		Time*Gender	-	-	-	-	0.001 (0.001)	740	0.01 (0.02)	739
		Time*Age	-	-	-	-	0.01 (0.02)	740	0.001 (0.001)	739
Move Care	Teacher Rated Self-Regulatory Behaviors	Intercept	5.10*** (0.16)	778	5.10*** (0.16)	777	5.09*** (0.15)	776	5.08*** (0.15)	775
		Time	0.34*** (0.03)	778	0.34*** (0.03)	777	0.35*** (0.03)	776	0.35*** (0.03)	775

Table 12, continued

		Move Care	-0.23 (0.24)	778	-0.14 (0.35)	777	-0.26 (0.24)	776	-0.18 (0.35)	775
		Time* Move Care	-	-	-0.03 (0.08)	777	-	-	-0.03 (0.08)	775
		Gender	-	-	-	-	1.19*** (0.34)	143	1.19*** (0.34)	143
		Age	-	-	-	-	-0.02 (0.02)	143	-0.02 (0.02)	143
		Time*Gender	-	-	-	-	0.02 (0.08)	776	0.02 (0.08)	775
		Time*Age	-	-	-	-	0.01 (0.004)	776	0.01 (0.004)	775
	Time Outs	Intercept	0.49*** (0.04)	742	0.49*** (0.04)	741	0.49*** (0.04)	740	0.49*** (0.04)	739

Table 12, continued

		Time	0.01† (0.01)	742	0.01† (0.01)	741	0.02* (0.01)	740	0.02* (0.01)	739
		Move Care	0.08 (0.09)	742	0.07 (0.13)	741	0.10 (0.09)	740	0.10 (0.13)	739
		Time*Move Care	-	-	0.005 (0.03)	741	-	-	0.001 (0.001)	739
		Gender	-	-	-	-	-0.34*** (0.09)	140	-0.34*** (0.09)	140
		Age	-	-	-	-	-0.002 (0.005)	140	-0.002 (0.005)	140
		Time*Gender	-	-	-	-	0.01 (0.02)	740	0.01 (0.02)	739
		Time*Age	-	-	-	-	0.001 (0.001)	740	0.001 (0.001)	739

Table 12, continued

		Random Effects	Variance	Variance	Variance	Variance
Parent Arrest	Teacher Rated Self-Regulatory Behaviors	Intercept	2.99	2.99	2.75	2.75
		Time	0.08	0.08	0.08	0.08
	Time Outs	Intercept	0.21	0.21	0.18	0.18
		Time	0.003	0.003	0.003	0.003
Abuse	Teacher Rated Self-Regulatory Behaviors	Intercept	3.26	3.27	2.92	2.93
		Time	0.09	0.09	0.09	0.09
	Time Outs	Intercept	0.19	0.19	0.12	0.17
		Time	0.003	0.003	0.002	0.002

Table 12, continued

Move Care	Teacher Rated Self-Regulatory Behaviors	Intercept	3.25	3.25	2.91	2.91
		Time	0.09	0.09	0.09	0.09
	Time Outs	Intercept	0.19	0.19	0.16	0.17
		Time	0.003	0.003	0.002	0.002
		Model Fit Statistics				
Parent Arrest	Teacher Rated Self-Regulatory Behaviors	AIC	2286.87	2288.86	2283.42	2285.41
		Log Likelihood	-1136.43	-1136.43	-1130.71	-1130.70
		r^2	0.17	0.17	0.20	0.20
	Time Outs	AIC	710.24	711.77	704.54	706.32
		Log Likelihood	-284.12	-347.88	-341.27	-341.16
		r^2	0.0004	0.001	0.07	0.07

Table 12, continued

Abuse	Teacher Rated Self-Regulatory Behaviors	AIC	3076.04	3070.19	3066.12	3060.31
		Log Likelihood	-1531.02	-1527.10	-1522.06	-1518.16
		r^2	0.19	0.19	0.23	0.23
	Time Outs	AIC	1006.28	1005.99	996.11	995.75
		Log Likelihood	-496.14	-495.00	-487.05	-485.88
		r^2	0.01	0.01	0.07	0.07
Move Care	Teacher Rated Self-Regulatory Behaviors	AIC	3077.66	3079.53	3067.38	3069.28
		Log Likelihood	-1531.83	-1531.77	-1522.69	-1522.64
		r^2	0.19	0.19	0.23	0.23
	Time Outs	AIC	1005.76	1007.74	994.93	996.93
		Log Likelihood	-495.88	-495.87	-486.47	-486.47
		r^2	0.01	0.01	0.07	0.07

Table 12, continued

Note. Model A – model including only main effect of stressor occurrence as a predictor of children's behaviors. Model B – model including both main effect of stressor and interaction with time. Model C – model including only main effect of stressor controlling for age and gender. Model D – model including both main effect of stressor and interaction with time controlling for age and gender.

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, $^{\dagger}p < 0.10$

Table 13: Best fit model incorporating stressors for teacher self-regulatory behaviors and time outs

Outcome	**Fixed Effects**	**β (SE)**	**df**
Teacher Rated Self-Regulatory Behaviors	Intercept	5.33*** (0.17)	582
	Time	0.33*** (0.04)	582
	Parent Arrest	0.48* (0.22)	582
	Abuse	0.21 (0.20)	582
	Gender	1.08** (0.37)	106
	Time*Abuse	-0.11** (0.04)	582
	Time*Gender	-0.01 (0.08)	582
Time Outs	Intercept	0.50*** (0.04)	742
	Time	0.01[†] (0.01)	742

Table 13, continued

	Gender	-0.32*** (0.09)	141
	Time*Gender	0.002 (0.02)	742
		Variance	
Teacher Rated Self-Regulatory Behaviors	Intercept	2.78	
	Time	0.09	
Time Outs	Intercept	0.17	
	Time	0.003	
Model Fit Statistics			
Teacher Rated Self-Regulatory Behaviors	AIC	2273.81	
	Log Likelihood	-1125.90	
	r^2	0.22	
Time Outs	AIC	992.85	
	Log Likelihood	-488.42	
	r^2	0.07	

Note. ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, $^{\dagger}p < 0.10$

Table 14: Interactions between initial RSA (first month in the program) and abuse occurrence

		Model A		Model B	
Outcome	**Fixed Effect**	**β (SE)**	**df**	**β (SE)**	**df**
Teacher Rated Self-Regulatory Behaviors	Intercept	5.21*** (1.22)	1793	4.99*** (1.10)	1791
	Time	0.08*** (0.02)	1793	0.08*** (0.02)	1791
	Initial RSA	0.74** (0.27)	32	0.78** (0.24)	30
	Abuse	1.84 (1.28)	1793	1.79 (1.28)	1791
	Initial RSA*Abuse	-0.47 (0.29)	1793	-0.46 (0.29)	1791
	Time*Initial RSA	-0.01** (0.004)	1793	-0.01** (0.004)	1791

Table 14, continued

	Time*Abuse	-0.08† (0.05)	1793	-0.08† (0.05)	1791
	Time*Initial RSA*Abuse	0.02 (0.01)	1793	0.02 (0.01)	1791
	Gender	-	-	2.20** (0.77)	30
	Age	-	-	-0.02 (0.04)	30
	Time*Gender	-	-	-0.01 (0.01)	1791
	Time*Age	-	-	0.02 (0.01)	1791
Time Outs	Intercept	1.27** (0.46)	2338	1.30** (0.45)	2336

Table 14, continued

	Time	0.01 (0.01)	2338	0.01 (0.01)	2336
	Initial RSA	-0.08 (0.10)	32	-0.09 (0.10)	30
	Abuse	$1.44^{\dagger}$ (0.78)	2338	$1.46^{\dagger}$ (0.78)	2336
	Initial RSA*Abuse	-0.27 (0.17)	2338	-0.28 (0.17)	2336
	Time*Initial RSA	-0.002 (0.0002)	2338	-0.002 (0.002)	2336
	Time*Abuse	-0.03 (0.02)	2338	-0.03 (0.02)	2336
	Time*Initial RSA*Abuse	0.01 (0.005)	2338	0.01 (0.005)	2336

Table 14, continued

	Gender	-	-	-0.48 (0.32)	30
	Age	-	-	0.01 (0.02)	30
	Time*Gender	-	-	-0.01 (0.01)	2336
	Time*Age	-	-	-0.001 (0.0003)	2336
	Random Effects	**Variance**		**Variance**	
Teacher Rated Self-Regulatory Behaviors	Intercept	4.30		3.39	
	Time	0.001		0.001	
Time Outs	Intercept	0.61		0.56	

Table 14, continued

	Time	0.0001	0.0001
Model Fit Statistics			
Teacher Self-Regulatory Behaviors	AIC	7169.98	7168.45
	Log Likelihood	-3582.99	-3568.23
	r^2	0.14	0.24
Time Out	AIC	6833.85	6835.02
	Log Likelihood	-3404.93	-3401.51
	r^2	0.03	0.09

Note. Model A – model for interactions between initial RSA and abuse occurrence as predictors of children's behaviors. Model B – model controlling for age and gender. ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, $^{\dagger}p < 0.10$

Table 15: Interactions between RSA and abuse occurrence

		Model A		Model B	
Outcome	**Fixed Effect**	**β (SE)**	**df**	**β (SE)**	**df**
Teacher Rated Self-Regulatory Behaviors	Intercept	8.10*** (0.77)	118	7.90*** (0.77)	116
	Time	0.28 (0.12)	118	0.32† (19)	116
	RSA	0.09 (0.15)	118	0.13 (0.15)	116
	Abuse	-1.81 (1.40)	118	-1.70 (1.43)	116
	RSA*Abuse	-0.41 (0.290	118	0.37 (0.30)	116
	Time*RSA	-0.01 (0.04)	118	-0.01 (0.04)	116

Table 15, continued

	Time*Abuse	0.41 (0.29)	118	0.49 (0.40)	116
	Time*RSA*Abuse	-0.11 (0.08)	118	-0.10 (0.08)	116
	Gender	-	-	2.13* (0.86)	31
	Age	-	-	-0.02 (0.05)	31
	Time*Gender	-	-	-0.11 (0.15)	116
	Time*Age	-	-	0.002 (0.008)	116
Time Outs	Intercept	1.20*** (0.33)	124	1.17*** (0.34)	122

Table 15, continued

	Time	-0.05 (0.08)	124	-0.05 (0.08)	122
	RSA	-0.08 (0.07)	124	-0.08 (0.07)	122
	Abuse	0.13 (0.62)	124	0.22 (0.64)	122
	RSA*Abuse	0.001 (0.13)	124	-0.02 (0.13)	122
	Time*RSA	0.01 (0.02)	124	0.01 (0.02)	122
	Time*Abuse	-0.08 (0.18)	124	-0.10 (0.18)	122
	Time*RSA*Abuse	0.01 (0.03)	124	0.01 (0.03)	122

Table 15, continued

	Gender	-	-	-0.57 (0.34)	31
	Age	-	-	0.01 (0.02)	31
	Time*Gender	-	-	0.01 (0.05)	122
	Time*Age	-	-	0.002 (0.003)	122
	Random Effects	**Variance**		**Variance**	
Teacher Rated Self-Regulatory Behaviors	Intercept	4.39		3.49	
	Time	0.05		0.05	
Time Outs	Intercept	0.59		0.53	

Table 15, continued

	Time	0.004	0.004
Model Fit Statistics			
Teacher Self-Regulatory Behaviors	AIC	584.89	585.50
	Log Likelihood	-280.44	-276.75
	r^2	0.10	0.24
Time Out	AIC	332.86	332.56
	Log Likelihood	-154.43	-150.28
	r^2	0.02	0.15

Note. Model A – model for interactions between initial RSA and abuse occurrence as predictors of children's behaviors. Model B – model controlling for age and gender. ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, $^{\dagger}p < 0.10$

Table 16: Relationship between occurrence of abuse and change in RSA

	Model A		Model B		Model C		Model D	
Fixed Effects	**β (SE)**	**df**	**β (SE)**	**df**	**β (SE)**	**df**	**β (SE)**	**df**
Intercept	4.21*** (0.20)	140	4.32*** (0.22)	139	4.22*** (0.21)	138	4.32*** (0.22)	137
Time	0.08* (0.03)	140	0.03 (0.05)	139	0.08 (0.04)	138	0.04 (0.05)	137
Abuse	0.07 (0.22)	140	-0.22 (0.32)	139	0.09 (0.22)	138	-0.21 (0.33)	137
Time*Abuse	-	-	0.09 (0.07)	139	-	-	0.10 (0.08)	137
Gender	-	-	-	-	-0.19 (0.46)	31	-0.19 (0.46)	31
Age	-	-	-	-	-0.02 (0.02)	31	-0.02 (0.02)	31

Table 16, continued

Time*Gender	-	-	-	-	0.02 (0.09)	138	0.03 (0.09)	137
Time*Age	-	-	-	-	0.0001 (0.005)	138	0.002 (0.01)	137
Random Effects	**Variance**		**Variance**		**Variance**		**Variance**	
Intercept	0.55		0.56		0.53		0.53	
Time	2.71e-09		2.79e-09		2.32e-09		1.5e-09	
Model Fit Statistics								
AIC	607.42		607.89		614.25		614/77	
Log Likelihood	-296.71		-295.95		-296.13		-295.38	
r^2	0.02		0.02		0.04		0.04	

Table 16, continued

Note. Model A – model including only main effect of abuse occurrence as a predictor of children's RSA. Model B – model including both main effect of abuse occurrence and interaction with time. Model C – model including only main effect of abuse occurrence controlling for age and gender. Model D – model including both main effect of abuse occurrence and interaction with time controlling for age and gender. ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, $^{\dagger}p < 0.10$

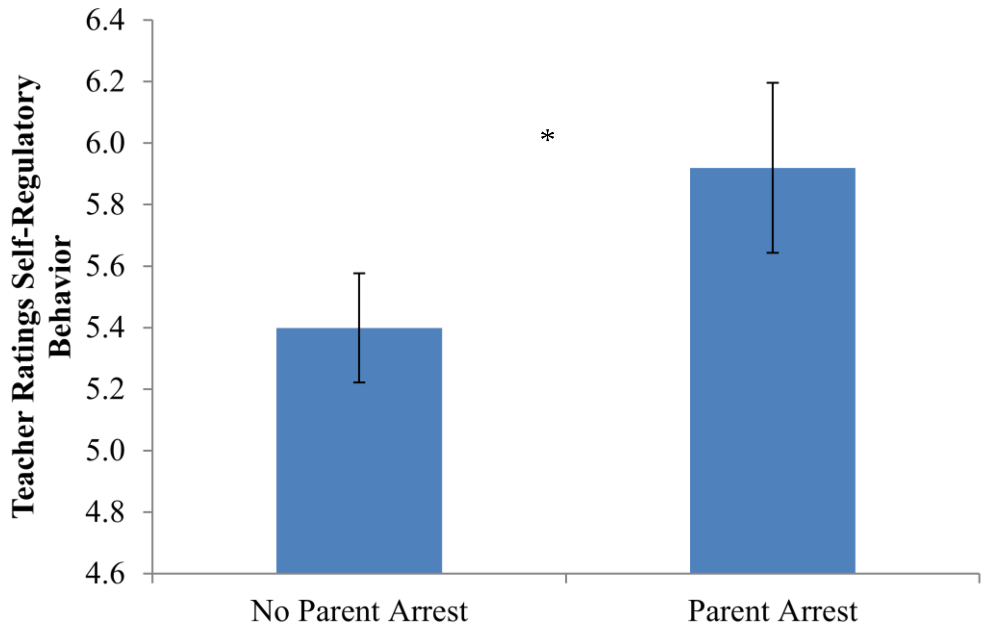

Figure 14: Relationship between occurrence of parent arrest and changes in children's self-regulatory behavior. *$p < 0.05$

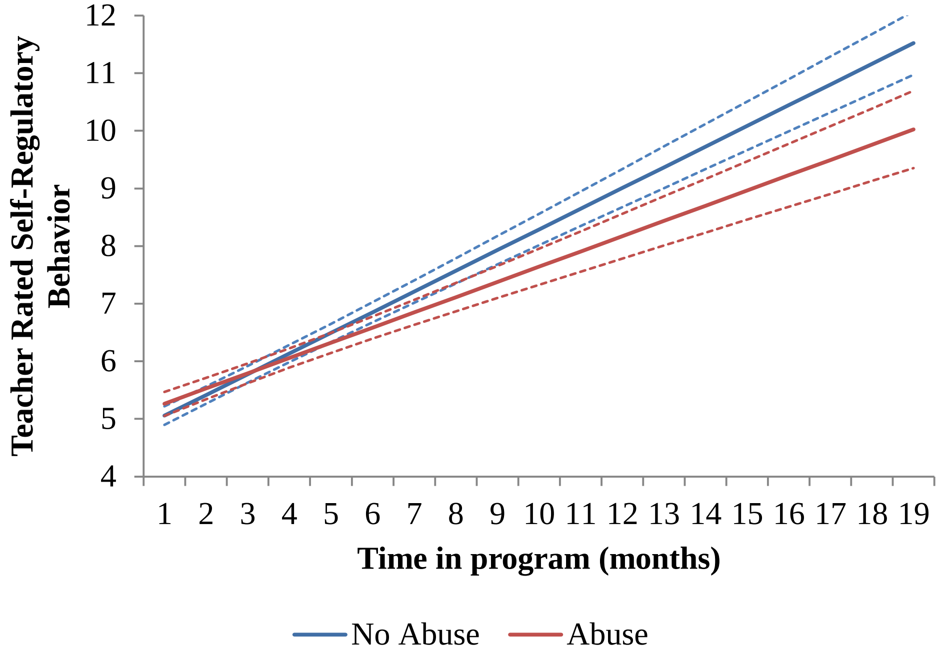

Figure 15: Relationship between abuse and children's change in self-regulatory behaviors

Chapter 6: General Discussion and Conclusions

Through the integration of a range of child and family factors, and incorporation of a recognition of the important role perception plays in responses to stress, the current work has attempted to elucidate some of the mechanisms and interactions between these factors that support individual differences in children's responses to chronic and/or extreme stress early in life. Specifically, this work examined three primary questions: 1) How do factors associated with instability in the home environment influence children's self-regulatory behaviors, and do these factors shape individual differences in behavior change during the course of a preschool program aimed at helping support self-regulatory behaviors in children in at-risk environments; 2) What is the relationship between parasympathetic cardiac regulation and children's self-regulatory behaviors, with a focus on examining if children's parasympathetic cardiac regulation changes during the preschool program and the implications of these changes for children's behavior; and 3) How does children's behavior change after the occurrence of a significant stressful event (parent arrest, abuse, or moving care) and is parasympathetic cardiac functioning related to this change?

In brief, this work found that environmental indices of stability were associated with differential patterns of change, with the primary predictors of individual differences in children's behaviors being living with biological parents or in foster care/guardianship and completion of the program. In examining changes in parasympathetic cardiac regulation and the relationship of observed changes to children's self-regulatory behaviors, children's initial levels of parasympathetic cardiac regulation predict patterns of change in children's behaviors. Children with lower parasympathetic cardiac functioning at the start of the program demonstrated poorer initial behaviors but also greater improvements in behavior during the program. Additionally, children demonstrated significant increases in parasympathetic cardiac functioning during the program and these increases were associated with improvements in behavior. Lastly, this work found that children demonstrate differential behavioral responses to different types of early life stress, and these responses are not related to general parasympathetic cardiac regulation. Overall, these results have important implications for understanding children's responses to early life stress and the role of interactions between children's environment, physiological functioning, and perceptions of stress in these responses.

6.1 Environmental Influences on Changes in Children's Self-Regulatory Behaviors

Findings from Studies 1 and 2 indicate the important role of multiple influences on patterns of self-regulatory behavior and behavioral change in children exposed to early life stress. Study 1 suggests that certain features of children's environments play an important role in modulating self-regulatory behaviors. Most interestingly, I found that children living in foster care/guardianship as compared to those still living with their biological parents, demonstrated better initial behaviors but also less susceptibility to positive change over the course of the program. One likely mechanism for this effect is that children living in more variable environments may be better able to cope with the stress of starting a new school due to their prior experience with changing home environments. However, this experience with unpredictable and unreliable environments, also results in these children being less susceptible to the beneficial effects of the imposed predictability and reliability of the classroom environment. Indeed, there is strong evidence that early exposure to unpredictable environments or unreliable adults changes children's expectations about their broader environment and shifts their behaviors towards those of immediate gratification, which are typically categorized as problematic self-regulation (de Baca & Ellis, 2017; Kidd, Palmeri, & Aslin, 2013). This leads to an additional important point –

many of the behaviors identified as decreased self-regulation in the current sample of children exposed to early life stress may be not represent problematic behavioral manifestations of self-regulatory processes, but rather are adopted as effective strategies aimed at survival within the child's current unpredictable, unreliable context (Ellis et al., 2017; Pollak, 2008).

Importantly, children's self-regulatory behaviors were also predicted by whether or not children completed the preschool program, and these effects appeared to be independent of the amount of months children spent in the program. This provides further evidence for efficacy of the preschool program in supporting self-regulatory behaviors in these children. Additionally, at least for some indices of self-regulation, there was an interesting interaction effect between children's completion of the program and whether they were living with their biological parents. The difference in number of time outs at the start of the program between children living with their biological parents and children not living with their biological parents was only significant for children who completed the program. This suggests that children not living with their biological parents who are better able to cope with starting the preschool program may also be those children most likely to complete the program itself. This suggests an interesting potential individual difference for children who may be more at risk and in need of the services provided by the preschool that should be further explored.

6.2 The Relationship Between Parasympathetic Cardiac Regulation and Children's Self-Regulatory Behaviors

The idea that chronic/extreme stress early in life negatively shapes the development of stress response systems is one that is predominant within the early life stress literature. Indeed, research hypothesizes that early life stress results in alterations in the development of physiological stress response systems, and there is good evidence of altered functioning in children, adolescents, and adults exposed to early life stress (Giuliano et al., 2018; Koss & Gunnar, 2017; Lunkenheimer et al., 2018; Quas et al., 2014). However, there is little work examining patterns of change over development in these systems and how environmental factors shape these systems development (Alkon et al., 2011; Esposito et al., 2016; Jewell et al., 2017; M. Johnson et al., 2017). The current work provides insight into these questions, examining changes in children's parasympathetic autonomic cardiac functioning and the relationship of these changes to children's self-regulatory behaviors.

This work replicates previous literature (Blair et al., 2013; El-Sheikh & Erath, 2011; Katz & Gottman, 1995), finding that children's initial parasympathetic cardiac functioning is associated with differential patterns of behavior and behavior change such that having low parasympathetic cardiac regulation during the first month in the program is associated with poorer initial self-regulatory behaviors, but also steeper patterns of positive change. This indicates that low parasympathetic activity may not be as stable of a marker of risk in young children as it appears to be in adults (Thayer, Ahs, Fredrikson, Sollers, et al., 2012; Thayer & Lane, 2000). These findings evidence a pattern where children in high-risk environments with low parasympathetic regulation exhibit more negative initial behaviors, but once placed in a context of relatively increased safety and security, the preschool, they demonstrate improvement in these behaviors. Additionally, parasympathetic cardiac regulation also increases over the course of the program and these increases are related to observed behavior changes. Together, these findings suggest that the preschool program, possibly through its provision of a stable safe environment for these children, may be engaging threat inhibitory circuits in the CAN, represented by the observed increased parasympathetic cardiac regulation, that supports the observed increases in self-regulatory behaviors in these children.

The observed changes in parasympathetic cardiac functioning also have implications for understanding the development of this stress response system. The current findings indicate that children's parasympathetic cardiac regulation is malleable early in life and subject to environmental influences. This is in line with the hypothesized literature that parasympathetic cardiac regulation changes during development, indexing changes at the level of cortical systems, specifically increased cortical inhibition of lower brainstem areas (Porges, 2001, 2011). It also supports the hypothesis that exposure to early life stress results in changes in these cortical systems (Belsky & De Haan, 2011), reflected in changes in peripheral physiological functioning, that support observed differences in these children's psychological and behavioral processes (Pechtel & Pizzagalli, 2011; Pollak, 2005, 2008). It is important that future work continue to explore developmental changes in children's parasympathetic cardiac functioning, in the context of both normative development and early life stress, to better understand how early experience may be shape the development of these systems and the implications this has for children's psychological functioning.

6.3 Children's Responses to Stress

The current work provided a unique context in which to study children's behavior immediately prior to and after the occurrence of a severe/extreme stressor as well as whether parasympathetic cardiac regulation is related to these changes. These are questions that have been difficult to explore in previous research due to the limitation that, in most research settings, researchers identify a population after the occurrence of a stressor and infer effects of the stressor based on comparisons with populations that were not exposed to the stressor (Cicchetti, 2016; Koss & Gunnar, 2017; Pollak, 2005). However, the large quantity of high frequency data collected within the context of the preschool, at both the level of the school and home environment, allows for the identification of potential stressors and exploration of children's responses to those stressors.

The three main stressors explored were: 1) parent arrest; 2) experience of abuse; and 3) moving care source. This work found significant effects on behavior for both parent arrest and experience of abuse but not moving care source. Interestingly, and in contrast to previous work examining effects of parent incarceration on children's self-regulatory behaviors (Dallaire & Wilson, 2010; Dallaire et al., 2015; Murray & Farrington, 2005; Wilbur et al., 2007), the current work found that parent arrest was associated with improvement in children's self-regulatory behaviors rather than decreases. As discussed in Chapter 5 Section 5.4, one potential explanation for these effects could be due to the parent arrest removing a source of stress from the child's life, resulting in improved self-regulatory behaviors. This is especially interesting given the fact that previous work has suggested that it is not the event of a parent arrest or incarceration itself that results in the previously observed negative effects on children's behavior, but rather structural components of the household, including parenting styles and parent mental health (Kinner et al., 2007). These structural factors may be alleviated for a short time following the arrest of a parent which could account for the observed improvement in children's behaviors immediately following the parent arrest. Future work should explore children's perceptions of the event itself to examine if the parent arrest is accompanied by reduced perceptions of stress in the child.

Experience of abuse, while not associated with an immediate change in behavior, was associated with reduced improvement in children's self-regulatory behaviors over time, or a slowing of positive behavioral change. This indicates that the experience of abuse may impede some of the beneficial effects of a positive environment such as that of the preschool classroom.

This is especially important when considering intervention for children at-risk of abuse, as these children may need alternative forms of aid and support immediately after the occurrence of an incident of abuse in order to counteract the negative effects of experiences of abuse. Of course, as discussed in Chapter 5 Section 5.4, these results are somewhat limited due to their reliance on child and parent perception and report of the child's environment. However, as discussed extensively in Chapter 1, it is an individual's perception of their environment as stressful, rather than the environment itself, that elicits psychological and physiological responses aimed at addressing the perceived stressor (McEwen, 2007, 2016). The fact that children and parents report an event they perceive as potential abuse indicates these events are salient to the child and/or parent, meaning that regardless of whether or not they meet CPS criteria for abuse, they likely elicit physiological and psychological stress responses that have implications for children's behavior and development.

Interestingly, and in contrast to previous work (Newton et al., 2000; Rubin et al., 2007b), there were no significant effects of moving care (into or out of foster care) on children's self-regulatory behaviors in either the positive or negative direction. This is somewhat surprising. However, it is possible that these children are in such variable environments that changes in care source are not significant enough to elicit a stress response and associated behavioral changes. Additionally, these changes in care source could be associated with increased perceived quality of care or relief of environmental stressors for these children which may explain the lack of observed effects of moving care on children's behaviors. Future work should explore children's perceptions of changes in care and attempt to differentiate positive perceptions of change of care from negative in order to better understand how these events affect the child.

There were also no significant interactions between children's parasympathetic cardiac regulation and exposure to stress or effects of exposure to stress on parasympathetic cardiac regulation. However, as discussed in Chapter 5, Section 5.4, this is likely in part due to the coding of the data. In order to better understand any potential relationships between parasympathetic cardiac functioning and children's behavioral responses to a stressor, it will be helpful to examine parasympathetic cardiac regulation immediately prior to and after the occurrence of a stressor.

6.4 General Conclusions

Taken together, these three studies illustrate the complex nature of interactions between children's early environment, psychophysiological functioning, and their responses to early life stress. Utilizing a high frequency holistic data collection approach and integrating an understanding of the important influence perception plays in modulating children's responses to stress, this work provides novel insight into our understanding of the influence of children's environment on their psychological functioning. Indeed, it suggests that children in an environment of instability and high levels of change, may initially cope with change more positively than their peers, but also may be less susceptible to the influences of a stable, positive environment. Additionally, this work is the first to assess children's psychophysiological functioning at high frequency intervals, finding that children's environment facilitates changes in parasympathetic cardiac regulation which index meaningful changes in children's self-regulatory behaviors. Lastly, this work provides important insight into children's immediate responses to the occurrence of stressors, finding complex patterns of behavioral responses that would not necessarily be expected based on the existing literature. Future work should continue to explore these relationships, integrating environmental, physiological, and psychological indices utilizing high frequency data collection measures to better understand children's responses to early life stress, which in turn will provide a basis for more effective, targeted interventions for at-risk children and families.

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Appendix D: Teacher Rating Items

Teacher Monthly Ratings:

Rated using a scale from 0 – 4 with 0 being never and 4 being always

1) Child expresses anger appropriately

2) Child copes with disappointment or change

3) Child controls impulses

Items were summed to form a composite score of children's teacher rated self-regulatory behaviors.

Teacher Daily Ratings:

Rated using following 5 item Likert scale:

Never – Almost Never – Occasionally/Sometimes – Almost Always – Always

1) Child uses appropriate techniques (e.g. stomping out anger) while expressing anger

2) Child demonstrates minimal physical aggression when upset or angry

3) Child is able to cope with changes in the classroom with little or no redirection or extra attention needed and no accompanying emotional outbursts

4) Child follows direction in the classroom such as being asked to share a toy or take turns with little or no redirection or extra attention needed and no accompanying emotional outburst.

5) Child is able to keep his/her hands to him/herself

6) Child is able to follow redirection from teachers without conflict

Items 1 and 2 were averaged for a score for children's ability to express anger appropriately. Items 3 and 4 were averaged for children's ability to cope with disappointment or change. Items 5 and 7 were averaged for children's ability to control impulses. Scores for each subscale were then summed to form a composite rating of children's teacher rated self-regulatory behaviors.

Items for each subscale were developed in collaboration with the preschool teachers based on the factors they take into account when rating children on the broader items used for the monthly ratings (expressing anger appropriately, coping, and controlling impulses).

Appendix E: Intake Interview Stressors Checklist

Please check those events that have occurred in the child's family*:

- Divorce
- Financial Hardship
- Inadequate Housing
- New Baby
- Death of a Loved One
- Mental Health Issues in Immediate Family
- Child Abuse in Family
- Spousal Abuse
- Alcohol or Drug Use
- Parent in Prison
- Child or Sibling Lived Out of the Home

With Who: ________________ How Long: ________________

*Preschool staff conducting interview emphasized that the focus should be on events occurring within the child's time in the family

Appendix F: Search Terms for Identifying Occurrence of Abuse and Maltreatment

Abuse:

Abuse	Kick	Fight
DCS	Injury	Argue
CPS	Bruise	Spank
Case	Scratch	Slap
Case manager	Stab	Molest
Case worker	Whoop	Sex
CASA	Whip	Neglect
Beat	Bleed	Smack
Violence	Private	Mark
Physical	Belt	PTSD
Shoot	Police	Pinch
Knife	Hit	Bite
Gun	Violent	
Punch	Yell	

Move Care:

Move	Foster	Home
Moving	Supervised visits	Bio
Moved	Caseworker	Transition