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Development of Effortful Control as a Moderator of the Longitudinal Relations of
Negative Reactivity and Symptoms in Preschool

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A dissertation

submitted in partial fulfillment of the
requirements for the degree of

Doctor of Philosophy

University of Washington

2016

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Program Authorized to Offer Degree:

Psychology

University of Washington

Abstract

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Aspects of children's temperament, or biologically based differences in reactivity and regulation, are often studied in relation to symptoms of psychopathology. Specifically, children's propensity to experience negative emotions, or negative reactivity, has been related to both internalizing and externalizing symptoms (Muris, 2006). Negative reactivity is a multifaceted construct capturing heterogeneous dimensions that may differentially confer risk for psychopathology. Specifically, evidence suggests that high fear reactivity may be related to risk for internalizing symptoms, while frustration reactivity appears more strongly related to externalizing symptoms, though may be a more pervasive risk for both symptom types (Kagan, Snidman, Zentner, & Peterson, 1999; Rothbart, 2007). In contrast, effortful control, one component of self-regulation, has been associated with reduced symptoms of psychopathology

and is defined as the capacity to inhibit a dominant response in favor of a subdominant, more adaptive behavior (Eisenberg et al., 2001). This regulatory component of temperament may, therefore, serve as a moderator of the relation between negative reactivity and children's symptoms. While temperament-by-temperament interactions appear very likely, particularly between reactive and regulatory components, little research has examined interactions between these factors in predicting growth of children's internalizing and externalizing symptoms over time. Further, very few studies have examined fear and frustration as independent components of negative reactivity within the same model.

The current study tested effortful control as a moderator of both fear and frustration on children's internalizing and externalizing symptoms to allow for differential effects of components of reactivity on symptom type. Additionally, longitudinal data was used to examine how the development of effortful control moderates growth between reactivity and symptoms over time. A community based sample of 306 children and their female primary caregivers were assessed across four waves of data when the children were 3 to 5 years old. Multiple assessment methods were implemented, including physiological and observed measures, neuropsychological assessment, and mother-report questionnaire data. The results suggest a complex pattern of interactions between temperament dimensions predicting trajectories of symptom growth. Specifically, frustration reactivity and initial effortful control predicted growth in internalizing and externalizing symptoms, whereas, fear reactivity interacted with both initial levels and growth in effortful control to predict externalizing symptoms only. Overall, these findings point to potentially different pathways to risk for internalizing and externalizing symptoms and highlight potential targets for treatment based on temperamental vulnerability.

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ACKNOWLEDGEMENTS

I wish to thank the many mentors, individuals, and organizations that supported this research. To my advisor, Dr. Liliana Lengua, I would like to express my sincere appreciation for her invaluable guidance, teaching, patience and encouragement throughout my graduate school career. She has served as an incredible role model, helping to expand my thinking and persistently pursue my passions. I would like to acknowledge my supervisory committee members, Drs. Kevin King, Lynn Katz, and James Mazza for their support, constructive suggestions, and review of this dissertation, as well as Dr. Mark Pettet for providing support in processing the physiological data vital to this study. Additionally, I thank my fellow lab members and colleagues, Maureen Zalewski, Cara Kiff, Stephanie Thompson, Eika Ruberry, Melanie Klein, and Kristina Ponischil, as well as a team of talented undergraduate research assistants without whom this research would not have been possible. I also wish to express gratitude to my family and friends for their unwavering support and ability to keep me smiling throughout this process. Finally, I would like to recognize the time and willingness of the families who elected to participate in this study and for their contribution to improving our understanding of child development.

Funding for this research was provided by grants from the National Institute of Mental Health to Lyndsey Moran (F31MH086171) and the National Institute of Child Health and Development awarded to Liliana Lengua (R01 HD54465).

DEDICATION

To my parents, Robert and Lynda Moran,
for instilling in me a lifelong love of learning and a dedication to helping others.

Chapter 1. INTRODUCTION

It is estimated in the United States that 9-12% of preschool children (aged 2-5 years) will demonstrate serious emotional disturbances resulting in functional impairment, while as many as 25% will demonstrate more general problem behaviors (Egger & Angold, 2006; Merikangas & He, 2014; Perou et al., 2013). Additionally, evidence suggests possible continuity between preschool behavioral and emotional problems, later childhood psychopathology, and adult psychiatric disorders (Caspi, Moffitt, Newman, & Silva, 1996; Mesman & Koot, 2001). Thus, problem behaviors that emerge in preschool may set individuals on trajectories of continuing or worsening problems across the lifespan. Understanding the biological and temperamental underpinnings of psychopathology is critical for elucidating developmental pathways to maladjustment. Research on the development of psychopathology in children has often focused on individual differences in temperament, which have been found to impact a wide range of emotions and behaviors (Rothbart & Bates, 2006).

1.1 TEMPERAMENT

Temperament is often defined as biologically based individual differences in reactivity of affect and behavior and the regulation of these responses that, while relatively stable, develop with maturation and are influenced by the environment (Rothbart, Ahadi, & Hershey, 1994). Although there are a number of theoretical approaches to conceptualizing temperament (Mervielde & DePauw, 2012), the current study focuses on the psychobiological approach developed by Rothbart and colleagues, which represents the most current understanding of the psychophysiological underpinnings of children's temperament, and is also the model most frequently used in contemporary studies of temperament (Rothbart, 1981; Rothbart & Ahadi,

1994; Rothbart & Bates, 2006). This model classifies temperament based on underlying neural systems related to motivation, attention, and their interactions. Broadly, motivational systems serve appetitive, defensive, and nurturant needs of an individual. These systems are based within the limbic circuits of the brain, which receive perceptual inputs from the thalamus and conceptual inputs from the cortex, and promote adaptive responses to these inputs through connections with motor, autonomic, and attentional mechanisms in the brainstem (Derryberry & Rothbart, 1997). Specifically, four motivational systems (the appetitive system, the defensive/fearful motivational system, the frustrative and aggressive behavior system, and the affiliative/nurturant system) drive the behavioral and emotional aspects of personality. Although these motivational systems play a role in regulating attention and perception, they may also alternatively be regulated by attentional systems. Derryberry & Rothbart (1997) delineate three attentional systems that serve to maintain and adjust alertness (the vigilance system), flexibly shift attention (posterior attentional system), and maintain behavior in accordance with a goal (anterior attention system or executive attention).

Temperament, therefore, can be viewed as resulting from interactions between the strength/sensitivity of competing appetitive and defensive motivational systems (i.e., reactivity) and the regulatory potency of executive attention (i.e., effortful control; Rothbart & Derryberry, 1981). In previous research, both reactive and regulatory components of temperament have been identified as important predictors of children's adjustment, including both positive adjustment and symptoms of psychopathology (Lengua, 2002; Liew, Eisenberg, & Reiser, 2004; Muris & Ollendick, 2005). Accounting for relations between different temperament characteristics, both additive and interactive, in predicting child outcomes is particularly important, as the implication a given temperament trait has on psychosocial adjustment may largely depend on other traits

present in the individual (Rothbart & Bates, 2006). Additionally, interactions between the propensity for emotional reactivity and the ability to regulate this reactivity seems quite germane in relation to children's adjustment, as symptoms of psychopathology are frequently associated with increased negative emotionality and uncontrolled behaviors (Eisenberg et al., 1996).

1.2 NEGATIVE REACTIVITY

Negative reactivity, one aspect of emotional reactivity, describes a child's individual predisposition to experience negative emotions, including the threshold, intensity, and duration of emotions (Rettew & McKee, 2005). Specifically, temperamental reactivity may reflect discrete and mutually inhibitory affective motivational systems, including the behavioral inhibition system (BIS), behavioral activation system (BAS), and the fight/flight system (F/FLS) that drive the characteristic and intensity of reactivity in response to motivations related to reward, novelty, punishment, and threat (Derryberry & Rothbart, 1997). Additionally, research examining behavioral assessments of various dimensions of temperament found non-significant intercorrelations between the dimensions subsumed under the negative reactivity composite (Gagne, Van Hulle, Aksan, Essex, & Goldsmith, 2011). Taken together, this suggests that there may be added value to examining these dimensions independently. Rothbart's model of negative reactivity includes five components: fear, anger/frustration, discomfort, sadness, and low soothability (Mervielde & De Pauw, 2012). However, several of these components have not been extensively studied, have not consistently related to adjustment, and are not relevant across all developmental periods. The current study, therefore, focused on the two most commonly and consistently studied components, reactivity to fear and frustration.

Typically, reactivity to negative emotions occurs within the context of threat, is accompanied by increased autonomic arousal, and is perceived as either fear if the threat is to be

avoided or frustration in the case of approach (Rothbart, Derryberry, & Posner, 1994). Higher negative reactivity has been related to increased adjustment problems in children, including both internalizing and externalizing symptoms (Eisenberg et al., 1996; Lengua, 2002; Lengua, 2006). Although negative reactivity is often studied as an aggregated construct, fear and frustration appear to result from differing neural connections to the amygdala (specifically hippocampal and hypothalamic projections, respectively) and can be differentially recognized even in infancy (Rothbart, Derryberry et al., 1994). While very few studies have simultaneously included both fear and frustration as independent components, limited previous research has shown unique effects of fear and frustration reactivity on adjustment (Lengua, 2008; Moran, Lengua, & Zalewski, 2012; Rothbart, Ahadi et al., 1994).

1.2.1 *Fear Reactivity*

Fear reactivity, synonymous with the defensive/fearful motivation system of temperament, describes the propensity to experience negative affect, inhibition, or withdrawal in response to novel or challenging situations, as well as reflects a degree of sensitivity to punishment (Derryberry & Rothbart, 1997). Underlying these behavioral expressions are neural circuits that translate threat cues from the environment into behavior; often described as the behavioral inhibition system (BIS; Rothbart & Jones, 1998). Specifically, sensory input from the environment associated with nonreward, punishment or novelty passes from the thalamus through direct connections to the amygdala, while projections from the amygdala to brain stem cell groups result in modulation of autonomic and somatic responding typical of fear reactions.

Additionally, connections between the BIS and the autonomic nervous system (ANS) result in increased sympathetic activity, which implies that peripheral measures of activation, particularly when assessed in the context of a fear eliciting stimuli, may reflect individual

differences in fear reactivity (Fowles, 1980). One such peripheral measure of sympathetic nervous system activity is electrodermal activity (EDA). EDA, also described as galvanic skin response or skin conductance response, is a method of measuring the electrical conductance of the skin, which varies with its moisture level. Sweat gland secretory cells in the hypodermis are innervated by the sympathetic nervous system (SNS). With increased arousal of the SNS, these sweat ducts fill and release sweat onto the epidermis, or surface of the skin. The epidermis usually has a high resistance to electrical current, but as sweat, a relatively good electrical conductor, emerges, the electrical conductance of the skin improves. Measuring changes in electrical conductance of the skin across time becomes a proxy for assessment of SNS activation and within the context of tasks known to reliably elicit fear reactions, a measure of fear reactivity (Boucsein, 2012). Multiple phenomena captured by EDA have been explored in relation to SNS activation, including tonic measures of the level of skin conductance in response-free recording intervals (i.e., electrodermal level, EDL) and as the number or nature of phasic reactions to a stimulus in a given time window (i.e., electrodermal response or reaction, EDR). Comparing either mean EDL or rate or amplitude of EDR during a rest period to these same indices during a period in which fear is elicited produces an index of reactivity to fear over baseline activation, with higher electrodermal reactivity over baseline reflecting higher fear reactivity. Additionally, observation of EDA in arousing states specifically accompanied by negative emotions and characterized by the presence of fear- or punishment-relevant stimuli further supports associations between EDA and BIS activity and thereby the use of EDA as an index of temperamental fear (Boucsein, 2012; Fowles, 1980).

Temperamental fear has frequently been examined as a vulnerability factor relating to the development of later psychopathology. Specifically, fear reactivity has been associated with

children's internalizing, as opposed to externalizing, symptoms, with higher fear relating to higher levels and greater severity of problems (Hayward, Killen, Kraemer, & Taylor, 1998; Hill-Soderlund & Braungart-Rieker, 2008; Oldehinkel, Hartman, De Winter, Veenstra, & Ormel, 2004; Rothbart, 2007; Rydell, Berlin, & Bohlin, 2003). Further supporting the role of fear in internalizing symptoms, a large body of research has explored relations between fear and the development of later anxiety (Goldsmith & Lemery, 2000; Kagan & Fox, 2006), demonstrated associations between fear in children as young as infancy to toddlerhood, and related fear to symptoms both concurrently and longitudinally through adolescence (Kagan et al., 1999; Kagan, Snidman, Kahn, & Towsley, 2007; Lemery, 1999).

Although research has consistently shown higher fear reactivity to relate to aspects of maladjustment, fear also relates to markers of positive adjustment, such as lower aggression and higher rates of empathy. For example, fear reactivity in infancy was positively correlated with later empathy, guilt and shame, and negatively with aggression (Rothbart, Ahadi et al., 1994), as well as associated with higher prosocial behavior in preschoolers (Rydell et al., 2003).

Associations between fear and prosocial behaviors potentially reflect the inhibitory influence of fear on aggression. Additionally, as fear reactivity is synonymous with sensitivity to punishment and arousal of the behavioral inhibition system, fearful children are more likely to be responsive to social punishments and inhibit punishable behaviors, thus fostering children's socialization. (Rothbart & Bates, 1998). Fear reactivity has also been found to relate to the development of conscience, with more fearful children presumably responding with optimal arousal and discomfort to parental cues indicating wrongdoing or disappointment (Fowles & Kochanska, 2000; Kochanska, 1991; Kochanska, 1997; Rothbart, Ahadi, & Evans, 2000).

These results have led many researchers to view fear reactivity as a protective factor, particularly for the development of externalizing disorders and antisocial behaviors (Keiley, Lofthouse, Bates, Dodge, & Pettit, 2003), which has led to examination of the impact of low fear reactivity or fearlessness on adjustment. Theoretically, children relatively low on fear reactivity may more quickly approach unfamiliar situations or people and may test limits with caregivers more frequently as a result of diminished fear of punishment and consequences to misbehavior (Shaw, Gilliom, Ingoldsby, & Nagin, 2003). A number of prospective studies have supported this hypothesis, finding that fearless children are at higher risk for developing conduct problems in middle childhood and adolescence (Raine, Reynolds, Venables, Mednick, & Farrington, 1998; Schwartz, Snidman, & Kagan, 1996; Shaw et al., 2003).

Overall, the current literature strongly supports high fear reactivity as increasing vulnerability for internalizing problems, particularly anxiety, while conversely also relating to positive adjustment such as prosocial behaviors, conscience, and reduced vulnerability to externalizing problems, which appear more likely in the context of fearlessness. Connections between the amygdala (emotion processing) and the anterior cingulate cortex (ACC; attention control), which is also impacted by social learning and plays a role in the development of conscience, may, in part, account for associations between fear and positive adjustment (Rothbart, Ahadi et al., 1994; Kochanska, 1991). These mixed results appear to allude to a possible curvilinear relation between fear and children's development with risk for different types of psychopathology conferred at either extreme of reactivity.

1.2.2

Frustration Reactivity

Frustration reactivity, also described as anger or irritability and equivalent to the frustrative and aggressive behavior system (Derryberry & Rothbart, 1997), is thought of as distress to

limitations and represents an affective response to experiences of failure, having a goal blocked or removed, or to the interruption of an ongoing task (Rothbart, Derryberry et al., 1994). Specifically, frustration is seen as a response to unconditioned aversive stimuli resulting in the production of defensive or aggressive behaviors, as opposed to inhibition or escape seen in conjunction with fear responses (Gray & McNaughton, 2000). In the Fight/Flight system of motivational theory, frustration presents as aggressive and defensive behaviors produced in response to unconditioned punishment or non-reward processed by interconnections between the amygdala, hypothalamus, regions of the midbrain, and somatic and motor effector nuclei of the lower brain stem (Gray, 1982; Rothbart, Derryberry et al., 1994). Prior research has also highlighted that different underlying neural pathways exist based on the motivation behind the specific type of frustration or anger. Anger that functions as self-defense appears to activate similar circuits as fear (e.g., the amygdala), whereas anger motivated by competition for resources, removing a frustrating obstacle, and offensive aggression appears to rely on a monoamine dopamine system (Blanchard & Takahashi, 1988; Lawrence & Calder, 2004; Rothbart & Bates, 2006). This latter type of frustration is additionally linked to appetitive and reward seeking behaviors, which suggests that the behavioral activation system (BAS) of reward and punishment sensitivity may also play a role (Deater-Deckard & Wang, 2012; Depue & Iacono, 1989). These varying pathways suggest there may be heterogeneity with regard to the source, function, and outcome of different types of frustration.

Similar to fear, individual differences in reactivity within these pathways can theoretically be measured through their connection to the autonomic nervous system using peripheral physiological assessments. In particular, heart rate reactivity, a nonspecific indicator of arousal, has been used in conjunction with frustration eliciting tasks as a proxy for frustration

reactivity in previous research (Panee & Ballard, 2002; Zalewski, Lengua, Wilson, Trancik, & Bazinet, 2011). Specifically, increases in heart rate over resting rates suggest higher reactivity to frustration during these tasks. Additionally, Fowles (1980), in integrating numerous animal and human psychophysiological studies, concluded that heart rate was potentially a more accurate index of BAS activity than observable behavior, suggesting assessment through physiological measures may more precisely capture individual differences in children's frustration reactivity.

Although frustration reactivity has a number of adaptive functions, including mobilizing physical and psychological resources to defend against potential threats, overcome obstacles, and persevere in the face of adversity, a number of studies have found relations between high frustration and maladaptive outcomes, particularly an increased risk of externalizing problems (Cole, Teti, & Zahn-Waxler, 2003; Deater-Deckard et al., 2010; Eisenberg et al., 2001; Gilliom, Shaw, Beck, Schonberg, & Lukon, 2002; Lemerise & Harper, 2010; Lemery, Essex, & Smider, 2002; Lengua, 2003; Oldehinkel, Hartman, Ferdinand, Verhulst, & Ormel, 2007; Rydell et al., 2003; Zhou, Lengua, & Wang, 2009). Additionally, mirroring the distinct pathways underlying frustration related to defensive behaviors (i.e., Fight/Flight system) versus reward motivated behaviors (i.e., BAS), distinct types of aggressive behaviors appear related to externalizing symptoms in children. Specifically, contrasts have been made between reactive aggression, reflecting defensive responses to threat and over-activation of emotional responding, and proactive aggression, reflecting more coercive and deliberate aggression used to obtain a desired goal (Connor, Steingard, Cunningham, Anderson, & Melloni, 2004). Children demonstrating more reactive aggression, likely reflecting higher reactivity of the Fight/Flight system, tend to have higher rates of comorbid anxiety, impulsivity and general distress, as well as higher autonomic nervous system arousal. In contrast, children engaging in more proactive aggression,

potentially reflecting higher BAS reactivity, tend to demonstrate more controlled behavior, are sometimes described as callous-unemotional, and are at heightened risk for severe psychopathology in adulthood (Dierckx et al., 2014).

Unlike fear reactivity, frustration may be a more widespread predictor of problems, relating to social difficulties and internalizing symptoms as well (Eisenberg et. al, 2001; Kiff, Lengua & Bush, 2011; Rothbart, 2007). For instance, preschool children expressing more frustration, as assessed by observed behavior as well as parent and teacher ratings, were more frequently rejected or victimized by their peers (Hanish, Eisenberg, Fabes, Spinrad, Ryan, & Schmidt, 2004), potentially leading to symptoms of depression or anxiety. This relation, including peer rejection and social withdrawal, was particular true for children demonstrating behaviors associated with more reactive aggression, potentially stemming from frustration reactivity related to defensive systems, as opposed to proactive, or more reward motivated, aggression (Hubbard et al., 2002). Further, research examining adolescents and adults suggests that anger and irritability play a role in the etiology of depression and anxiety disorders. Higher levels of anger intensified symptoms of both depression and anxiety (Deater-Deckard & Wang, 2012) and was associated with the intensity of depression symptoms, presence of comorbid anxiety, and suicidality (Perlis et al., 2009; Riley, Treiber, & Woods, 1989). Although the research examining internalizing symptoms is more limited, particularly in younger age groups, frustration reactivity may act as a risk factor for internalizing disorders or potentially increase the severity of internalizing symptoms. Despite the fact that relations between frustration and externalizing problems are much more prevalent and consistent in the literature, these results taken together suggest that frustration may be a predictor of severity of maladjustment in general, and may serve as a pervasive risk factor across problem types.

To summarize, research examining direct effects of negative reactivity on adjustment suggest that fear reactivity, and possibly frustration reactivity, may relate to increased risk for internalizing symptoms. Externalizing symptoms may relate strongly with frustration reactivity, while fear reactivity may serve as a protective factor against development of externalizing symptoms.

1.3 EFFORTFUL CONTROL

Examination of the role of self-regulation, or effortful control, as moderating the effects of reactivity may help to clarify the developmental pathways between reactivity and psychopathology. Effortful control describes the component of self-regulation particularly associated with voluntary regulation and, specifically, the ability to purposefully regulate behavior, to resist interference, or to suppress a dominant response in favor of a subdominant response (Murray & Kochanska, 2002; Bjorklund & Kipp, 1996). Effortful control first emerges in nascent forms between 6 and 12 months of age when maturation of the frontal lobe occurs, including development of frontal structures underlying executive attention and connections with parietal structures involved in orienting and sustaining attention (Ruff & Rothbart, 1996). Development of effortful control progresses slowly across the first and second year of life, with subsequent rapid development during the preschool years (Rothbart et al., 2000; Rothbart, Ellis, Rueda, & Posner, 2003). The ability to effortfully inhibit a prepotent behavioral or emotional response and subsequently engage in an adapted or entirely different response requires the recruitment of multiple self-regulatory skills. Thus, effortful control is a multifaceted construct, which incorporates aspects of executive attention, including attention shifting and sustained attention, and conscious behavioral and cognitive inhibitory control, including both inhibiting

and activating responses as needed (Davis, Bruce, & Gunnar, 2002; Liew et al., 2004; Rueda, 2012).

Effortful control is generally thought of as a protective factor, fostering positive adjustment and is associated with resiliency and lower externalizing and internalizing symptoms (Eisenberg et al., 2004; Lengua, 2006; Lengua, Bush, Long, Kovacs, & Trancik, 2008; Murray & Kochanska, 2002; Rothbart & Bates, 2006). More specifically, deficits in effortful control are consistently associated with greater symptoms of anxiety (Eisenberg, et. al., 2009; Klein, Dyson, Kujawa, & Kotov, 2012; Muris, de Jong, & Engelen, 2004; Muris, van der Pennen, Sigmond, & Mayer, 2008), although inconsistently linked with symptoms specific to depression in children and adolescents (Loukas & Robinson, 2004; Muris et. al., 2008). Additionally, negative associations between effortful control and symptoms of ADHD, conduct disorder, drug use, delinquency, and aggression have been established (Eisenberg et al., 2001, 2009; Frick, & Morris, 2004; Lengua, 2003; Murray & Kochanska, 2002; Olson, Sameroff, Kerr, Lopez, & Wellman, 2005; Valiente et al., 2003; Wong et al., 2006). Deficits in self-regulation may directly contribute to disruptive behaviors by causing difficulties in managing challenges faced during development but may also indirectly contribute to symptom growth by limiting children's opportunities to learn adaptive coping skills or reducing responsiveness to redirection or consequences (Calkins & Keane, 2009).

Understanding the neurobiology thought to underlie effortful control abilities highlights the important role effortful control may play in regulating affect and behavior and promoting positive adjustment. Specifically, effortful control is thought to reflect activation of the executive attention network, which includes frontal neural substrates such as the anterior cingulate cortex (ACC) and lateral prefrontal areas, and is synonymous with the anterior attention system in

Rothbart's psychobiological approach to temperament (Petersen, & Posner, 2012; Posner, & Petersen, 1990). This network has been shown to activate during situations that require coordination of action (particularly novel or dangerous contexts), detection and correction of errors, overcoming automatic responses, and subsequently plays an important role in controlling thoughts, emotions, and behavior (Posner & DiGirolamo, 1998). Further, evidence from imaging studies suggests that while activation of dorsal ACC occurs in contexts where monitoring and resolution of a conflict in responding is needed, likely relating to effortful control, activation of rostral and ventral ACC relate to appraisal of emotion information and regulation of emotion responses (Bush, Luu, & Posner, 2000). Thus, the ACC may play an important role in the integration of attention processing and emotion relevant input from the amygdala. Through connections with sensory, motor, and affective systems, the ACC has the potential to direct attention, integrate information across a variety of systems, and influence subsequent behavior. These findings as a whole support the role of the executive attention network, and the ACC more specifically, as underlying effortful control as it serves to monitor behavior, inhibit ineffective and activate adaptive behavioral and emotional responses. Coordination of these systems allows a child to effectively direct and control affect and behavior, suggesting effortful control is a plausible moderator of the effect of negative reactivity on children's adjustment. The development of strong effortful control abilities may, therefore, mitigate the relation between high reactivity and the development of symptoms of psychopathology.

1.4 INTERACTIONS BETWEEN REACTIVITY AND REGULATION

Although direct relations between reactivity, regulation, and child adjustment have been extensively studied, interactions between temperament characteristics are rarely studied. Despite

less empirical attention, interactions between children's temperamental propensity for negative reactivity and the ability to regulate this reactivity seem highly likely (Eisenberg et al., 1996). Specifically, high negative reactivity may put children at risk, but self-regulatory abilities may moderate this relation, with high effortful control providing children with the capability to alter or cope with emotionality. In contrast, children with low effortful control may be inflexible or ineffectual in their ability to deal with stressors that provoke negative emotion leading to less adaptive strategies such as avoidance or aggression (Muris & Ollendick, 2005).

1.4.1 *Internalizing Symptoms*

Internalizing symptoms include features such as high anxiety or depression, maladaptive models of emotion regulation, and behavioral inhibition. Subsequently, fear reactivity, in particular, is hypothesized to be a specific risk factor for higher internalizing problems with effortful control viewed as a potential buffer that reduces this association. However, a number of researchers have also hypothesized that very high levels of effortful control may alternatively be a risk factor for internalizing problems, particularly that high inhibitory control may actually exacerbate fear reactivity leading to worsening problems. Counter to this hypothesis, a number of studies spanning infancy through adolescence have found significant interactions between fear reactivity and effortful control predicting internalizing problems, such that high levels of regulation reduce or even eliminate the positive association between fear and internalizing symptoms and support the role of effortful control as a protective factor (Crockenberg & Leerkes, 2006; Muris, 2006; Oldehinkel et al., 2007; Sportel, Nauta, de Hullu, de Jong, Hartman, 2011; White, McDermott, Degnan, Henderson, & Fox, 2011). In contrast, two additional studies did not find significant interactions between fear and effortful control predicting internalizing symptoms (Moran et al., 2013; Rydell et al., 2003).

Despite direct effects between frustration and internalizing symptoms, interactions between frustration and effortful control in predicting internalizing problems in childhood have generally not been supported (Eisenberg et al., 2004; Kim & Deater-Deckard, 2011; Marcynyszyn, 2007; Moran et al., 2013; Oldehinkel et al., 2007; Rydell et al., 2003).

1.4.2 *Externalizing Symptoms*

Externalizing symptoms are characterized, in part, by increased aggression, conduct problems, and hyperactivity. These characteristic symptoms may result from deficits in the regulation of anger and the ability to control behaviors, and may show interactive effects between high frustration and deficits in effortful control. Significant interactions between negative reactivity and self-regulation (broadly) have been reported, with high levels of regulation acting as a buffer against the effects of both moderate and high negative emotionality (Eisenberg et al., 2009; Muris, 2006). There is also growing evidence supporting the role of effortful control as a moderator of the relation between frustration reactivity and externalizing problems, with fairly consistent results suggesting moderate to high levels of effortful control function primarily as a protective factor, as opposed to deficits in effortful control functioning as an exacerbating risk factor. For example, the relation between frustration and externalizing problems was found to be significant only at low levels of effortful control suggesting that moderate to high effortful control buffers children against the influences of high frustration on externalizing problems (Degnan, Calkins, Keane, & Hill-Soderlund, 2008; Diener & Kim, 2004; Eisenberg, Ma, Chang, Zhou, West, & Aiken, 2007; Eisenberg et al., 2004; Moran et al., 2013; Oldehinkel et al., 2007). However, a number of studies have also found nonsignificant interactions effects, and nonsignificant effects emerge more frequently when maternal- or parent-reported frustration

reactivity was used (Eisenberg et al., 2007; Eisenberg et al., 2004; Marcynyszyn, 2007; Moran et al., 2013; Olson et al., 2005; Rydell et al., 2003).

Research examining relations between externalizing symptoms and interactions specifically between fear and effortful control is limited and generally non-conclusive. Three studies found the interaction between fear reactivity and various measures of regulation, including emotion regulation, attention control, and effortful control, to be a nonsignificant predictor of externalizing behavior problems, which mirrors the largely nonsignificant direct effects of fear on externalizing problems that have been found (Belskey, Friedman, & Hsieh, 2001; Oldehinkel et al., 2007; Rydell et al., 2003). In contrast, significant interactions were found suggesting inhibitory control served to reduce the risk of externalizing problems for adolescents with low levels of fearfulness (Pardini, Lochman, & Wells, 2004), whereas effortful control mitigated relations between high fear reactivity and preschoolers' externalizing behavior problems (Moran et al., 2013). This limited research may suggest that effortful control is acting as a moderator of a curvilinear relation between fear reactivity and externalizing problems with extreme levels of fear reactivity, either high or low, potentially putting children at risk for externalizing behaviors only when higher (i.e., above average) levels of effortful control are not present. Specifically, children with low effortful control and low fear may demonstrate callous-unemotional traits and be more prone to engaging in proactive forms of aggression. In contrast, children with low effortful control and high fear may reflect children with unchecked emotion reactivity who are more likely to engage in reactive forms of aggression.

While these findings offer preliminary support to the hypothesis that effortful control will moderate relations between negative reactivity and both internalizing and externalizing symptoms, specific effects of fear and frustration and the nature of these interactions modeled

over time remain to be determined. Additionally, it is important to note limitations in the methodology of the current literature that may impact our understanding of interactions between these dimensions of temperament. Specifically, a large majority of existing studies rely on single-method designs (i.e., mother reported temperament and outcomes) with few including observational measures of temperament, and almost none assessing reactivity using physiological indices. In particular, it may be important to include physiological indicators of emotional arousal when testing moderation by effortful control as both laboratory observations and maternal reports of emotion reactivity capture only observable behavior. Observable behavior can be considered as expression of internal experiences of emotion reactivity that have been filtered through self regulatory processes, which may shift expression to better suite larger goals. Behaviors that are observable to others naturally occur downstream of effortful control and, therefore, use of these methods to assess reactivity likely confounds reactivity with regulation. Although not without flaws, physiological indices of reactivity are more likely to be assessed upstream of regulation and may represent a more proximal and pure measure of CNS substrates of temperamental reactivity than either questionnaire or observed measures (Brenner, Beauchaine, & Sylvers, 2005).

1.5 CURRENT STUDY

Despite having important implications for understanding development of psychopathology in children, few studies explore moderated linkages between temperament characteristics. The current study adds to the literature by clarifying the differential effects of fear and frustration on internalizing and externalizing symptoms and explores relations across time by testing growth in children's negative reactivity and symptoms as moderated by the development of effortful control. Specifically, a longitudinal design was used to examine interactions between reactivity

and initial levels of regulation, as well as how growth in these factors interact to predict trajectories of symptom growth during the preschool years, a developmental period when effortful control rapidly matures and symptoms emerge.

Examination of growth as opposed to solely levels of both temperament characteristics and symptoms of psychopathology allows for a better understanding of these relations within the context of development. Although temperament is considered to be relatively stable across the lifespan, it is also understood that both maturation and environmental factors may shift and shape temperament at different points (Rothbart & Bates, 2006). This suggests that, in addition to the expected rapid growth of effortful control across the preschool years, reactivity may actually change at this age as well. It is thus relevant to understand if and how much additional risk is conferred not just by levels of reactivity, but also increases or decreases in reactivity.

Additionally, by testing growth in effortful control as a moderator, the current study assessed not just the impact of levels of regulation at particular points in development, but also how gains in regulation in developmentally appropriate or inappropriate ways related to children's risk and resilience. Capturing the impact of both levels and growth of effortful control on the relation between reactivity and psychopathology may also help to clarify the timing of effects and subsequently inform the timing of possible interventions.

This research is unique in that few studies have explored interactions between temperament characteristics and even fewer have simultaneously tested individual components of reactivity. Further, no studies to date have tested these relations across time using developmental growth models nor examined these relations using multi-method assessments and physiological indicators of reactivity. In order to address these gaps in the literature, the current study used distinct measurement methods by assessing reactivity using physiological measures

(EDL and heart rate reactivity), observed tasks, and questionnaire measures to examine the following specific aims:

Specific Aim 1: Fear and frustration reactivity were tested as predictors of trajectories of internalizing and externalizing psychopathology, and expected to be particularly predictive of symptoms when children had below average effortful control.

Hypothesis 1. Fear reactivity was expected to be a specific risk factor for growth in internalizing symptoms, whereas frustration reactivity would relate to both internalizing and, more strongly, to externalizing symptoms.

Hypothesis 2. Initial effortful control was expected to moderate relations between initial reactivity and levels and growth of symptoms.

Hypothesis 2.1. High initial effortful control would moderate high initial fear reactivity, relating to fewer symptoms and less growth in internalizing over time.

Hypothesis 2.2. High initial effortful control would moderate high initial frustration reactivity, resulting in fewer symptoms and less growth in symptoms over time, regardless of symptom type.

Hypothesis 3. Growth in effortful control was expected to moderate relations between initial reactivity and symptoms levels and growth with greater increases in effortful control relating to reduced symptoms even if initial effortful control was low.

Hypothesis 3.1. Large growth in effortful control would result in lower levels and less growth in internalizing symptoms for children with high initial fear reactivity.

Hypothesis 3.2. Large growth in effortful control would result in lower levels and less growth in both symptom types for children with high initial frustration reactivity.

Hypothesis 4. Initial effortful control was expected to moderate the relation between growth in reactivity and final levels and growth in symptoms.

Hypothesis 4.1. High initial effortful control would moderate increasing fear reactivity, relating to fewer symptoms and less growth in internalizing over time.

Hypothesis 4.2. High initial effortful control would moderate increasing frustration reactivity, resulting in fewer symptoms and less growth in symptoms over time, regardless of symptom type.

Hypothesis 5. Growth in effortful control was expected to moderate the relation between increasing emotion reactivity and worsening symptoms. Children who were more reactive over time but had increasing effortful control would show reduced symptom growth even if initial effortful control was low.

Hypothesis 5.1. Growth in effortful control would uncouple the relation between increasing fear reactivity and internalizing symptom growth resulting in smaller increases in symptoms over time.

Hypothesis 5.2. Growth in effortful control would uncouple the relation between increasing frustration reactivity and externalizing, as well as internalizing, symptom growth resulting in smaller increases in symptoms over time.

Specific Aim 2: As prior research has suggested that highly fearful children exhibit fewer externalizing symptoms, fear reactivity was tested as a protective factor against growth in externalizing symptoms and effortful control was tested as a moderator of this relation.

Hypothesis 6. High fear reactivity was expected to relate to lower externalizing symptoms only when effortful control was above average to average.

Exploratory Aim 1: As children's reactivity was assessed by physiological measures, mother-report, and observed behaviors, the feasibility of combining these three different assessments into a single index to be used for all analyses was tested using Confirmatory Factor Analysis. If results suggested distinct measures of reactivity could not be aggregated, only the physiological indices would be used for all following analyses.

Chapter 2. METHOD

2.1 PARTICIPANTS

The current study is part of a larger study conducted by Dr. Lengua (NICHD #5R01 HD54465-01) examining parenting, family adversity and low income in relation to child temperament and adjustment in preschoolers. Participants are a community-based sample of 306 children (50% female) and their mothers who were assessed across 4 equally spaced waves of data occurring every 9 months. Time 1 assessments began when children were 36-months ($M = 36.67$ mos., $SD = 0.89$, $Range = 35.52 - 40.34$). Children were 45-months at Time 2 ($M = 46.02$ mos., $SD = 1.28$, $Range = 43.56 - 51.29$), 54-months at Time 3 ($M = 55.08$ mos., $SD = 1.13$, $Range = 51.71 - 59.56$), and, finally, at Time 4, children were 63-months old ($M = 63.92$ mos., $SD = 1.49$, $Range = 54.70 - 76.19$).

Families were recruited from the community using multiple methods. The majority of families (68%) were recruited from the University of Washington Subject Pool, a database of potential participants made available to researchers at the university for a fee. After giving birth at the University of Washington Medical Center, mothers were approached by university staff and voluntarily gave consent to be contacted for future research studies. The remaining families (32%) were recruited from a number of public- and privately-funded organizations that were

initially informed of the study through a letter outlining the study goals. Interested sites, including preschools, co-ops, daycares, libraries, health clinics, and charitable agencies, were given further information over the phone and provided with Family Contact Information forms to distribute to mothers of approximately 3-year-old children. Families who completed and returned the forms to the study coordinator were contacted for potential inclusion in the study.

Additionally, as an incentive to participate, agencies and organizations were provided with an honorarium based on the response rate of referred families (e.g., \$100 if $\geq 90\%$ response rate, \$75 for 75% response rate, or \$50 for 50% response rate).

Only one child in the target age range per family was permitted to participate and families were required to live within King County, WA. Children with developmental disabilities (except learning disabilities) and families not fluent in English were excluded from the study to ensure adequate comprehension of the procedures. A female primary caregiver was required to participate. Altogether, 1,459 families were initially contacted for prospective inclusion in the study, of which 318 families were scheduled for initial visits and 306 completed Time 1 assessments. Of the families who were not included in the Time 1 assessments ($N = 1,141$), 57% were ineligible due to the exclusionary criteria listed above. Additionally, the sample was explicitly recruited to stratify all income categories. To ensure a flat distribution across incomes, families were declined participation if a sufficient number of participants within an income category had already been recruited.

As such, the sample over-represented families in poverty and low income, making this an economically diverse sample. Based on the 2009 federal poverty guidelines, which assesses an income to needs ratio, 29% of the sample fell at or near poverty (at or below 150% of the federal poverty threshold), 28% at low income (below the local median income of \$58K), 25% at middle

income (above the median income to \$100K), and 18% were upper income (above \$100K). As summarized in Table 1, a comparison of family income category by recruitment source showed few differences. Despite the economic diversity of the families, this was a relatively well-educated sample. Mothers' educational attainment included 3% with less than a high school degree, 6% high school graduates, 35% with some college experience, 30% college graduates, and 36% with some or completed graduate degree. Demographic characteristics of the sample reflect the urban area surrounding the university in the Pacific Northwest. Based on maternal report of their children's racial background, the sample consisted of 9% African Americans, 3% Asian Americans, 2% Native Americans, 10% Latino or Hispanic, 64% European Americans, and 12% children with other or multiple backgrounds. Families consisting of two-parent households made up 81% of the sample.

Attrition was low with approximately 95% of participants remaining in the study at all time-points. Of the 306 families assessed at Time 1, only three missed the assessment at Time 2, 14 at Time 3, and 10 at Time 4.

2.2 PROCEDURE

At all time points, mothers and children came to the University of Washington for 2-hour sessions to complete all questionnaire measures, physiological recordings, and observational assessments. After attaining maternal consent and child assent, children were administered the effortful control and emotion-eliciting tasks described below. Tasks taken from the developmental neuropsychological assessment (NEPSY-II; Korkman, Kirk, & Kemp, 1998) were administered first after which baseline heart rate recordings were collected. Children were encouraged using popular cartoon characters to try on electrocardiograph (ECG) leads and a respiration belt. After connecting physiological recording equipment, the experimenter read the

child a neutral story for 3.5 minutes. Experimenters were trained to read in a neutral tone of voice and were instructed not to engage or elicit speech from the child. Throughout collection of all physiological indices, a trained technical experimenter observing the child tasks flagged start and stop times, as well as any notable variation from protocol in order to ensure proper collection and sync recordings with task stimuli presentations. Subsequent to baseline heart rate collections, children completed day–night, bear-dragon, and dimensional change card sort (DCCS) tasks prior to a second physiological baseline recording. The second baseline recording assessed resting skin conductance levels and responses during the reading of another neutral story. To reduce noise, children were encouraged to stay still by placing their hand on a cutout handprint. After one minute of baseline recording, children completed the fear eliciting task. As children needed full dexterity to engage with the stimuli, electrodes collecting skin conductance were removed prior to completing the frustration eliciting task. Finally, gift delay (not used in the current study) and head, toes, knees, shoulders (HTKS) were administered. All tasks completed by the child were conducted by trained experimenters while the child’s mother was in an adjacent room joined by a one-way mirror. Children’s responses to the tasks were later coded by trained undergraduate research assistants, who attended weekly supervision and received more than 90 hours of initial training. Coders were blind to the study aims and unfamiliar with family participants. To assess inter-rater reliability, 20% of all tasks were independently re-scored and intra-class correlations ranged from .72 to .98 at Time 1.

Simultaneous to the child tasks, mothers completed questionnaires in a separate room about family demographics, and children’s temperament and adjustment. In an effort to minimize errors in interpretation and account for variability in parental literacy, trained interviewers read all instructions and items from the questionnaires to participating mothers. Assessment

procedures were identical across time points. Families were compensated \$70 at Time 1, with reimbursement increasing by \$20 at each subsequent assessment.

2.3 MEASURES

2.3.1 *Income*

At Time 1, mothers reported on household income from all sources on a 14-point scale that provided a fine-grained breakdown of income, facilitating identification of families at the federal poverty cutoff (e.g., 1 = \$14,570 or less, 2 = \$14,571–\$18,310, 3 = \$18,311–\$22,050, and so on). The 14-point variable representing the full range of income was used as a covariate in this study. The mean income was 8.75 ($SD = 3.93$, $range = 1.00–14.00$).

2.3.2 *Child Cognitive Ability*

Verbal and nonverbal cognitive ability was assessed by the Comprehension of Instructions and Block Design subtests of the NEPSY-II (Korkman, Kirk, & Kemp, 1998). Comprehension of Instructions, which assesses the child's ability to receive, process, and execute oral instructions, requires the child to follow a series of increasingly more complex behavioral instructions read by the experimenter (e.g., "Point to all the crosses and then to a red circle."). Block Design requires the child to replicate two-dimensional representations of figures using blocks and assesses motor and visual perception. Scores from both tasks were converted to proportion of total possible score and averaged to create a single index of child cognitive ability. Cognitive ability was included as a control variable as intelligence is moderately correlated with executive function and should be accounted for when examining effortful control (Krikorian & Bartok, 1998). The mean at Time 1 was .23 ($SD = .08$, $range = .00–.40$).

2.3.3

Negative Reactivity

Multi-method measures of children's negative reactivity, including mother-report, observed behavior and physiological reactivity to emotion eliciting tasks, were collected to capture differing perspectives on children's temperament.

2.3.3.1 Mother-report of Reactivity

Mother-reported reactivity was assessed using the fear and frustration subscales of the Child Behavior Questionnaire, which was developed for use with children 3–6 years, and has demonstrated adequate internal consistency and validity (Goldsmith & Rothbart, 1991; Rothbart, Ahadi, Hershey, & Fisher, 2001). Mothers responded to items on a scale ranging from 1 (*very false*) to 7 (*very true*). Each scale consisted of 6 items. Sample fear and frustration items include 'My child is afraid of burglars or the boogie man' and 'My child gets frustrated when prevented from doing something s/he wants to do', respectively. Subscale scores for fear and frustration were calculated as the mean weighted sum of the items on a subscale, resulting in range of possible scores from 1 to 7. Internal consistency reliabilities for mother-reported fear and frustration were .66 and .74, respectively.

2.3.3.2 Observed Fear Reactivity

Observed fear reactivity was assessed by observed fear expressions and behaviors to a scary object. Children were prompted to touch a toy spider triggered to jump when the child approached it. Behaviors were coded for intensity of a fear response, ranging from 0 (*no observed response*) to 2 (*obvious, strong response*). Coded behaviors included body motions (e.g., jumping/withdrawing, shaking/fluttering), facial expressions (e.g., widened eyes, tensing face), and vocalizations (e.g., non-language noises, verbal refusals). An overall fear score for

each prompt was assigned based on the number of behaviors coded. In addition, latency to touch the spider after the prompt was given was assessed, with potential latencies ranging from 0 to 5 seconds. Total scores were the average overall rated fear across three prompts that also took into account the latency for the child to touch the spider. At Time 1, internal consistency of the fear scale was .89, and the inter-rater ICC, based on double coding of 20% of cases, was .97.

2.3.3.3 Observed Frustration Reactivity

Observed frustration reactivity was assessed by observed distress to a blocked goal, with specific details of the task varying slightly across time points in an attempt to reduce participants' memory of the task. At Time 1 and Time 3, children were instructed to try to access a desirable toy that had been locked inside a translucent box, despite unknowingly being given incorrect keys. Each child was required to work on the box for 2 minutes without interaction with the experimenter. At Time 2 and Time 4, children were given a sack that had been knotted shut and informed that they could have the prize inside when they untied the sack; however the sack had unknowingly been sewn shut and could not, therefore, be opened. Children were required to work on opening the sack without interaction from the experimenter for 2.5 minutes. At all time points, child behaviors were coded over 30-second epochs for intensity of frustration, ranging from 0 (*no observed response*) to 2 (*obvious, strong response*). Coded behaviors included body motions (e.g., frustrated hand movements, slamming the keys/sack), facial expressions (e.g., furrowed brow, pursed lips), vocalizations (e.g., sighs, grunts), and annoyance directed toward the experimenter (e.g., glancing at experimenter, questions/statements posed to experimenter). Appropriately asking the experimenter for help was not included in scores of frustration. At Time 1, experimenters remained in the room with the child throughout the task due to the child's young age, but were instructed not to respond to or engage with the child. At all remaining time

points, the experimenter left the room after the initial instructions were given. An overall frustration score for each 30-second epoch was assigned based on the number of behaviors coded. Total scores were the average overall rated frustration across all epochs. At Time 1, internal consistency of the frustration scale was .72, and the inter-rater ICC was .79.

2.3.3.4 Physiological Fear Reactivity

Physiological fear reactivity was assessed using indices of skin conductance (SC) measured during the fear-eliciting (i.e., spider) task. SC was measured with two sensors placed on distal phalanges of middle and pointer finger of the child's non-dominant hand with Gel 100 from Biopac applied to the sensors to assure skin contact was maintained. A Biopac MP 100 MSW data collection and amplifier system was used to record both SC and heart rate (HR; described below) directly onto the hard drive of a computer. Both SC and HR data were collected in raw form using Biopac's Acknowledge software 3.9.2 and exported to Matlab version 7 for processing.

SC recordings, collected at 1 kHz sampling rate, were imported into custom Matlab software to calculate mean levels and detect electrodermal responses (EDRs), as well as screen for artifacts. SC sequences were smoothed with a bidirectionally-applied (i.e., zero-phase-distortion) 10th-order Butterworth low-pass filter having 3 dB attenuation at 1.2Hz and then decimated to a new sample rate of 5 Hz. A first-order polynomial was fit to the decimated function and then subtracted to remove the first-order linear trend. The fourier transform of the detrended sequence was passed through an ideal high-pass filter (cutoff 0.0125) and then inverse transformed to recover a band-pass filtered signal (0.0125-1.2Hz) suitable for EDR detection.

EDR peaks were assigned as local maxima exceeding the threshold of 0.05 uMhos above the preceding local minimum, and were also separated from any neighboring EDRs by at least

0.6 seconds (McIntosh, Miller, Shyu, & Hagerman, 1999). The leading edge of each EDR was defined as the time interval spanning the peak and the immediately-preceding local minimum, with the amplitude of the EDR defined as the conductance increase during this leading interval.

To ensure accuracy of acquired data, trained undergraduate research assistants screened all SC data for artifacts. Screeners received specialized training specific to processing SC data and received ongoing, weekly supervision meetings with project staff. Artifacts caused by mechanical disruption of the sensor's contact with children's skin were screened by overlaying line segments depicting the EDRs on the SC waveform. This allowed simultaneous visualization of both EDR magnitude as well as the cumulative drift of SC when multiple EDRs occurred in quick succession. In this view, mechanical artifacts were readily visible as short bursts of high-frequency interference. Any interference peaks incorrectly designated as EDRs by the automatic detection algorithm were manually flagged by screeners and excluded from analysis. After screening and exclusion of artifacts, EDR events were divided by timestamps signaling the associated task and categorized according to any behavioral markers flagged for the episode (i.e., "fear task start", "prompt given", "child talking", etc.). For both the baseline and fear eliciting tasks, the mean and maximum EDR amplitude (μMho) and the EDR rate (number of EDRs divided by duration of assessment episode; Hz) were calculated. Finally, the mean electrodermal level was estimated from the detrended, low-pass filtered SC waveform across the task (μMho). For the current study, only mean electrodermal level was used and will be referred to here forward as EDL.

To create an index of fear reactivity, EDL collected during baseline (described above) was subtracted from EDL collected during the fear eliciting task (i.e. EDL reactivity). Large, positive scores, therefore, reflect increases in electrodermal activity in response to the fear

eliciting stimuli over baseline and arousal of the sympathetic nervous system. Negative scores reflect reduced electrodermal activity during the fear eliciting task and may reflect blunted sympathetic arousal (Hubbard et al., 2002). Prior research has reliably used EDL reactivity in fear eliciting paradigms as a proxy of fear reactivity (Boucsein, 2012; Zalewski et al., 2011). Although electrodermal activity has previously been assessed in both fear and frustration paradigms, results show electrodermal activity to be non-significant during frustration tasks (Holden & Barlow, 1986; Wallien, van Goozen, & Cohen-Kettenis, 2007).

2.3.3.5 Physiological Frustration Reactivity

Physiological frustration reactivity was assessed using children's heart rate (HR) reactivity measured during the frustration-eliciting (i.e., locked box/knotted sack) task. HR is a non-specific indicator of arousal; however, when assessed in the context of a frustration-eliciting task, it is assumed that HR reactivity reflects children's reactivity specific to the emotion elicited by the task (i.e., frustration; Zalewski et al., 2011). HR was measured using a 2-lead electrocardiograph (ECG), purchased from Biopac PRO Lab 3.7.1 (Goleta, CA). Electrodes were placed on the child's right clavicle and lower left abdomen with a ground electrode on the left, upper chest.

ECG R-waves were detected and time stamped using Acqknowledge software (Goleta, CA) and exported into the same suite of custom Matlab software designed to integrate and coordinate analysis of psychophysiological and behavioral observation data. Logs of timestamps marking associated task start and end points, stimuli presentations, and procedural errors are integrated with physiological recordings, allowing the Matlab user interface to extract concurrent time segments of electrophysiological data for signal processing, artifact screening, and statistical analysis. For ECG data, inter-beat interval (IBI) time series marking the peak of each

R-wave were overlaid on the ECG waveforms for each task. Visualization of ECG waveforms allowed the accuracy of the R-wave detection to be verified and provided a method for detecting abnormalities in the R-spikes. Epochs contaminated by large mechanical artifacts or electrical interferences that distorted or obscured the ECG waveforms were selectively excluded from analyses. Artifact-free segments of the corrected waveforms were included in measures of heart rate, calculated as RR interval in beats per minute (bpm). Similar to the SC data, trained undergraduate research assistants, who received specialized training in ECG data and received ongoing supervision, processed each file to edit and clean ECG data prior to HR calculation.

To create an index of frustration reactivity, mean HR collected during baseline (described above) was subtracted from mean HR collected during the frustration eliciting task. Large, positive scores, therefore, reflect increases in HR in response to the frustration eliciting stimuli over baseline and arousal of the autonomic nervous system, whereas negative scores reflect reduced HR during the frustration and potential under-arousal of the autonomic nervous system (Hubbard et al., 2002).

2.3.4 *Effortful Control*

Multiple components of effortful control, including attention regulation and cognitive and behavioral inhibitory control were assessed using six neurocognitive measures. Multiple tasks were taken from the NEPSY-II, which were designed for use with children 5 and older (Korkman, Kirk, & Kemp, 1998). However, the scales were administered to allow use of identical measures of effortful control over time. Thus, these tasks were understandably difficult for children in this sample.

Attention regulation (focusing and shifting) was assessed using the NEPSY-II auditory attention subscale and Dimensional Change Card Sort (DCCS). The Auditory Attention subtest

is a continuous performance test assessing the ability to be vigilant and to maintain and shift a selective auditory set. Children are required to listen to a series of words and respond only when they hear a specific target word, while refraining from response to all other words. Total scores were calculated as the proportion of correct responses to the total possible score, with a potential range of 0 to 1. Average score at T1 was 0.09 ($SD = 0.24$, $Range = 0.00-0.93$). DCCS assesses attention focusing and set shifting, as well as cognitive inhibitory control (Zelazo, Muller, Frye, & Marcovitch, 2003). Children were instructed to sort cards into one of two black boxes, each labeled by a target card, according to either the shape or color properties on the target cards. Children were instructed to sort cards according to first the shape (6 trials) and then color (6 trials) properties on the target cards. The experimenter stated the sorting rule before each trial, and presented a card and labeled it according to the current dimension (e.g., on a shape trial, “Here’s a truck. Where does it go?”). If children correctly sorted $\geq 50\%$ of cards, they advanced to the next level in which the target cards integrated the sorting properties. Target cards consisted of a colored figure on a white background (i.e., blue star and red truck), and children were again instructed to sort according to shape (6 trials) and then color (6 trials). If they again correctly sorted $\geq 50\%$ of the cards, children advanced to the final level in which they were instructed to sort by one dimension (i.e., color) if the card had a border on it and by the other dimension (i.e., shape) if the card lacked the border (12 trials). The score was the proportion of correct trials out of the total possible of 36 trials (at T1, $M = 0.42$, $SD = 0.20$, $Range = 0.00-0.89$).

Cognitive inhibitory control was assessed using the Inhibition task on the NEPSY-II and a Stroop-like task, Day/Night (Gerstadt, Hong, & Diamond, 1994). Inhibition requires the child to inhibit a dominant response in order to enact a novel response. Specifically, children are shown an array of circles and squares and asked to label each shape in an opposite manner (e.g.,

say circle when they see square) while being timed (at T1, $M = 0.18$, $SD = 0.32$, $Range = 0.00-1.00$). Day/Night requires the child to respond by saying “day” when shown a picture of the moon and stars and “night” when shown a picture of the sun (Gerstadt, Hong, & Diamond, 1994). Children’s responses were scored 1 for correctly providing the non-dominant response or 0 for providing the dominant response. Total scores were the proportion of correct responses (at T1, $M = 0.44$, $SD = 0.33$, $Range = 0.00-1.00$).

Behavioral inhibitory control was measured using Bear-Dragon, a simplified version of the game Simon Says (Kochanska, Murray, Jacques, Koenig, & Vandegest, 1996), and Head, Toes, Knees, Shoulders (HTKS; Ponitz, McClelland, Jewkes, Connor, Farris & Morrison, 2008). Children are asked to perform actions when a bear puppet but not a dragon puppet gives the direction. Scores range from 0-3, with children’s actions scored as 0 (*performing no movement*), 1 (*a wrong movement*), 2 (*a partial movement*), or 3 (*a complete movement*) for bear prompts and reverse scored for dragon prompts. Total scores were the proportion of the score across both bear and dragon items to the total possible score (at T1, $M = 0.62$, $SD = 0.20$, $Range = 0.33-1.00$). Finally, HTKS integrates behavioral inhibitory control and attention. Children are asked to follow the instructions of the experimenter, but to enact the opposite of what the experimenter directs (e.g., touch toes when asked to touch head). Behaviors were coded as 0 (*touched directed body part*), 1 (*self-corrected his/her behavior*), and 2 (*only touched opposite body part*). Total scores were the proportion of the score across items to the total possible score (at T1, $M = 0.01$, $SD = 0.07$, $Range = 0.00-0.65$).

Consistent with previous research, an overall effortful control score, integrating attention shifting and focusing (Auditory Attention, DCCS), cognitive inhibitory control (Inhibition, Day-Night), and behavioral inhibitory control (Bear-Dragon, HTKS), was computed as the mean of

the proportion scores of the six tasks (Carlson & Moses, 2001; Kochanska et al., 1996; Lengua, Hornado, & Bush, 2007). Effortful control scores were considered missing if > 50% of the component scores were missing. Internal consistency of the composite effortful control measure at Time 1 was .67, and the inter-rater ICC was .83.

2.3.5 *Adjustment Outcomes*

Children's internalizing and externalizing symptoms were assessed using mothers' reports on the Child Behavior Checklist (CBCL, 4-18 years; Achenbach, 1991), which utilizes a 3-point scale (0 = *not true* to 2 = *very/often true*). The scales were augmented with problem behavior items from the preschool version (ages 2-3; 11 items) that do not overlap with the 4-18 version (34 items) to allow for administration of identical measures across all time points. The CBCL has a strong empirical history and has been shown to be both a valid and reliable measure of children's psychopathology (Achenbach, 1991). However, among problems with the CBCL for examining distinct etiology and the developmental course of symptoms of psychopathology, is the inclusion of items not specific to symptoms and, particularly, items that overlap with characteristics more associated with temperament. To reduce this overlap in assessment, an alternative scoring system for the CBCL was used, which has been found to provide better sensitivity, positive predictive power, and discriminate validity above the original scales (Lengua, Sadowski, Friedrich, & Fisher, 2001). Internalizing symptoms were assessed by summing maternal responses on the Anxiety (12 items) and Depression (12 items) scales, and externalizing included the Aggression and Delinquency scales (21 items). Sample items includes 'My child complains of loneliness' for internalizing symptoms and 'My child is disobedient at home' for externalizing symptoms. At Time 1, the alphas were .69 and .74 for internalizing and externalizing problems, respectively.

2.4 ANALYTIC PLAN

Families were included if they had available data from at least one time point. Of the original 306 families, 50 families were missing data on one or more study variables at any time point. Missing data within an assessment occurred due to technical errors and/or child noncompliance. Potential bias introduced by missing data was examined for covariates (family income, child gender and cognitive ability), predictors (effortful control, fear and frustration reactivity), and outcomes (internalizing and externalizing symptoms) by comparing participants with missing data on any variable at any time point ($N = 50$) to those with complete data on all variables at all time points ($N = 256$). The t tests (Table 2) indicated that participants with missing data differed from those with no missing data on effortful control at Time 1 and 3, as well as family income and child cognitive ability. Specifically, children with missing data were more likely to have lower effortful control, income, and cognitive ability. However, the relations of each of these variables to missingness were small effects ($r = -.15$ to $-.16$) and did not reach thresholds for introducing substantial bias ($r > .40$; Collins, Schafer, & Kam, 2001), which suggests little bias was introduced due to missing data. Analyses, therefore, were based on the full sample of 306 families.

Full Information Maximum Likelihood Estimation (FIMLE) was used to handle missing data, which uses all data available simultaneously to calculate parameter estimates and has been found to be less biased and more efficient than other techniques for handling missing data (Arbuckle, 1996). Our examination of bias in missing data (above) suggested that the pattern of missing data introduced minimal bias and aligned with the assumptions of FIMLE.

Latent growth curve (LGC) modeling with latent interactions was used to test moderation. Mplus version 6.11 was used to evaluate how effortful control may moderate the

effect of negative reactivity on symptom growth (Muthén & Muthén, 1998-2006). As the full theoretical model is complex (Figure 1), sequential approximations of the full model were tested. First, as negative reactivity was assessed using multiple methods, it was necessary to test the feasibility of combining reports into single composite indicators prior to testing any models. Two models were tested, one for fear and one for frustration reactivity, using confirmatory factor analysis (CFA). In each model, three measurement methods, physiological, observed, and mother-reported reactivity, loaded on three latent factors, one for each time point. Latent reactivity at each time point was subsequently loaded on a single latent indicator of reactivity across time. Additionally, covariation based on measurement method was accounted for by allowing identical methods to correlate over time. After assessing aggregation of the physiological indices, unconditional LGC's for each factor (effortful control, fear and frustration reactivity) and outcome (internalizing and externalizing symptoms) were tested. After successful specification of the unconditional LGC's, covariates (family income, child gender and cognitive ability) were added, followed by direct effects of the intercept and slopes of reactivity and effortful control, and finally by tests of moderation by effortful control by including latent interactions between the intercept and slope of effortful control with intercept and slope of reactivity.

Inclusion of latent interactions requires the models to be specified with random slope and intercept factors, which results in individual subject differences in variances of Y. Commonly used indices of model fit based on the fit of a single covariance matrix are, therefore, not relevant with these models (Muthén & Muthén, 2010).

Chapter 3. RESULTS

3.1 DATA REDUCTION

Results from the CFA assessing aggregation across measurement methods for indices of reactivity (*Exploratory Aim 1*) suggested that the model fit the data well for fear reactivity ($\chi^2(16) = 9.17, p = .91$; RMSEA = 0.00; CFI = 1.00; SRMR = .03). However, none of the measures of fear demonstrated significant factor loadings on the latent construct at each time point (Figure 2). Additionally, a similar model testing aggregation of measures of frustration reactivity did not converge despite repeated attempts to improve the model through modifications. These results suggest that the creation of a single latent factor for fear or frustration reactivity using physiological, observational, and questionnaire indicators was not plausible.

Post hoc, alternative models were tested to explore the structure of the data, including regressing the three measurements on latent factors at each time point independently, including latent factors for both fear and frustration in a single model, and a multi-trait, multi-method model. These alternative models were unstable, did not fit the data, or resulted in nonsignificant factor loadings. When fitting the model with three latent factors capturing each measurement method (e.g., physiological fear, observed fear, and mother-reported fear) regressed on the corresponding method across time (e.g., physiological fear on EDL reactivity at Time 1, Time 2, Time 3), the factor loadings were all significant. Correlations across latent factors capturing different methods suggest that mothers' reports of reactivity, in particular, do not covary in predictable ways with other assessment methods. For instance, mother-reported frustration was positively correlated with both mother-reported ($r = .28$) and observed ($r = .02$) fear, but negatively correlated with physiological frustration ($r = -.33$) and unrelated to observed

frustration. These results suggest that assessment methods that appear to capture the same constructs may fundamentally differ. Thus, the main hypotheses were tested using only physiological reactivity, which may more directly assess biological processes underlying temperamental reactivity and help to reduce the potential of shared method variance given child outcomes were assessed by maternal report.

3.2 CORRELATIONS AMONG STUDY VARIABLES

Means, standard deviations, and correlations for all variables in the study are shown in Table 3. EDL reactivity (fear) and HR reactivity (frustration) were not related to each other suggesting these physiological indicators are likely capturing unique aspects of children's emotion reactivity. Interestingly, the physiological indicator of frustration was positively correlated with effortful control ($r = .16-.25$), as well as positively correlated with children's cognitive ability ($r = .15-.17$). This suggests that children with larger differences between heart rate at baseline and during the emotion eliciting task also demonstrated higher effortful control and intelligence. Indices of children's reactivity surprisingly, were largely unrelated to adjustment outcomes. It was initially hypothesized that fear reactivity would specifically relate to internalizing symptoms, whereas frustration reactivity would relate more strongly with externalizing symptoms. Contrary to expected relations, however, fear was unrelated to children's internalizing symptoms and instead demonstrated inconsistent though positive correlations with externalizing symptoms (Time 2 fear reactivity with Time 1 externalizing, $r = .27$, and Time 2 externalizing, $r = .16$). Frustration reactivity showed one positive relation to internalizing symptoms (Time 1 frustration reactivity with Time 2 internalizing, $r = .17$) and unexpectedly a negative relation to externalizing symptoms (Time 3 frustration reactivity with Time 2

externalizing, $r = -.14$). Also, unexpectedly, children's effortful control was largely unrelated to internalizing and externalizing symptoms. Despite an unexpected lack of relations at the correlational level, examination of growth factors and interactions between reactivity and regulation may reveal patterns not captured by correlations alone. Symptoms were significantly related to each other, with moderate to strong relations between initial and later symptoms (internalizing $r = 0.51 - 0.68$; externalizing $r = .54 - .74$) indicating a modest to moderate degree of individual differences in symptom growth to account for. Finally, family income, child gender, and child cognitive ability were included in all models as covariates due to consistent relations with study variables. Specifically, higher family income consistently related to higher effortful control and lower adjustment problems across time points. Gender (coded 0 = *female*, 1 = *male*) was related to effortful control at Time 2 and externalizing symptoms across time points, such that boys were more likely to have lower effortful control and higher externalizing symptoms. Additionally, consistent with prior research (Rothbart & Posner, 2005), child cognitive ability was positively related to effortful control across time points.

3.3 UNCONDITIONAL GROWTH MODELS

For predictor variables (i.e., fear, frustration, and effortful control), the average initial level of each factor at Time 1 was defined as the intercept, whereas the slope factors were specified as the linear rate of change across 18 months (in 9 month intervals). Only data from Time 1 through 3 were used in creating growth factors for predictor variables to allow for temporal precedence with the outcome status (i.e., final time point). For the outcome variables, the intercept was set as the average level at Time 4 to allow for prediction of final levels of symptoms. The slope for the outcome variables was specified as the linear rate of change across 27 months (in 9 month

intervals). Examination of unconditional growth reveals whether linear growth fits the data, and whether individuals significantly differ in their levels (intercept) and rate of change (slope). Significant means for each intercept indicate that average levels at a particular time point are non-zero, while significant means for slopes indicate that levels, on average, change over time. Further, significant variances for intercept and slope indicate the existence of between-individual differences in levels and rates of change, respectively. Estimates and standard errors of growth factors and fit statistics for the unconditional models are summarized in Table 4.

3.3.1 *Negative Reactivity*

Unconditional growth models for fear reactivity and frustration reactivity specifying linear growth resulted in nonsignificant χ^2 tests for both models suggesting the models fit the data well. The model for fear reactivity initially resulted in a Heywood case with a negative variance emerging for the slope term ($Var = -0.33, p = .54$). As this variance was small and non-significant, the slope variance for fear was fixed to zero (Kolenikov & Bollen, 2012). The final model for growth in fear resulted in intercept and slope means significantly different from zero, as well as significant variance around the intercept mean, but not slope mean. Specifically, results for fear reactivity suggest that on average, children began with fear reactivity at 2.23 uMho with children varying around this mean ($SD = 1.17$) and on average increased by 0.39 uMho per assessment. As these are difference scores from baseline, intercept reactivity equal to zero would suggest no difference between mean EDL at baseline and during the emotion eliciting task. The positive reactivity value for intercept and slope suggests that on average at Time 1 children's electrodermal activity was stronger during the fear eliciting task ($M = 6.01$ uMho, $SD = 6.31$) compared to baseline ($M = 3.86$ uMho, $SD = 4.44$) and that this difference increased by about 17% over time.

The model for frustration reactivity resulted in significant means but non-significant variance for both intercept and slope, indicating that children began at 4.41 in frustration reactivity and increased 1.00 unit per assessment with no significant individual variability around these means. Similar to fear reactivity, at Time 1 children on average demonstrated higher heart rate during the frustration eliciting task ($M = 109.97$ bpm, $SD = 7.29$) compared to baseline ($M = 105.47$ bpm, $SD = 7.73$) and differences between baseline heart rate and heart rate during the emotion eliciting task increased by about 25% at each time point.

Given individual variation in growth was not apparent in either fear or frustration reactivity, growth factors for these predictors were not included in the final analyses. Instead, an average score was calculated combining reactivity across the first three time points to simplify analyses. These results necessarily precluded the testing of Hypotheses 4 and 5, which proposed examination of relations between growth in reactivity to symptom trajectories. Average reactivity scores across Time 1 through Time 3 were used in all conditional models. Descriptive statistics for physiological indices including levels at baseline and emotion eliciting task at each time point, as well as the averaged scores used in conditional models are summarized in Table 5.

Additionally, to aid in interpretation of reactivity scores, mean levels during baseline and the emotion eliciting task were compared at high and low extremes of each reactivity measure (Table 6). For fear, children with reactivity scores at or below one standard deviation from the mean demonstrated blunted sympathetic arousal with baseline and reactivity mean levels much lower than other children. Additionally, children with low fear reactivity show a slight, potential reduction in activation to the emotion eliciting task. Thus, low scores of fear reactivity may actually reflect under arousal of the sympathetic nervous system. In contrast, children high in fear reactivity show somewhat elevated baseline responding compared to children at the average,

but EDL to the emotion eliciting task almost double reflecting a strong sympathetic response to the fear inducing context.

For frustration reactivity, children with high reactivity scores had lower resting heart rate and more arousal, or higher heart rate, to the frustration task compared to children with average and low reactivity scores. In addition to elevated resting heart rate, children with low reactivity scores showed a small decrease from baseline heart rate during the frustration task.

3.3.2 *Effortful Control*

Similar to models estimating growth in reactivity, the χ^2 test assessing model fit for unconditional linear growth in effortful control was non-significant suggesting good fit to the data. For effortful control both intercept and slope demonstrated significant means and variances. As the score for effortful control is a proportion of the total possible score with a maximum of one, results suggest that children on average began the study relatively low on effortful control ($M = 0.29$) with individual variability around this mean ($SD = 0.13$). Additionally, children on average increased over time, as expected, and with individual variability around this average slope ($M = 0.20$, $SD = 0.07$). Figure 3 demonstrates the unconditional growth curve for effortful control including the average trajectory (bolded line), as well as variance around this trajectory (dashed lines) by plotting the curve at one standard deviation above and below the intercept mean and slope mean while accounting for covariance between intercept and slope ($r = -.21$).

3.3.3 *Internalizing Symptoms*

The unconditional growth model specifying linear growth in internalizing symptoms demonstrated poor fit to the data ($\chi^2(5) = 17.18$, $p < 0.01$, RMSEA = 0.09, CFI = 0.98, SRMR = 0.05), therefore an unconditional model including a quadratic growth term was tested. A non-

significant χ^2 test suggested that the model including quadratic growth fit the data well. Both the mean and variance for the intercept (Time 4) of internalizing symptoms were significant ($M = 5.10$, $SD = 4.39$). As the internalizing scale ranges from 0 to a maximum of 48 points, average levels of internalizing symptoms at Time 4 were relatively low. The linear and quadratic growth terms did not significantly differ from zero on average ($M = 0.15$, $p = .54$; $M = 0.004$, $p = .95$; respectively), but did have significant variances around the means ($Var = 11.04$, $p < .01$; $Var = 0.67$, $p = .001$; respectively). As seen in Figure 4, although children on average did not significantly change in internalizing symptoms across the study (bolded line), significant individual variation in both linear rates of change ($SD = 3.32$) and change in these rates ($SD = 0.82$) exist. This variance in growth is captured by the dashed lines in Figure 4, depicting trajectories at one standard deviation above and below the mean intercept and slopes and accounting for covariance between the intercept and both linear ($r = .55$) and quadratic ($r = .40$) slopes. Additionally, the linear and quadratic components of growth were significantly and highly correlated ($r = .98$). This high correlation resulted in instability in the conditional models, and as such, the covariation between the linear and quadratic components was fixed at the estimated level derived from the unconditional models ($Var = 2.66$, $r = .98$). As these results suggest that the linear and quadratic slope factors were, in essence, perfectly collinear, only the linear slope factor was used as an outcome in the conditional models, as predictor effects are likely to be equivalent across these growth components. High collinearity between the status and slope factor is not the case when the status is assigned to a different time point (e.g., Time 1); however, capturing levels of symptoms at the last time point by assigning the status to Time 4 is theoretically meaningful to the aims of this study.

3.3.4

Externalizing Symptoms

For externalizing symptoms, the χ^2 test assessing model fit for the unconditional linear growth in symptoms was non-significant suggesting good fit to the data. Both intercept and slope demonstrated significant means and variances. Externalizing symptom scores range from 0 to a maximum of 42 points and children ended the study with rates of externalizing symptoms on average at 5.22 with significant individual variation around this mean ($SD = 3.61$). Over the course of the study, children had decreasing symptoms on average, but varied in the rates of change with some children actually showing worsening symptoms (i.e., positive slopes) over time ($M = -0.25$, $SD = 0.85$; Figure 5). Finally, as with internalizing symptoms, externalizing symptom intercept and slope were significantly and positively correlated ($r = .59$) such that higher slopes related to higher levels of symptoms at the final time point.

3.4 CONDITIONAL GROWTH MODELS

Building on the unconditional LGC's, average fear reactivity, average frustration reactivity and both the intercept and slope of effortful control were tested as direct predictors of the intercept (i.e., final level) and slope of both internalizing and externalizing symptoms. Fear and frustration reactivity were included as simultaneous direct predictors to assess the unique effect of each factor. Including both intercept and slope of effortful control as predictors allows for comparisons of the impact of a child's initial level of regulation versus the effect of change in these abilities over time on growth and final levels of symptoms. Finally, effortful control was tested as a moderator of the relation between reactivity and symptom growth and final levels. In total, eight interaction terms were tested predicting each symptom type: fear x intercept of effortful control predicting final level (1) and slope (2) of symptoms, fear x slope of effortful

control predicting final level (3) and slope (4) of symptoms, frustration x intercept of effortful control predicting final level (5) and slope (6) of symptoms, frustration x slope of effortful control predicting final level (7) and slope (8) of symptoms.

Latent interactions between growth factors and continuous variables were computed and analyzed following guidelines by Muthén and Asparouhov (2003). Mplus allows for an interaction term comprised of the multiplicative of latent factors, thereby estimating interactions with growth parameters. Per recommendations by Muthén, growth factors included in interactions were estimated with means equal to zero, as such both intercept and slope of effortful control were fixed to zero in all conditional models (Muthén & Muthén, 2010). Additionally, family income, child gender, and child cognitive ability were included as covariates in all models. Thus the final models predicted final levels and growth of internalizing and externalizing symptoms by simultaneously testing direct effects of the covariates, average levels of reactivity, the intercept and slope of effortful control, and their interactions (intercept x reactivity and slope x reactivity). Including all eight latent interaction effects in a single model led to instability in the model. Therefore, two separate growth models for each outcome were tested (four total). Each model included all direct effects described above, but effortful control's interactions with fear and frustration reactivity were tested in two separate models.

As interpreting the effects of latent interactions on growth factors is complex, significant interactions were probed in multiple ways to explore both the nature of the interaction and its effect on the shape of overall growth trajectories. Interactions were first plotted at +/- 1 SD from the mean of the predictor and moderator. Effects of the interactions on trajectories of growth in symptoms were then explored by plotting conditional latent growth curves (LGC) comparing the mean trajectory (i.e., level and slope when predictor and moderator are at their mean, in this case

equal to zero) to patterns of growth at +/- 1 SD from the mean of the predictor and moderator. For consistency and ease of interpretation, across all graphs of conditional LGC's, blue lines represent low levels of reactivity, red lines represent high reactivity, dashed lines reflect low effortful control, and solid lines reflect high effortful control. Additionally, each graph also depicts the mean trajectory with a solid black line.

3.4.1 *Internalizing Symptoms*

Table 7 summarizes parameter estimates for the two models testing predictors of internalizing symptoms. Very few significant effects emerged in relation to internalizing symptoms. With regard to direct effects, only family income was significant and negatively related to both the final level and slope of internalizing symptoms, suggesting that higher economic resources related to lower final symptoms, as well as smaller increases in symptoms over time. No other significant direct effects emerged (*Hypothesis 1*).

One interaction effect also emerged between frustration reactivity and the intercept of effortful control (*Hypothesis 2.2*) predicting the slope of internalizing symptoms ($b = -0.41$, $SE = 0.16$, $p = .01$). Plotting this interaction shows that the relation between frustration reactivity and growth in internalizing symptoms depends on children's initial level of effortful control (Figure 6). Predicted slopes suggest that for children with low frustration, high initial effortful control is related to the largest slope or increasing internalizing symptoms ($m = .50$), whereas low initial effortful control related to a negative, or decreasing, slope ($m = -.38$). Given the hypothesized protective role of effortful control, the relation between high effortful control and increasing symptoms in the context of low frustration is unexpected. However, interpreting the magnitude and directionality of slope factors out of the context of symptom levels does not capture the full context of children's symptom expression over time. Conditional latent growth curves (Figure 7)

extend our understanding of this relation. Children with low frustration and high effortful control began the study with the lowest rates of internalizing symptoms and demonstrated growth in these symptoms across the study resulting in a large positive slope (solid blue line). Despite this increase, children's symptoms were about equivalent with average symptom rates at the end of the study. In contrast, children with low frustration and low effortful control began with the highest initial symptoms that remained relatively constant across the study (dashed blue line).

At high levels of frustration, however, the plot of the interaction shows this relation is reversed with high effortful control relating to a small negative slope and low effortful control related to a positive slope. The conditional LGC's show that when frustration reactivity is high (red lines), children with high effortful control begin with about average levels of symptoms that modestly grow during the first half of the study and then begin to mitigate (solid red line), whereas children with low effortful control begin with fewer symptoms that increase more steadily across the study (dashed red line). It is difficult to interpret this interaction, as a consistent pattern is not obvious. It seems that low frustration, particularly in combination with low effortful control puts children at risk for internalizing symptoms. Although it is unclear why this particular association has emerged, it is possible that high effortful control may be protective especially at early ages when in combination with low frustration.

None of the other interactions significantly predicted levels or growth in internalizing symptoms. Contrary to expectations, fear did not significantly predict growth or levels of internalizing symptoms (*Hypothesis 2.1 and 3.1*) either directly or through interactions with effortful control.

Table 8 summarizes parameter estimates from the two models testing predictors of externalizing symptom levels and growth. Similar to internalizing symptoms, few direct effects emerged.

Income consistently and negatively predicted both status and slope. Negative relation to the status of externalizing symptoms suggests that lower family resources related to higher symptom levels at the end of the study. Additionally, as the unconditional slope of externalizing symptoms was negative, a negative relation to the slope suggests that fewer economic resources related to smaller decreases or even increases in externalizing symptoms over time. Child gender positively predicted externalizing status, but not slope, suggesting boys were more likely to have higher levels of symptoms at the end of the study than girls. In addition to the limited direct effects, three interaction effects were significant: frustration by effortful control intercept predicting growth ($b = -0.21$, $SE = 0.10$, $p = .03$), fear by effortful control intercept predicting growth ($b = 0.41$, $SE = 0.20$, $p = .05$) and fear by effortful control slope predicting the status of symptoms ($b = 2.75$, $SE = 1.29$, $p = .03$).

Figure 8 depicts the plot of the interaction between frustration and the intercept of effortful control predicting the slope of externalizing symptoms and Figure 9 displays graphs of the conditional LGC's extending this interaction over time (*Hypothesis 2.2*). The plot of the interaction shows that compared to children high in frustration, children low in frustration demonstrate very different patterns of growth in externalizing symptoms depending on initial levels of effortful control. Specifically, low frustration in combination with high effortful control related to a large positive slope whereas low frustration in combination with low effortful control was associated with a small negative slope. Examining the LGC's shows that indeed children with low frustration and high effortful control begin with about average levels of externalizing

symptoms that increase across the study (solid blue line). In contrast children with low frustration and low effortful control begin with somewhat elevated symptoms that reduce to just below average levels by the end of the study (dashed blue line). This pattern is contradictory to the hypothesized protective effect of effortful control, in which high levels of effortful control would have been expected to relate to reductions, not increases, in symptoms over time.

Consistent with the hypothesized role of effortful control, children with high frustration (red lines) showed a reverse pattern with the lowest rates of symptoms at onset and only small growth for children who also demonstrated initially high effortful control (solid red line). Symptom growth was very similar for children with high frustration and low effortful control ($m = 0.36$) compared to high frustration and high effortful control ($m = 0.24$), however, initial levels were much higher for those with low effortful control resulting in consistently elevated symptom levels compared to children with high effortful control. Frustration reactivity also did not significantly interact with growth in effortful control in relation to externalizing symptoms (*Hypothesis 3.2*).

Two significant interactions between fear and effortful control also emerged. Figure 10 depicts the first interaction between fear and effortful control intercept predicting the slope of externalizing symptoms. The plot of the interaction suggests that for children with low fear reactivity, initial levels of effortful control relate only to small discrepancies in externalizing symptom growth. Estimated slopes for children with low fear in combination with low effortful control ($m = 0.39$) versus high effortful control ($m = 0.26$) did not vary greatly. However, estimates of slopes for children with high fear reactivity reflected more dramatic differences across high ($m = 0.09$) and low ($m = -0.50$) initial levels of effortful control. Specifically, the combination of both high fear reactivity and high effortful control related to a small positive

slope or relatively consistent symptom expression across time. High fear reactivity in combination with low initial effortful control, however related to a relatively large negative slope or decreases in symptoms across time. Again, the relation between negative reactivity and effortful control follows an unexpected pattern. However, it is important to consider not just rates of change of symptoms, but also levels that put growth in context.

The second interaction, between fear and slope of effortful control predicting the status (i.e., final level) of externalizing symptoms, is depicted in Figure 11. It is important to highlight that as all prior interactions predicted growth of symptoms, the Y-axis of corresponding interaction plots represented slope factors. This final interaction, however, predicted the status of externalizing symptoms and as such the plot depicted in Figure 11 represents symptom levels at Time 4 on the Y-axis. Additionally, in this interaction the slope of effortful control emerged as a moderator and thus points were plotted at ± 1 SD from the mean slope of effortful control. The interaction, therefore, demonstrates that at high rates of growth in effortful control (large positive slope) there were minimal differences between final levels of externalizing symptoms between children low ($Y = 5.61$) versus high ($Y = 6.34$) in fear reactivity. In contrast, children with small growth in effortful control (small positive slope) showed greater differences in the final levels of externalizing symptoms across low ($Y = 8.44$) and high ($Y = 3.43$) levels of fear reactivity. These results suggest that highest risk for externalizing symptoms is conferred with the combination of low fear reactivity and small growth in effortful control, and that either high fear reactivity or maturation and growth of effortful control may be protective factors (*Specific Aim 2; Hypothesis 6*).

Initial levels and growth in effortful control were significantly and negatively correlated ($r = -.21$ in the unconditional model) suggesting that children with high initial levels of effortful

control show smaller growth than children with lower initial levels. To understand the full context of the interactions between fear and effortful control in relation to externalizing symptom expression, LGC's which model both interactions predicting externalizing status and slope simultaneously were examined (Figure 12). Trajectories were plotted at +/- 1 SD from the mean of fear reactivity and initial effortful control while simultaneously accounting for the correlation between the intercept and slope of effortful control. Regression equations for each line included direct effects of fear, intercept, and slope of effortful control on the status and slope of externalizing symptoms, as well as the interaction effect between fear and the slope of effortful control on externalizing status and the interaction between fear and the intercept of effortful control on the slope of symptoms. Within this full context, a complex pattern between these factors emerged.

The plot of the interaction between fear and effortful control predicting externalizing slopes suggested similar slopes for children low in fear regardless of initial effortful control, which is reflected in the graph by nearly parallel blue lines. It is important to take into account the interaction between fear and effortful control slope predicting the status of externalizing symptoms when interpreting these latent growth curves. At low levels of fear reactivity (blue lines), children with smaller growth in effortful control demonstrated a somewhat higher externalizing status. As children with high initial effortful control also were more likely to have less growth in effortful control, it is consistent with the results of the interaction plot that children low in fear but high in effortful control (solid blue line) demonstrated higher rates of problems than those low in both fear and initial effortful control (dashed blue line). This pattern, however, is very unexpected given prior research showing effortful control to be a protective factor in relation to externalizing symptoms.

The slopes for children high in fear (red lines), in contrast, varied across high (solid red line) and low (dashed red line) levels of effortful control, such that children with high effortful control had fairly flat slopes or maintenance of symptoms, whereas children with low effortful control showed improvement in symptoms. Despite the mitigation of symptoms seen in children with high fear and low effortful control, symptom levels in these children began relatively high resulting in approximately average levels of symptoms by the end of the study. In contrast, children with both high fear and initial effortful control began the study with the lowest levels of symptoms and maintained these low levels throughout. This pattern is again consistent with results from the interaction plot predicting the status of externalizing symptoms, in which children with smaller growth in effortful control (i.e., likely higher initial levels) would have the lowest final level of symptoms.

Chapter 4. DISCUSSION

The current study tested the role of effortful control as a moderator of the relation between physiological negative reactivity and children's internalizing and externalizing symptoms over time. In general, the results were surprising and somewhat contradictory to expectations. Based on prior research, it was expected that components of children's negative reactivity might show specificity in relation to symptom type. Specifically, fear reactivity has frequently been shown to increase risk for internalizing problems in particular. However, in the current study, only frustration reactivity, in interaction with effortful control, emerged as a predictor of internalizing symptom growth. Consistent with expectations, frustration reactivity demonstrated relations more generally with both internalizing and externalizing symptoms, however again, only in interactions with effortful control. Very surprising was the lack of zero order correlations or any

direct effects between indices of reactivity and regulation and children's adjustment. This was surprising given the wealth of prior research showing relations between reactivity and increased risk for psychopathology, as well as relations between effortful control and resiliency or positive adjustment.

An important consideration, which may account for some of the unexpected or even contradictory results compared to prior research, is a difference in methodology used to assess temperament across studies. As seen in the results of the confirmatory factor analysis, despite intending to capture the same construct, different assessment methods may actually be capturing fundamentally different characteristics of children's temperament. As the current study used physiological indicators of reactivity, in contrast to the more commonly used questionnaire or (less commonly used) observed measures, different patterns may be emerging.

Psychophysiological markers of temperament are the most underutilized method across this literature, which contributes to difficulty in interpreting results. A review of the literature (Moran, in preparation) found that of 47 studies testing interaction effects between temperamental reactivity and regulation, only two assessed physiological markers of temperament (Degnan et al., 2008; Eisenberg et al., 1996). Thus, conclusions about the effect of interactions between reactivity and regulation on children's adjustment are almost exclusively equated to results drawn from questionnaire reports. Comparisons across methods may be problematic given evidence suggesting that the pattern of these interactions is, at least to some degree, influenced by the source of information (e.g., Eisenberg et al., 2004; 2007; Moran et al., 2013). Although correspondence across measures may be low, this does not necessarily suggest that any measure lacks veracity or utility. Each method may still be useful for examining relations between specific domains of temperament and children's outcomes. Additionally,

discrepancy among reports may actually contain useful information that may speak to individual differences in both reactivity and regulation or to specific conditions under which patterns of reactivity emerge (Lanteigne, Flynn, Eastabrook, & Hollenstein, 2014).

It will be imperative for future research to examine varying viewpoints of temperament by more heavily utilizing both behavioral and physiological methods of assessment in combination with questionnaires, which may help to clarify expected relations between these methods and unique components of children's temperament captured by each. In the current study, a number of significant interactions reflecting complex patterns of associations between children's temperament and adjustment over time suggest relations between children's physiological reactivity, effortful control, and symptom expression are more complex than would be presumed from results of analyses using single-method, questionnaire designs or examining direct effects only.

4.1 FEAR REACTIVITY

Relations between fear reactivity and children's symptoms were somewhat unexpected given the lack of association between fear and internalizing symptoms. Fear was assessed through reactivity in skin conductance levels, comparing differences in mean electrodermal levels from baseline to a fear-inducing task. One possible explanation for the lack of associations may be a failure of the assessment to appropriately capture fear reactivity or to elicit fear responding during the emotion eliciting task. Examination of the raw data, however, suggests that electrodermal responding did show reliable increases during the fear eliciting task as compared to responding that occurred while children listened to a neutral story (Table 5), as would be expected. Similar assessment methods have been used in prior research and shown to reliably

elicit electrodermal responses in toddler and preschool aged children (Fowles, Kochanska, Murray, 2000). The range of responses recorded in the current study was also consistent with expectations, further supporting the accurate assessment of children's electrodermal responding (Kochanska, Brock, Chen, Aksan, & Anderson, 2015). Additionally, examination of direct-effect only models (although not reported in the current study) showed expected relations between children's EDL reactivity and internalizing symptom slope, both linear ($b = 0.23$, $SE = 0.10$, $p = .02$) and quadratic ($b = 0.06$, $SE = 0.03$, $p = .03$). However, inclusion of covariates (particularly income), frustration or effortful control as direct effects in the model attenuated this effect.

It is still possible, however, that measurement method plays a role in the lack of findings with relation to internalizing symptoms. The majority of prior research examining relations between fear reactivity and risk for internalizing symptoms relied on maternal report or observed behavioral responses. These assessment methods necessarily occur downstream of regulation processes that may muddle internal reactivity with regulatory processes that produce observable, external behaviors. Thus, alternative measurement methods may not capture the same characteristics of fear as physiological reactivity, which likely reflects more direct sympathetic nervous system arousal. In fact, in the current study there were no associations between maternal report of child fear reactivity and the physiological measure of fear at any time point. Thus, it is possible that physiological fear captures a different aspect of children's temperament that is not relating to mothers' perceptions of children's internalizing symptoms at this developmental stage.

A second aim of this study was to explore the role of fear in the expression of externalizing symptoms. Fear reactivity, in addition to relations with avoidance and withdrawal behaviors associated with internalizing symptoms, has been shown to relate to higher empathy,

lower aggression, and the development of conscience (Rothbart, 2007). As such, high fear has been hypothesized to be a protective factor reducing risk of externalizing problems. Results from the current study largely support this relation, particularly for children with concurrent high effortful control. Children demonstrating increased sympathetic arousal during the fear eliciting task and also scoring highest on measures of effortful control consistently demonstrated the lowest levels of externalizing symptoms across all time points. High electrodermal reactivity may reflect strength or hyper-reactivity of the behavioral inhibition system, which may result in enhanced fear of social punishment and development of conscience and prosocial behaviors (Kempes, Matthys, de Vries, & van Engeland, 2005). Children with high fear reactivity may be more prone to inhibit even pleasurable behaviors out of fear of punishment or aversive consequences. Thus, highly fearful children may be more risk averse, apprehensive, or prone to inhibit behaviors resulting in lower maternal ratings of externalizing symptoms. In combination with high effortful control, reflecting children's ability to inhibit a dominant response in favor of more adaptive and effective behaviors, highly fearful children may be able to maximally benefit from social learning. The interaction of high effortful control and fear may allow children to balance restraint from socially unacceptable behaviors with the flexibility to overcome physiological reactivity and appropriately approach feared stimuli as needed.

Highly fearful children with low effortful control, in contrast, may be overly inhibited reflecting sensitivity of the BIS without the ability to override this system when needed. These children appear to have higher rates of externalizing behaviors at earlier ages that declined across the study. Highly fearful children, without the benefit of well-developed effortful control, may display aggression, tantrum behaviors, and disobedience in fear eliciting contexts resulting in higher perceived rates of externalizing symptoms by their mothers. Equivalently reactive

children with better regulation may be more capable of adapting to fearful situations without resorting to noncompliance or tantrums. Overtime, however, children with high fear reactivity and low effortful control showed mitigation of externalizing symptoms, potentially as children become more verbal and capable of expressing fear in ways more similar to internalizing as opposed to externalizing problems.

In contrast, children with low fear reactivity appeared to be at somewhat higher risk for externalizing problems. This is consistent with prior literature finding relations between electrodermal hyporeactivity, poor fear conditioning, and symptoms associated with externalizing problems (Fowles et al., 2000). For children with both high and low levels of effortful control, low fear reactivity related to increasing externalizing symptoms across the study. This is particularly interesting given results from the unconditional growth model found average trajectories of externalizing symptoms to be decreasing as children matured. Thus, particular risk for externalizing symptoms may be conferred by blunted reactivity to fear eliciting stimuli or hyporeactive sympathetic nervous system activation. Low fear reactivity may make it difficult for children to appropriately develop aspects of conscience, including guilt and empathy, due to blunted arousal in response to behaviors that transgress against others or have been previously punished (Frick & Viding, 2009). Results from a meta-analysis support this conclusion with evidence indicating that compared to control children, those with conduct problems elicited lower skin conductance levels and responses (Lorber, 2004). Additionally, similar patterns of reduced fear arousal have been found in research examining children with high aggression, oppositional defiant disorder, conduct disorder, ADHD, and strong impulsivity (Beauchaine, Katkin, Strassburg, & Sharr, 2001; Jimenez-Carmargo, Lochman, DeCaro, Parker, Salekin, & Sellbom, 2014; Posthumus, Böcker, Raaijmakers, Engeland, & Matthys, 2009).

Unexpected is the pattern of relation between low fear arousal, effortful control and externalizing growth. Children with both low fear and high effortful control demonstrated the highest levels of symptoms across the study. It is difficult to explain why children with low fear and low effortful control appear to have lower levels of externalizing symptoms than children with high effortful control. It was hypothesized that high levels of effortful control might moderate risk conferred by reactivity by providing children with the ability to flexibly alter behavior by overcoming avoidance and withdrawal responses typical of high fear, slowing approach drives associated with low fear, or dampening reward oriented drives associated with frustration reactivity. Although for children with high reactivity, effortful control does appear to confer added resiliency, when fear reactivity is low, high effortful control appears to inflate risk.

It is possible that different types of externalizing behaviors relate to temperament factors differently, such that certain temperament characteristics only confer risk in combination. For instance, prior research has found different psychophysiological correlates to aggression based on the function of aggressive behaviors (Vitiello & Stoff, 1997). Impulsive forms of aggression, typically associated with reactive or defensive responses to perceived threat or provocation, have been associated with heightened skin conductance reactivity and high levels of emotional arousal to anger and fear. In contrast, non-impulsive aggression, associated with proactive or goal-oriented responses to perceived rewards, is associated with reduced or blunted physiological and emotional arousal (Hubbard et al., 2002). As such, similar disobedient or antisocial behaviors may serve different functions and stem from unique underlying processes. For instance, telling a lie may reflect reactive externalizing behavior when used defensively by a child accused of a misdeed, but may reflect proactive externalizing behavior when used by a child to obtain a reward or advantage. High levels of externalizing symptoms by children with both low fear and

high effortful control may, therefore, reflect children who are non-impulsive and goal-oriented in their use of antisocial/externalizing behaviors as a means for achieving certain rewards (Vitiello & Stoff, 1997). Children with low fear and low effortful control may not be as skilled in controlling behavior or potentially profiting from this type of aggression and may be less prone to engage in proactive aggression at earlier ages. Additionally, deficits in attention and executive functioning have been found to exacerbate reactive forms of aggression, resulting in increased externalizing symptoms; a pattern not found for proactive aggression (Kempes et al., 2005). Thus, low effortful control in combination with higher sympathetic reactivity may place children at risk for more reactive forms of externalizing behaviors, which appears to be consistent with the findings of this study. Also consistent with the pattern found in this study, reactive behaviors were negatively associated with children's age, showing decreases in frequency as children matured (Connor et al., 2004). Thus the complex pattern of interaction between children's EDL reactivity and effortful control may reflect risk to a heterogeneous set of externalizing behaviors.

4.2 FRUSTRATION REACTIVITY

As expected, frustration reactivity was a non-specific predictor of both internalizing and externalizing symptoms. However, results of the interaction between frustration reactivity and levels of effortful control were unexpected. For both internalizing and externalizing symptoms, low frustration, as opposed to high, with low effortful control appeared to put children at heightened risk for initial symptom levels. Although it is not surprising that deficits in effortful control might relate to increased symptomatology, it is difficult to explain why the combination with low frustration reactivity would confer risk for both internalizing and externalizing

symptoms. This unexpected relation may be due to unique attributes of the assessment of frustration using physiological indices.

Frustration was assessed in this study using heart rate reactivity, comparing children's average heart rate during the reading of a neutral story to average heart rate while engaging with a difficult and frustrating task. Although heart rate is a nonspecific physiological indicator, it was hoped that assessing heart rate during a task specifically designed to elicit frustration would capture children's reactivity within this specific emotion. Heart rate, however, indexes not just emotional arousal, but also attention. Specifically, periods of sustained attention are related to decreases in heart rate (Oakes, 2015). It is possible that the frustration eliciting task used in the study elicited not just frustration, but also interest and attention, making it more difficult to interpret changes in heart rate from baseline.

Generally, children with high reactivity scores had lower resting heart rate and more arousal, or higher heart rate, to the frustration task compared to children with low reactivity scores (Table 6). It is possible that children with high reactivity scores reflect those with lower baseline heart rate due to recruitment of attention processes during the reading of a neutral story in combination with increased physiological arousal to the emotional task. Children with low reactivity scores had higher heart rate at baseline, as well as a small decrease from baseline heart rate during the frustration task. This decrease in HR from baseline may reflect either recruitment of attention that was not engaged during the reading of the story or a deficient response of the autonomic nervous system to the difficult, emotion-eliciting task. Supporting this latter assumption, lowered heart rate during challenging or emotion eliciting tasks has been hypothesized to reflect under-arousal of the autonomic nervous system relating to boredom and apathy (Dierckx et al., 2014). Additionally, as frustration has been linked to the BAS, blunted

autonomic response in a frustrating context may reflect low reward sensitivity or lowered motivation to appetitive stimuli, and hence relate to early anhedonia or depressive symptoms (Bijttebier, Beck, Claes, & Vandereycken, 2009). If low reactivity in this context is considered to reflect under-arousal of approach systems and reward sensitivity, it is less surprising that the combination of low reactivity and low effortful control may have conferred heightened risk for internalizing problems. Children with a combination of low arousal and low regulation may have difficulty persisting with challenging tasks or overcoming barriers to achieving goals. These children may appear to mothers as withdrawn, apathetic, avoidant, or easily defeated resulting in elevated internalizing symptoms.

Low reactive children with high initial effortful control began the study with far fewer symptoms, suggesting capable attention and inhibitory control may be sufficient to overcome under-arousal at early ages. However, it is unclear why children with low frustration and high initial effortful control demonstrate the most dramatic growth in symptoms across time. It is possible that aspects of children's reactivity, or even early symptomatology, may interfere with or overwhelm young children's developing effortful control and relate to reduced growth in effortful control across the preschool years despite initially higher levels. This would suggest mediation may also be at play, wherein reactivity may actually influence the development of effortful control. Although not tested in the current study, exploring mediated-moderation models of this data may help to further clarify many of these results.

For children with high frustration reactivity, a different pattern emerged. In combination with low effortful control, children's symptoms worsened over time. Heightened autonomic arousal to a blocked goal in the absence of adept regulation may reflect children who are overwhelmed by emotional reactivity and ineffective in emotion eliciting contexts. As such,

these children may increasingly display avoidant, helpless, or hopeless behaviors, particularly as demands increase as children mature. In contrast, highly reactive children who also have high effortful control may be able to harness autonomic arousal in effective ways leading to persistence and increased mastery or capability over time reflected in the eventual reduction in symptoms at older ages.

Further supporting the beneficial combination of high heart rate reactivity and high effortful control, children with these characteristics consistently demonstrated the lowest levels of externalizing symptoms across time. This is consistent with prior research demonstrating strong evidence for moderate to high levels of effortful control functioning as a buffer against the influences of high frustration on externalizing symptoms. Specifically, the relation between frustration and symptoms was found to be significant only at low levels of effortful control (Degnan et al., 2008; Diener & Kim, 2004; Eisenberg et al., 2007; Eisenberg et al., 2004; Moran et al., 2013; Oldehinkel et al., 2007). In the current study, highly reactive children with low effortful control began with about average levels of externalizing symptoms with growth in symptoms across the study suggesting that increased physiological arousal to frustrating tasks may put children at risk for externalizing symptoms if not moderated by high effortful control. Highly reactive children with deficient regulation may be prone to escalated behavior or tantrums in contexts where goals are blocked leading to ratings of higher externalizing symptoms. These children may be particularly vulnerable to reactive aggression and emotional impulsivity with less skill to regulate their responses, similar to the relation found between externalizing symptoms and heightened skin conductance reactivity only in the context of low, and not high, effortful control (Cole, Zahn-Waxler, Fox, Usher, Welsh, & Strauss, 1996).

Contrary to our hypothesis, children with low frustration reactivity appeared to be at higher risk for externalizing symptoms. Again, viewing low frustration reactivity as under-arousal may suggest that these children are more prone to aggression, particularly proactive aggression. Prior research has found reduction to below baseline levels in men's heart rate during a conflict (similar to the pattern seen in children on the low extreme of reactivity in this study) was related to high levels of aggression, as well as antisocial and callous tendencies (Gottman et al., 1995). Additionally, under-arousal of the autonomic nervous system may lead to sensation seeking behaviors and risk taking in attempts to increase stimulation (Dierckx, 2014).

Interestingly, prior research examining preschool aged children with varying degrees of behavior problems found distinct response styles to negative mood induction related to increased externalizing symptoms (Cole et al., 1996). Specifically, two response styles emerged, one over-responsive indexed by lowered basal heart rate and high autonomic change and a second under-responsive indexed by a high stable heart rate with minimal reactivity. Autonomic arousal patterns found for the over-responsive group mirror the pattern found for highly reactive children in the current study and likely reflect children whose externalizing behaviors are primarily impulsive and threat reactive (Viding, Fontaine, & McCrory, 2012). The under-responsive group was found to have patterns of autonomic arousal more similar to those associated with antisocial traits in adults as opposed to the lower resting heart rate associated with aggression in school aged children (Raine, Venable, Mednick, 1997). Under-responsive children were found to have high levels of externalizing problems at both preschool and elementary school ages, as well as a greater likelihood to experience depressive and anxious symptoms by age 7. These results are consistent with findings for both externalizing and internalizing symptoms in the current study.

The role of effortful control in moderating the relation between low reactivity and externalizing symptoms is difficult to interpret. As opposed to acting as a buffer as it does for children with high reactivity, high effortful control appears to exacerbate externalizing symptoms for children with low reactivity. One possible explanation is that high effortful control may actually increase children's ability to engage in more planned and covert externalizing behavior, such as lying. Prior research has found measures of children's executive functioning to positively predict the likelihood a child would lie about a prohibited behavior (Talwar & Lee, 2008). Low reactivity and high effortful control may reflect children who are prone to more composed, rule-breaking and limit testing behaviors as compared to more emotionally reactive and impulsive behaviors. These types of behaviors are similar to conceptualizations of callous-unemotional traits and research on these characteristics may also support the current findings.

Callous-unemotional traits are characterized by a lack of guilt and empathy, shallow affect and difficulty learning from negative consequences, but generally are not related to deficits in intelligence or executive functioning seen in children with conduct problems without callous-unemotional traits (Frick & Viding, 2009). Correlational analyses demonstrated positive associations between ratings of children's callousness and uncaring characteristics with a number of indices of executive functioning, including inhibitory control, emotional control, working memory, and planning/organization (Ezpeleta, de la Osa, Granero, Penelo, & Domenech, 2013). Callous-unemotional traits are also associated with more severe and longer term behavioral problems than children demonstrating externalizing behaviors without these traits (Viding et al., 2012). Additionally, associations between low heart rate reactivity and callous-unemotional traits have been found in school-aged children (Anastassiou-Hadjicharalambous & Warden, 2008). Thus, it is possible that low heart rate reactivity to a frustrating task, high effortful control and

above average and increasing externalizing symptoms reflect children either prone to or at risk for callous-unemotional traits and potentially more severe symptoms at older ages.

Although it is not inconsistent that under-aroused children with low effortful control would have high initial externalizing symptoms, it remains unclear why children with low reactivity and low effortful control demonstrate reduction in symptoms over time. Given that high effortful control appears to exacerbate symptoms for low reactive children, maybe diminished ability to overtly regulate behavior actually reduces these children's engagement in the more severe and covert externalizing behaviors over time.

4.3 SUMMARY AND CONCLUSIONS

The current study explored individual variability in growth of temperament factors and how these factors may interact to shape children's adjustment over time. Although many of the findings were unexpected, they highlight the importance of exploring interactions between temperament factors as the impact of these factors on children's adjustment may vary greatly when considered in combination.

For children at risk or demonstrating early internalizing symptoms, regardless of reactivity, having higher effortful control resulted in improved symptom trajectories over time. Interestingly, frustration, and not fear, reactivity emerged as particularly salient for internalizing symptoms. Children with blunted reactivity to frustrating contexts or situations in which a goal is blocked appear to be uniquely susceptible to internalizing symptoms, but only in the context of low effortful control. Thus, for these children interventions geared at fostering regulatory abilities may be particularly important. It may be that blunted autonomic arousal in combination with deficits in attention and inhibitory control prevents children from persisting at difficult tasks

or rallying the resources needed to be effective resulting in higher levels of avoidance and withdrawal behaviors associated with internalizing symptoms. Additionally, if low frustration reactivity reflects under-arousal of BAS, interventions, like behavioral activation, focused on increasing exposure and sensitivity to rewarding contexts in an effort to reverse patterns of low approach may be effective for these children (Bijttebier et al., 2009).

For externalizing symptoms, two unique patterns appear to emerge that may be capturing different subtypes of externalizing behaviors. Specifically, children with high reactivity, either to frustrating or fear inducing contexts, demonstrated exacerbated symptom trajectories in the context of low effortful control. For these children, heightened emotion reactivity in combination with low regulation may result in impulsive, emotion driven or reactive behaviors resulting in increased symptom expression. In this context, early interventions that target strategies for regulating emotions and behavioral impulses may be most effective at reducing reactive behaviors stemming from hyperactive emotion reactivity. In contrast, children at the low extreme of either fear or frustration appear to demonstrate underarousal of physiological indices of emotion reactivity. This underarousal may relate to maladaptive behaviors either through diminished capacity to learn from mistakes and negative consequences or as efforts to increase stimulation through sensation seeking and risk taking behaviors. For these children, high effortful control does not appear to act as a buffer and may even facilitate proactive aggressive behaviors. Externalizing symptoms related to blunted emotion reactivity are unlikely to respond to interventions geared at emotion regulation strategies, suggesting different approaches to treatment are needed for these different subgroups.

4.4 STRENGTHS AND LIMITATIONS

A considerable strength of this study was the use of multiple assessment methods, including physiological, observed, neurocognitive, and questionnaire data, which helps minimize effects of reporter bias and shared method variance. Additionally, assessing reactivity using physiological indices, although likely complicating interpretation of results, was an important strength of this study. As effortful control was tested as a moderator of the relation between reactivity and children's adjustment, it was vital to assess reactivity at a level upstream of volitional regulatory processes to avoid confounding reactivity with regulation. In the current study, single indicators of physiological arousal were used for each dimension of reactivity, which were selected based on prior research suggesting these measures may more reliably capture individual differences in emotion reactivity (Zalewski et al., 2011).

Despite this strength in assessment, neither EDL nor HR reactivity are specific indicators of fear or frustration. As the physiological indicators selected are not unique to either fear or frustration responses, it is possible that they are not differentiating these components of negative reactivity despite being assessed during tasks designed to elicit a specific emotion. Rather these indices may reflect more general autonomic arousal. Additionally, prior research has found that EDA may reflect a more pure measure of emotional arousal than heart rate reactivity, which varies due to both emotional arousal and attentional focusing (Hubbard et al., 2004; Winton, Putnam, & Krauss, 1984). Unfortunately, measurement of EDA severely restricts hand mobility and as such EDA could not be assessed during the frustration eliciting task, which required children to have full range of dexterity to manipulate the task stimuli. The use of single indicators, the lack of precision in these measures, and lack of significant variability in latent growth factors may limit interpretations and limit the utility of these measures for exploring

developmental questions. Inclusion of additional physiological indices assessed across multiple tasks would strengthen these findings. Additionally, further research is needed to better understand relations between average levels of physiology, dynamic changes in physiology, and the constructs they are purported to measure.

Developmental research is optimal when it examines actual growth, which requires longitudinal designs and modeling of growth factors. Limited studies examining interactions between temperament characteristics have employed longitudinal designs and of the studies that have, very few controlled for prior levels of symptoms allowing for examination of relative change in outcomes and unique contribution of temperament to changes in outcomes. The current study is thus unique, adding to the literature through the use of longitudinal data, supporting conclusions about direction of effects, as well as examining transactional growth within a developmental framework.

Several additional limitations of the study are noted. First, the use of a community rather than clinical sample may limit the rates at which problem behaviors are exhibited, and, in fact, the level of symptoms reported by mothers was relatively low. Despite this, the use of a community sample allows for the examination of both normative levels of behaviors and the emergence of problems. Additionally, the sample was recruited to be diverse across family income, resulting in an economically diverse sample in which higher levels of psychopathology may be expected.

Second, the age of the participants was specifically chosen for a larger study examining the emergence and development of effortful control. This age range (toddler through preschool) is understood as a period of rapid development of effortful control and may be a particularly important window for understanding the impact of developmental trajectories of effortful control

on children's adjustment. Additionally, much of the current literature examining the interactions between temperament factors assesses temperament in infancy when reactivity is measurable but regulatory systems have not matured or in much later childhood, relying on parent or self-report of temperament. Few studies, however, have examined interactive effects of temperament during preschool when regulatory abilities first begin to stabilize and problem behaviors emerge. However, the young age of the participants in this study may have contributed to lower rates of symptoms, limiting the ability to relate temperament to later dysfunction. Additionally, children's effortful control abilities may not have matured enough for interactions with emotion reactivity to emerge. Thus, future research is encouraged to examine patterns of interactions between temperament factors at different developmental stages and over longer developmental periods.

Third, although the economic diversity of the sample may relate to increased range of reported symptoms and important heterogeneity of growth across time, it is possible that inclusion of such diverse environmental contexts may muddle interpretation of results. Specifically, prior research has found discrepant relations between children's psychophysiology and adjustment outcomes dependent on environmental contexts, like the chronic stress of living in poverty (Blair & Raver, 2012; Evans & Kim, 2013). Although income was included as a covariate predicting adjustment outcomes, small numbers of participants at each income level prevented the examination of possible differences based on children's environment, which may limit the generalizability of these findings. It will be important for future research to include larger subsamples to explore how patterns of emotion reactivity may relate to children's adjustment in different environmental contexts.

Finally, children's symptoms were assessed through mother-report only. Problem behaviors may emerge differently depending on context (e.g., home versus school), and with young children, mothers may have limited experience with other children by which to compare their own children's behaviors. Thus, the use of a single reporter may introduce bias in the outcome measures. It will be important for future analyses to test these relations with more comprehensive assessments of children's adjustment (e.g., teacher reports, observational measures).

4.5 IMPLICATIONS AND FUTURE DIRECTIONS

There is currently little to no research examining the relation between growth in temperament characteristics over time, interactions between temperamental reactivity and regulation, and how these interactions relate to the development of psychopathology. Given limited prior research and a number of unexpected relations, replication of these findings is important. Continued research is needed to establish a consistent pattern of findings and clarify the relation between reactive and regulatory dimensions of temperament and how these dimensions may interact to shape children's adjustment across development. Additionally, researchers are encouraged to employ multi-method designs that capture temperament from varying perspectives, the results from which may help to clarify current inconsistencies in the findings as well as shed light on what aspects of temperament are captured or overlooked when different sources of information are used. Establishing a better understanding of the more basic interactions between temperament dimensions may then allow for examination of more complex models that account for factors more distal from the child that are likely to impact the interplay between temperament and adjustment, such as environmental factors, like poverty or neighborhood risk, and familial

factors, like parenting styles. These more complex designs may require testing three-way interactions, latent profiles, or mediated-moderation models that help to explain not only under what conditions (i.e., through moderation) temperamental vulnerabilities influence adjustment, but also how (i.e., through mediation) this risk or resiliency is conferred.

It was hoped that this research would help to elucidate relations between emotion reactivity and symptoms of psychopathology, identify the importance of effortful control as a moderator of reactivity, and clarify whether initial levels or growth in effortful control impacts trajectories of symptom growth in children. Interactions implicating initial levels of effortful control as an important moderator of the relation between reactivity and symptom growth suggest that prevention efforts need to begin at earlier ages to boost the emergence of adequate regulation abilities for vulnerable children. Moderation by growth in effortful control, in contrast, suggests that the timing of interventions is less critical and that interventions designed to foster the strengthening and maturation of existing abilities may be sufficient.

Importantly, results from this study imply that strengthening effortful control abilities may not in fact provide resilience for all vulnerable children and may actually exacerbate symptoms for some. Children with patterns of physiological under-arousal to emotional contexts are, in particular, not protected against externalizing symptoms by higher effortful control, which should inform the approach of treatment. Children at risk for or displaying early externalizing symptoms who also demonstrate blunted emotion reactivity may benefit more from treatments that shape prosocial behaviors through contingency management to reduce antisocial or aggressive behaviors than from programs focused on emotion regulation strategies. Mindfulness-based strategies may be particularly relevant to help foster the appropriate development of empathy, conscience, and compassion in these children. In recent years, a number of

mindfulness-based interventions with young children have found promising results suggesting improved empathy, perspective-taking, emotional control, and prosocial behaviors, as well as decreased aggression and increased peer acceptance (Flook, Goldberg, Pinger, & Davidson, 2015; Schonert-Reichl et al., 2015; Weare, 2013). Additionally, as punishment related strategies are likely to be less effective for children with low physiological reactivity to fear, interventions emphasizing positive reinforcement and the rewards of prosocial behavior may be more effective (Viding et al., 2012).

Continued research in this domain may result in the development of more efficient and effective interventions by highlighting more specific targets for treatment, informing the optimal timing of intervention, and also identifying children who would most benefit from these interventions due to heightened risk from either higher reactivity and under-developed regulatory abilities or blunted reactivity to emotional contexts. Examining development through longitudinal models has shown that informed interventions may not only help to diminish concurrent symptoms, but also effectively place children on more adaptive developmental trajectories over the lifespan. The findings of this study highlight the complex interplay between dimensions of temperament and development. Continued research replicating and further exploring these patterns is direly needed.

REFERENCES

- Achenbach, T. M. (1991). *Manual for the Child Behavior Checklist/4-18 and 1991 Profile*. Burlington, VT: University of Vermont Department of Psychiatry.
- Anastassiou-Hadjicharalambous, X., & Warden, D. (2008). Physiologically-indexed and self-perceived affective empathy in conduct-disordered children high and low on callous-unemotional traits. *Child Psychiatry and Human Development, 39*, 503-517.
- Arbuckle, J. T. (1996). Full information estimation in the presence of incomplete data. In G. A. Marcoulides & R. E. Schumacker (Eds.), *Advanced structural equation modeling: Issues and techniques* (pp. 243-277). Hillsdale, NJ: Erlbaum.
- Beauchaine, T.P., Katkin, E.S., Strassberg, Z., & Snarr, J., (2001). Disinhibitory psychopathology in male adolescents: discriminating conduct disorder from attention-deficit/hyperactivity disorder through concurrent assessment of multiple autonomic states. *Journal of Abnormal Psychology 110*, 610–624.
- Belsky, J., Friedman, S. L., & Hsieh, K. H. (2001). Testing a core emotion-regulation prediction: Does early attentional persistence moderate the effect of infant negative emotionality on later development?. *Child Development, 72*, 1.
- Bijttebier, P., Beck, I., Claes, L., & Vandereycken, W. (2009). Gray's Reinforcement Sensitivity Theory as a framework for research on personality-psychopathology associations. *Clinical Psychology Review, 29*, 421-30.
- Bjorklund, D. F., & Kipp, K. (1996). Parental investment theory and gender differences in the evolution of inhibition mechanisms. *Psychological Bulletin, 120*, 163–188.
- Blair, C., & Raver, C. C. (2012). Child development in the context of adversity: Experiential canalization of brain and behavior. *American Psychologist, 67*, 309-318.

- Blanchard, D. C. & Takahasi, S. N. (1988). No change in intermale aggression after amygdala lesions which reduce freezing. *Physiology and Behavior*, *42*, 613-616.
- Brenner, S. L., Beauchaine, T. P., & Sylvers, P. D. (2005). A comparison of psychophysiological and self-report measures of BAS and BIS activation. *Psychophysiology*, *42*, 108-115.
- Boucsein, W. (2012). *Electrodermal activity*. Boston, MA: Springer US.
- Bush, G., Luu, P., & Posner, M. I. (2000). Cognitive and emotional influences in anterior cingulate cortex. *Trends in Cognitive Sciences*, *4*, 215-222.
- Calkins, S. D., & Keane, S. P. (2009). Developmental origins of early antisocial behavior. *Development and Psychopathology*, *21*, 1095-1109.
- Carlson, S. M., & Moses, L. J. (2001). Individual differences in inhibitory control and children's theory of mind. *Child Development*, *72*, 1032-1053.
- Caspi, A., Moffitt, T. E., Newman, D. L., & Silva, P. A. (1996). Behavioral observations at age 3 years predict adult psychiatric disorders: Longitudinal evidence from a birth cohort. *Archives of General Psychiatry*, *53*, 1033-1039.
- Cole, P. M., Teti, L. O., & Zahn-Waxler, C. (2003). Mutual emotion regulation and the stability of conduct problems between preschool and early school age. *Development & Psychopathology*, *15*, 1-18.
- Cole, P., Zahn-Waxler, C., Fox, N., Usher, B., Welsh, J., & Strauss, M. E. (1996). Individual differences in emotion regulation and behavior problems in preschool children. *Journal of Abnormal Psychology*, *105*, 518-529.
- Collins, L. M., Schafer, J. L., & Kam, C. M. (2001). A comparison of inclusive and restrictive strategies in modern missing-data procedures. *Psychological Methods*, *6*, 330-351.

- Connor, D., Steingard, R., Cunningham, J., Anderson, J., & Melloni, R. (2004). Proactive and reactive aggression in referred children and adolescents. *American Journal of Orthopsychiatry*, *74*, 129-136.
- Crockenberg, S. C., & Leerkes, E. M. (2006). Infant and maternal behavior moderate reactivity to novelty to predict anxious behavior at 2.5 years. *Development and Psychopathology*, *18*, 17-34.
- Davis, E. P., Bruce, J., & Gunnar, M. R. (2002). The anterior attention network: Associations with temperament and neuroendocrine activity in 6-year-old children. *Developmental Psychobiology*, *40*, 43-56.
- Deater-Deckard, K., Beekman, C., Wang, Z., Kim, J., Petrill, S. A., Thompson, L. A., et al. (2010). Approach/positive anticipation, frustration/anger, and overt aggression in childhood. *Journal of Personality*, *78*, 991-1010.
- Deater-Deckard, K., & Wang, Z. (2012). Anger and irritability. In M. Zentner & R. L. Shiner (Eds.), *Handbook of temperament* (pp. 124-144). New York, NY: Guilford Press.
- Degnan, K. A., Calkins, S. D., Keane, S. P., & Hill-Soderlund, A. L. (2008). Profiles of disruptive behavior across early childhood: Contributions of frustration reactivity, physiological regulation, and maternal behavior. *Child Development*, *79*, 1357-1376.
- Depue, R. A., & Iacono, W. G. (1989). Neurobehavioral aspects of affective disorders. In M. R. Rosenzweig & L. Y. Porter (Eds.), *Annual review of psychology* (Vol. 40, pp. 457-492). Palo Alto, CA: Annual Reviews.
- Derryberry, D., & Rothbart, M. K. (1997). Reactive and effortful processes in the organization of temperament. *Development and Psychopathology*, *9*, 633-652.

- Diener, M. L., & Kim, D. (2004). Maternal and child predictors of preschool children's social competence. *Applied Developmental Psychology, 25*, 3-24.
- Dierckx, B., Kok, R., Tulen, J., Jaddoe, V., Hofman, A., Verhulst, F., . . . Tiemeier, H. (2014). A prospective study of heart rate and externalising behaviours in young children. *Journal of Child Psychology and Psychiatry, 55*, 402-410.
- Egger, H. L., & Angold, A. (2006). Common emotional and behavioral disorders in preschool children: Presentation, nosology, and epidemiology. *Journal of Child Psychology and Psychiatry, 47*, 313-337.
- Eisenberg, N., Cumberland, A., Liew, J., Zhou, Q., Losoya, S. H., Valiente, C., et al. (2009). Longitudinal Relations of Children's Effortful Control, Impulsivity, and Negative Emotionality to Their Externalizing, Internalizing, and Co-Occurring Behavior Problems. *Developmental Psychology, 45*, 4, 988-1008.
- Eisenberg, N., Cumberland, A., Spinrad, T. L., Fabes, R. A., Shepard, S. A., Reiser, M., et al. (2001). The relations of regulation and emotionality to children's externalizing and internalizing problem behavior. *Child Development, 72*, 4.
- Eisenberg, N., Fabes, R. A., Guthrie, I. K., Murphy, B. C., Maszk, P., Holmgren, R., & Suh, K. (1996). The relations of regulation and emotionality to problem behavior in elementary school children. *Development and Psychopathology, 8*, 141-162.
- Eisenberg, N., Ma, Y., Change, L., Zhou, Q., West, S. G., & Aiken, L. (2007). Relations of effortful control, reactive undercontrol, and anger to Chinese children's adjustment. *Development and Psychopathology, 19*, 385-409.

- Eisenberg, N., Spinrad, T. L., Fabes, R. A., Reiser, M., Cumberland, A., Shepard, S. A., et al. (2004). The relations of effortful control and impulsivity to children's resiliency and adjustment. *Child Dev, 75*, 1, 25-46.
- Evans, G., & Kim, P. (2013). Childhood poverty, chronic stress, self-regulation, and coping. *Child Development Perspectives, 7*, 43-48.
- Ezpeleta, L., de la Osa, N., Granero, R., Penelo, E., & Domènech, J. (2013). Inventory of callous-unemotional traits in a community sample of preschoolers. *Journal of Clinical Child & Adolescent Psychology, 42*, 91-105.
- Flook, L., Goldberg, S. B., Pinger, L., & Davidson, R. J. (2015). Promoting prosocial behavior and self-regulatory skills in preschool children through a mindfulness-based kindness curriculum. *Developmental Psychology, 51*, 44-51.
- Fowles, D. C. (1980). The three arousal model: implications of gray's two-factor learning theory for heart rate, electrodermal activity, and psychopathy. *Psychophysiology, 17*, 87-104.
- Fowles, D. C., & Kochanska, G. (2000). Temperament as a moderator of pathways to conscience in children: The contribution of electrodermal activity. *Psychophysiology, 37*, 788- 795.
- Fowles, D., Kochanska, G., & Murray, K. (2000). Electrodermal activity and temperament in preschool children. *Psychophysiology, 37*, 777-787.
- Frick, P. J. & Morris, A. S. (2004). Temperament and developmental pathways to conduct problems. *Journal of Clinical Child and Adolescent Psychology, 33*, 54-68.
- Frick, P., & Viding, E. (2009). Antisocial behavior from a developmental psychopathology perspective. *Development and Psychopathology, 21*, 1111-31.
- Gagne, J.R., Van Hulle, C. A., Aksan, N., Essex, M. J., & Goldsmith, H. H. (2011). Deriving childhood temperament measures from emotion-eliciting behavioral episodes: Scale

- construction and initial validation. *Psychological Assessment*, 23, 337-353.
- Gerstadt, C.L., Hong, Y.J., Diamond, A. (1994). The relationship between cognition and action: Performance of children 3.5-7 years old on a Stroop-like day-night test. *Cognition*, 53, 129-153.
- Gilliom, M., Shaw, D. S., Beck, J. E., Schonberg, M. A., & Lukon, J. L. (2002). Anger regulation in disadvantaged preschool boys: Strategies, antecedents, and the development of self-control. *Developmental Psychology*, 38, 222–235.
- Goldsmith, H. H., & Lemery, K. S. (2000). Linking temperamental fearfulness and anxiety symptoms: A behavior-genetic perspective. *Biological Psychiatry*, 48(12), 1199-1209.
- Goldsmith, H. H., & Rothbart, M. K. (1991). Contemporary instruments for assessing early temperament by questionnaire and in the laboratory. In J. Strelau & A. Angleitner (Eds.), *Explorations in temperament: International perspectives on theory and measurement* (pp. 249–272). New York: Plenum.
- Gottman, J. M., Jacobson, N. S., Rushe, R. H., Shortt, J. W., Babcock, J. ... & Waltz, J. (1995). The relationship between heart rate reactivity, emotionally aggressive behavior, and general violence in batterers. *Journal of Family Psychology*, 9, 227-248.
- Gray, J. A. (1982). *The neuropsychology of anxiety: An enquiry into the functions of the septo-hippocampal system*. Oxford: Clarendon Press.
- Gray, J. A., & McNaughton, N. (2000). *The neuropsychology of anxiety: An enquiry into the functions of the septo-hippocampal system* (2nd ed.). Oxford: Oxford University Press.
- Hanish, L. D., Eisenberg, N., Fabes, R. A., Spinrad, T. L., Ryan, P., & Schmidt, S. (2004). The expression and regulation of negative emotions: Risk factors for young children's peer victimization. *Development & Psychopathology*, 16, 335-353.

- Hayward, C., Killen, J. D., Kraemer, H. C., & Taylor, C. B. (1998). Linking self-reported childhood behavioral inhibition to adolescent social phobia. *Journal of the American Academy of Child and Adolescent Psychiatry, 37*, 1308-1316.
- Hill-Soderlund, A. L., & Braungart-Rieker, J. M. (2008). Early individual differences in temperamental reactivity and regulation: Implications for effortful control in early childhood. *Infant Behavior & Development, 31*, 3.
- Holden, A. E., & Barlow, D. H. (1986). Heart rate and heart rate variability recorded in vivo in agoraphobics and nonphobics. *Behavior Therapy, 17*, 26-42.
- Hubbard, J. A., Parker, E. H., Ramsden, S. R., Flanagan, K. D., Relyea, N., Dearing, K. F., Smithmyer, C. M., ... Hyde, C. T. (2004). The Relations among observational, physiological, and self-report measures of children's anger. *Social Development, 13*, 14-39.
- Hubbard, J. A., Smithmyer, C. M., Ramsden, S. R., Parker, E. H., Flanagan, K. D., ... & Simons, R. F. (2002). Observational, physiological, and self-report measures of children's anger: Relations to reactive versus proactive aggression. *Child Development, 73*, 1101-1118.
- Jimenez-Camargo, L., Lochman, J., DeCaro, J., Parker, J., Salekin, R., & Sellbom, M.. (2014). *Predicting Childhood Externalizing Disorders in At-risk Youth: An Analysis of the Autonomic Nervous System, Temperament, and Parenting*, ProQuest Dissertations and Theses.
- Kagan, J. & Fox, N. A. (2006). Biology, culture, and temperamental biases. In N. Eisenberg, W. Damon, & R. M. Lerner (Eds.), *Handbook of child psychology: Vol. 3. Social, emotional, and personality development* (6th ed., pp. 167-225). New York: Wiley.

- Kagan, J., Snidman, N., Kahn, V., & Towsley, S. (2007). The preservation of two infant temperaments into adolescence. *Monographs of the Society for Research in Child Development, 72*, 1-95.
- Kagan, J., Snidman, N., Zentner, M., & Peterson, E. (1999). Infant temperament and anxious symptoms in school age children. *Developmental and Psychopathology, 11*, 209–224.
- Keiley, M. K., Lofthouse, N., Bates, J. E., Dodge, K. A., & Pettit, G. S. (2003). Differential risks of covarying and pure components in mother and teacher reports of externalizing and internalizing behavior across ages 5 to 14. *Journal of Abnormal Child Psychology, 31*, 267-83.
- Kempes, M., Matthys, W., de Vries, H., van Engeland, H. (2005). Reactive and proactive aggression in children: A review of theory, findings and the relevance for child and adolescent psychiatry. *European Child & Adolescent Psychiatry, 14*, 11-19. doi: 10.1007/s00787-005-0432-4
- Kiff, C. J., Lengua, L. J., & Bush, N. R. (2011). Temperament variation in sensitivity to parenting: Predicting changes in depression and anxiety. *Journal of Abnormal Child Psychology, 39*, 1199-1212.
- Kim, J., & Deater-Deckard, K. (2011). Dynamic changes in anger, externalizing and internalizing problems: Attention and regulation. *The Journal of Child Psychology and Psychiatry, 52*, 156-166.
- Klein, D. N., Dyson, M. W., Kujawa, A. J., Kotov, R. (2012). Temperament and internalizing disorders. In M. Zentner & R. L. Shiner (Eds.), *Handbook of temperament* (pp. 541-561). New York, NY: Guilford Press.

- Kochanska, G. (1991). Socialization and temperament in the development of guilt and conscience. *Child Development, 62*, 1379-1392.
- Kochanska, G. (1997). Multiple pathways to conscience for children with different temperaments: From toddlerhood to age 5. *Developmental Psychology, 33*(2), 228-240.
- Kochanska, G., Brock, R. L., Chen, K., Aksan, N., & Anderson, S. W. (2015). Paths from mother-child and father-child relationships to externalizing behavior problems in children differing in electrodermal reactivity: A longitudinal study from infancy to age 10. *Journal of Abnormal Child Psychology, 43*, 721-734.
- Kochanska, G., Murray, K., Jacques, T.Y., Koenig, A.L., & Vandegeest, K.A. (1996). Inhibitory control in young children and its role in emerging internalization. *Child Development, 67*, 490-507.
- Kolenikov, S., & Bollen, K. (2012). Testing negative error variances: Is a Heywood case a symptom of misspecification?. *Sociological Methods & Research, 41*, 124-167. doi: 10.1177/0049124112442138
- Korkman, M., Kirk, U., & Kemp, S. (1998). NEPSY: A Developmental Neuropsychological Assessment, Manual. Psychological Corporation.
- Krikorian, R., & Bartok, J. (1998). Developmental data for the Porteus Maze Test. *Child Neuropsychologist, 12*, 305-310.
- Lanteigne, D. M., Flynn, J. J., Eastabrook, J. M., & Hollenstein, T. (2014). Discordant patterns among emotional experience, arousal, and expression in adolescence: Relations with emotion regulation and internalizing problems. *Canadian Journal of Behavioural Science, 46*, 29-39.

- Lawrence, A. D. & Calder, A. J. (2004). Homologizing human emotions. In D. Evans & P. Cruse (Eds.), *Emotions, evolution, and rationality* (pp. 15-47). Oxford, England: Oxford University Press.
- Lemerise, E. A. & Harper, B. D. (2010). The development of anger from preschool to middle childhood: Expressing, understanding, and regulating anger. In M. Potegal, G. Stemmler, & C. D. Spielberger (Eds.), *International handbook of anger: Constituent and concomitant biological, psychological, and social processes* (pp. 219-230). New York: Springer.
- Lemery, K. S. (1999). Exploring the etiology of the relationship between temperament and behavior problems in children. Unpublished doctoral dissertation, University of Wisconsin, Madison.
- Lemery, K. S., Essex, M. J., & Smider, N. A. (2002). Revealing the relation between temperament and behavior problem symptoms by eliminating measurement confounding: Expert ratings and factor analyses. *Child Development, 73*, 867–882.
- Lengua, L. J. (2002). The Contribution of Emotionality and Self-Regulation to the understanding of Children's Response to Multiple Risk. *Child Development, 73*, 144-161.
- Lengua, L. J. (2003). Associations among emotionality, self-regulation, adjustment problems and positive adjustment in middle childhood. *Journal of Applied Developmental Psychology, 24*, 595-618.
- Lengua, L. J. (2006). Growth in temperament and parenting as predictors of adjustment during children's transition to adolescence. *Developmental Psychology, 42*, 819-832.

- Lengua, L. J. (2008). Anxiousness, frustration, and effortful control as moderators of the relation between parenting and adjustment in middle-childhood. *Social Development, 17*, 554-577.
- Lengua, L. J., Bush, N. R., Long, A. C., Kovacs, E. A., & Trancik, A. M. (2008). Effortful control as a moderator of the relation between contextual risk factors and growth in adjustment problems. *Development and Psychopathology, 20*, 509-528.
- Lengua, L. J., Honorado, E., & Bush, N. R. (2007). Contextual risk and parenting as predictors of effortful control and social competence in preschool children. *Journal of Applied Developmental Psychology, 28*, 40-55.
- Lengua, L. J., Sadowski, C. A., Friedrich, W. N., & Fisher, J. (2001). Rationally and empirically derived dimensions of children's symptomatology: Expert ratings and confirmatory factor analyses of the CBCL. *Journal of Consulting and Clinical Psychology, 69*, 683-698.
- Liew, J., Eisenberg, N., & Reiser, M. (2004). Preschoolers' effortful control and negative emotionality, immediate reactions to disappointment, and quality of social functioning. *Journal of Experimental Child Psychology, 89*, 4.
- Lorber, M.F., (2004). Psychophysiology of aggression, psychopathy and conduct problems: a meta- analysis. *Psychological Bulletin, 130*, 531–552.
- Loukas, A., & Robinson, S. (2004). Examining the moderating role of perceived school climate in early adolescent adjustment. *Journal of Research on Adolescence, 14*, 209-233.
- Marcynyszyn, L. A. (2007). Contributions of attentional and behavioral regulation to socioemotional adjustment and early academic success among head start graduates. Unpublished doctoral dissertation, Cornell University, Ithaca, NY.

- McIntosh, D. N., Miller, L. J., Shyu, V., Hagerman, R. J. (1999). Sensory-modulation disruption, electrodermal responses, and functional behaviors. *Developmental Medicine & Child Neurology, 41*, 608-615.
- Merikangas, K. R. & He, J. (2014). Epidemiology of mental disorders in children and adolescence: Background and U.S. studies. In J. Raynaud, S. S. Gau, & M. Hodes (Eds.), *From research to practice in child and adolescent mental health* (pp. 19-48), Lanham, MA: Rowman & Littlefield.
- Mervielde, I., & De Pauw, S. S. W. (2012). Models of child temperament. In M. Zentner & R. L. Shiner (Eds.), *Handbook of temperament* (pp. 21-40). New York, NY: Guilford Press.
- Mesman, J., & Koot, H. M. (2001). Early preschool predictors of preadolescent internalizing and externalizing DSM-IV diagnoses. *Journal of the American Academy of Child and Adolescent Psychiatry, 40*, 1029–1036.
- Moran, L. R., & Lengua, L. J. (in preparation). Negative emotionality and self-regulation: A review of interactive effects predicting social-emotional development.
- Moran, L. R., Lengua, L. J., & Zalewski, M. (2013). The interaction between negative emotionality and effortful control in early social-emotional development. *Social Development, 22*, 340-362.
- Muris, P. (2006). Unique and interactive effects of neuroticism and effortful control on psychopathological symptoms in non-clinical adolescents. *Personality and Individual Differences, 40*, 7, 1409-1419.
- Muris, P., de Jong, P. J., & Engelen, S. (2004). Relationships between neuroticism, attentional control, and anxiety disorders symptoms in non-clinical children. *Personality and Individual Differences, 37*, 789-797.

- Muris, P., & Ollendick, T. H. (2005). The role of temperament in the etiology of child psychopathology. *Clinical Child and Family Psychology Review*, 8, 271-289.
- Muris, P., van der Pennen, E., Sigmond, R., & Mayer, B. (2008). Symptoms of anxiety, depression, and aggression in non-clinical children: relationships with self-report and performance-based measures of attention and effortful control. *Child Psychiatry and Human Development*, 39(4), 455-467.
- Murray, K. T., & Kochanska, G. (2002). Effortful control: factor structure and relation to externalizing and internalizing behaviors. *J Abnorm Child Psychol*, 30, 5, 503-514.
- Muthén, B. O., & Asparouhov, T. (2003). Modeling interactions between latent and observed continuous variables using maximum-likelihood estimation in Mplus. *Mplus Web Notes*, 6, 1-9.
- Muthén, L. K. & Muthén, B. O. (2010). Mplus Short Courses. Growth modeling with latent variables using Mplus. Handout.
- Muthén, L. K. & Muthén, B. O. (1998-2006). *Mplus User's Guide*. Fourth Edition. Los Angeles, CA: Muthén & Muthén.
- Oakes, L. M. (2015). A biopsychosocial perspective on looking behavior in infancy. In S. D. Calkins (Ed.), *Handbook of infant biopsychosocial development* (pp. 38-70), New York, NY: Guilford Press.
- Oldehinkel, A. J., Hartman, C. A., Ferdinand, R. F., Verhulst, F. C., & Ormel, J. (2007). Effortful control as modifier of the association between negative emotionality and adolescents' mental health problems. *Developmental Psychopathology*, 19(2), 523-539.
- Oldehinkel, A. J., Hartman, C. A., De Winter, A. F., Veenstra, R., & Ormel, J. (2004). Temperament profiles associated with internalizing and externalizing problems in

- preadolescence. *Development and Psychopathology*, 16, 421-440.
- Olson, S. L., Sameroff, A. J., Kerr, D. C., Lopez, N. L., & Wellman, H. M. (2005). Developmental foundations of externalizing problems in young children: the role of effortful control. *Developmental Psychopathology*, 17, 25-45.
- Panee, C. D., & Ballard, M. E. (2002). High versus low aggressive priming during video-game training: Effects on violent action during game play, hostility, heart rate, and blood pressure. *Journal of Applied Social Psychology*, 32, 2458-2474.
- Pardini, D., Lochman, J., & Wells, K. (2004). Negative emotions and alcohol use initiation in high-risk boys: The moderating effect of good inhibitory control. *Journal of Abnormal Child Psychology*, 32, 505-518.
- Perlis, R. H., Fava, M., Trivedi, M. H., Alpert, J., Luther, J. F., Wisniewski, S. R., & John, R. A. (2009). Irritability is associated with anxiety and greater severity, but not bipolar spectrum features, in major depressive disorder. *Acta Psychiatrica Scandinavica*, 119, 282-289.
- Perou, R., Bitsko, R., Blumberg, S., Pastor, P., Ghandour, R., Gfroerer, J., . . . Huang, L. (2013). Mental health surveillance among children--United States, 2005-2011. *MMWR Supplements*, 62, 1-35.
- Petersen, S. E., & Posner, M. I. (2012). The attention system of the human brain: 20 years after. *Annual Review of Neuroscience*, 35, 73-89.
- Ponitz, C. E., McClelland, M. M., Jewkes, A. M., Connor, C. M., Farris, C. L., & Morrison, F. J. (2008). Touch your toes! Developing a direct measure of behavioral regulation in early childhood. *Early Childhood Research Quarterly*, 23, 141-158.
- Posner, M. I., & DiGirolamo, G. J. (1998). Executive attention: Conflict, target detection, and

- cognitive control. In R. Parasuraman (Ed.), *The attentive brain* (pp. 401-423).
Cambridge, MA: MIT Press.
- Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience, 13*, 25-42.
- Posthumus, J. A., Böcker, K. E., Raaijmakers, M. J., van Engeland, H. H., & Matthys, W. W. (2009). Heart rate and skin conductance in four-year-old children with aggressive behavior. *Biological Psychology, 82*, 164-168.
- Raine, A., Reynolds, C., Venables, P. H., Mednick, S. A., & Farrington, D. P. (1998). Fearlessness, stimulation-seeking, and large body size at age 3 years as early predispositions to childhood aggression at age 11 years. *Archives of General Psychiatry, 55*(8), 745-751.
- Raine, A., Venables, P. H., & Mednick, S. A. (1997). Low resting heart rate at age 3 years predisposes to aggression at age 11 years: Evidence from the Mauritius Child Health Project. *Journal of the American Academy of Child and Adolescent Psychiatry, 36*, 1457-1464.
- Rettew, D., & McKee, L. (2005). Temperament and Its Role in Developmental Psychopathology. *Harvard Review of Psychiatry, 13*, 14-27.
- Riley, W. T., Treiber, F. A., & Woods, M. G. (1989). Anger and hostility in depression. *The Journal of Nervous and Mental Disease, 177*, 668-674.
- Rothbart, M. K. (1981). Measurement of temperament in infancy. *Child Development, 52*(2), 569-578.
- Rothbart, M. K. (2007). Temperament, development, and personality. *Current Directions in Psychological Science, 16*, 4, 207-212.

- Rothbart, M. K., & Ahadi, S. A. (1994). Temperament and the development of personality. *Journal of Abnormal Psychology, 103*, 55-66.
- Rothbart, M. K., Ahadi, S. A., & Evans, D. E. (2000). Temperament and personality: Origins and outcomes. *Journal of Personality and Social Psychology, 78*, 122-135.
- Rothbart, M. K., Ahadi, S. A., & Hershey, K. L. (1994). Temperament and social behavior in childhood. *Merrill-palmer Quarterly: Journal of Developmental Psychology, 40*, 21-39.
- Rothbart, M. K., Ahadi, S. A., Hershey, K. L., & Fisher, P. (2001). Investigations of temperament at three to seven years: The Children's Behavior Questionnaire. *Child Development, 72*, 1394-1408.
- Rothbart, M. K., & Bates, J. E. (1998). Temperament. In W. Damon & N. Eisenberg (Eds.), *Handbook of child psychology: Social, emotional and personality development*, (5th ed.). New York: John Wiley & Sons.
- Rothbart, M. K., & Bates, J. E. (2006). Temperament. In W. Damon (Series Ed.) & N. Eisenberg (Vol. Ed), *Handbook of child psychology: Vol. 3. Social, emotional, and personality development* (6th ed.; pp. 105-176). New York: Wiley.
- Rothbart, M. K., & Derryberry, D. (1981). Development of individual differences in temperament. In M. E. Lamb & A. L. Brown (Eds.), *Advances in developmental psychology* (Vol. 1, pp. 37-86). Hillsdale, NJ: Erlbaum.
- Rothbart, M. K., Derryberry, D., & Posner, M. I. (1994). A psychobiological approach to the development of temperament. In J. E. Bates & T. D. Wachs (Eds.), *Temperament: Individual differences at the interface of biology and behavior* (pp. 83-116). Washington, DC: American Psychological Association.

- Rothbart, M. K., Ellis, L. K., Rueda, R. M., & Posner, M. I. (2003). Developing mechanisms of temperamental effortful control. *Journal of Personality, 71*, 1113-1144.
- Rothbart, M. K., & Jones, L. B. (1998). Temperament, self-regulation, and education. *School Psychology Review, 27*, 4.
- Rothbart, M., & Posner, M. (2005). Genes and experience in the development of executive attention and effortful control. *New Directions for Child and Adolescent Development, 109*, 101-108.
- Rueda, M. R. (2012). Effortful control. In M. Zentner & R. L. Shiner (Eds.), *Handbook of temperament* (pp. 145-167). New York, NY: Guilford Press.
- Ruff, H. A., & Rothbart, M. K. (1996). *Attention in early development: Themes and variations*. New York: Oxford University Press.
- Rydell, A. M., Berlin, L., & Bohlin, G. (2003). Emotionality, emotion regulation, and adaptation among 5- to 8-year-old children. *Emotion, 3*(1), 30-47.
- Schonert-Reichl, K. A., Oberle, E., Lawlor, M. S., Abbott, D., Thomson, K., Oberlander, T. F., & Diamond, A. (2015). Enhancing cognitive and social-emotional development through a simple-to-administer mindfulness-based school program for elementary school children: A randomized controlled trial. *Developmental Psychology, 51*, 52-66.
- Schwartz, C. E., Snidman, N., & Kagan, J. (1996). Early childhood temperament as a determinant of externalizing behavior in adolescence. *Development and Psychopathology, 8*, 527-537.
- Shaw, D. S., Gilliom, M., Ingoldsby, E. M., & Nagin, D. S. (2003). Trajectories leading to school-age conduct problems. *Developmental Psychology, 39*, 189-200.

- Sportel, B. E., Nauta, M. H., de Hullu, E., de Jong, P. J., Hartman, C. A. (2011). Behavioral inhibition and attentional control in adolescents: Robust relationships with anxiety and depression. *Journal of Child and Family Studies, 20*, 149-156.
- Talwar, V., & Lee, K. (2008). Social and cognitive correlates of children's lying behavior. *Child Development, 79*, 866–881.
- Valiente, C., Eisenberg, N., Smith, C. L., Reiser, M., Fabes, R. A., Losoya, S., et al. (2003). The Relations of Effortful Control and Reactive Control to Children's Externalizing Problems: A Longitudinal Assessment. *Journal of Personality, 71*, 6, 1171-1196.
- Viding, E., Fontaine, N. M. G., McCrory, E. J. (2012). Antisocial behavior in children with and without callous-unemotional traits. *Journal of the Royal Society of Medicine, 105*, 195-200.
- Vitiello, B., & Stoff, D. (1997). Subtypes of aggression and their relevance to child psychiatry. *Journal of the American Academy of Child and Adolescent Psychiatry, 36*, 307-15.
- Wallien, M. S. C., van Goozen, S. H. M., & Cohen-Kettenis, P. T. (2007). Physiological correlates of anxiety in children with gender identity disorder. *European Child & Adolescent Psychiatry, 16*, 309–315.
- Weare, K. (2013). Developing mindfulness with children and young people: A review of the evidence and policy context. *Journal of Children's Services, 8*, 141-153.
- White, L. K., McDermott, J. M., Degnan, K. A., Henderson, H. A., & Fox, N. A. (2011). Behavioral inhibition and anxiety: The moderating roles of inhibitory control and attention shifting. *Journal of Abnormal Child Psychology, 39*, 735-747.
- Winton, W. M., Putnam, L. E., & Krauss, R. M. (1984). Facial and autonomic manifestations of

the dimensional structure of emotion. *Journal of Experimental Social Psychology*, 20, 195–216.

Wong, M. M., Nigg, J. T., Zucker, R. A., Puttler, L. I., Fitzgerald, H. E., Jester, J. M., Glass, J. M., ... Adams, K. (2006). Behavioral control and resiliency in the onset of alcohol and illicit drug use: A prospective study from preschool to adolescence. *Child Development*, 77, 1016-1033.

Zalewski, M., Lengua, L. J., Wilson, A. C., Trancik, A., & Bazinet, A. (2011). Emotion regulation profiles, temperament, and adjustment problems in preadolescents. *Child Development*, 82, 951-966.

Zelazo, P. D., Muller, U., Frye, D., & Marcovitch, S. (2003). The development of executive function in early childhood. *Monographs of the society for research in child development*, 68(3), 1-151.

Zhou, Q., Lengua, L., & Wang, Y. (2009). The relations of temperament reactivity and effortful control to children's adjustment problems in China and the United States. *Developmental Psychology*, 45(3), 724–739.

Table 1. *Family Income Category Distributed by Recruitment Source*

	Poverty (n = 50)	150% Poverty (n = 44)	200% Poverty (n = 36)	Low Income (n = 56)	Middle & High Income (n = 120)
UW Subject Pool	31	31	29	47	72
Community Center	6	3	0	0	3
Daycares & Schools	7	6	5	5	25
Print Advertisements/Referrals	6	4	2	4	20

Note. UW = University of Washington.

Table 2. *Relations between Missing Data and Study Variables*

	Missing <i>Mean (SD)</i>	No Missing <i>Mean (SD)</i>	<i>t</i> Test <i>Estimate (df)</i>	Correlation <i>r</i>
Effortful Control				
Time 1	0.25 (0.13)	0.29 (0.15)	-2.11 (77.68)*	-.11
Time 3	0.61 (0.18)	0.69 (0.17)	-2.55 (286)*	-.15*
Covariates				
Income	7.34 (4.34)	9.00 (3.80)	-2.35 (64.47)*	-.15*
Cog. Ability	0.20 (0.09)	0.23 (0.07)	-2.81 (304)*	-.16**

Note. Missing coded 1 = missing on any variable, 0 = no missing; * $p < .05$; ** $p < .01$.

Table 3. *Estimated Means, Standard Deviations, and Correlations Among Study Variables*

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Income	-																			
2. Gender	-.05	-																		
3. Cog. Ab.	.23**	-.15**	-																	
4. Fear T1	-.01	-.15	.25*	-																
5. Fear T2	.12	.02	.03	.19	-															
6. Fear T3	-.01	-.01	.03	.23*	.11	-														
7. Frust. T1	-.12	.08	.11	.10	-.01	.01	-													
8. Frust. T2	.002	.01	.15*	.17	.04	-.03	.14	-												
9. Frust. T3	.10	.02	.17**	.12	.08	-.02	.15	.17*	-											
10. EC T1	.19**	-.09	.52**	.25*	-.06	.12	.07	.09	.16*	-										
11. EC T2	.24**	-.12*	.57**	.20	-.09	.08	.09	.11	.20**	.50**	-									
12. EC T3	.24**	-.11	.57**	.31**	.05	.04	.05	.18**	.25**	.53**	.61**	-								
13. Int. T1	.06	.02	.03	-.14	.08	-.04	.02	.03	-.04	-.01	-.01	-.03	-							
14. Int. T2	-.19**	-.02	.06	-.18	-.05	-.04	.17*	-.02	-.04	.01	-.03	-.07	.58**	-						
15. Int. T3	-.15*	-.01	.03	-.17	.01	-.01	.04	-.01	-.01	.02	-.03	-.03	.56**	.68**	-					
16. Int. T4	-.12*	.01	.07	-.02	.05	.04	.12	.01	-.02	.04	-.02	.01	.51**	.51**	.66**	-				
17. Ext. T1	-.02	.13*	-.07	-.18	.27**	-.03	.07	-.03	.02	-.08	-.08	-.11	.34**	.22**	.27**	.27**	-			
18. Ext. T2	-.16**	.14*	-.13*	-.15	.16*	-.02	.08	-.10	-.14*	-.11	-.12	-.16**	.27**	.39**	.31**	.28**	.66**	-		
19. Ext. T3	-.13*	.17**	-.08	-.10	.08	-.06	.11	-.05	-.03	-.05	-.09	-.07	.34**	.38**	.50**	.43**	.56**	.68**	-	
20. Ext. T4	-.19**	.13*	-.09	-.01	.11	.05	.12	-.04	-.10	-.06	-.08	-.08	.26**	.25**	.41**	.58**	.54**	.61**	.74**	-
<i>M</i>	8.75	-	0.23	2.27	2.61	3.05	4.56	5.07	6.56	0.29	0.49	0.68	4.67	4.87	4.91	5.15	5.87	5.91	5.56	5.23
<i>SD</i>	3.93	-	0.08	2.43	2.86	4.13	5.13	6.14	6.46	0.15	0.20	0.17	3.55	3.78	4.13	4.49	3.49	3.78	3.69	4.11

Note. * $p < .05$. ** $p < .01$. Cog. Ab. = child cognitive ability at Time 1; Frust. = physiological frustration reactivity; EC = effortful control; Int. = internalizing symptoms; Ext. = externalizing symptoms.

Table 4. *Estimates, Standard Errors, and Fit Statistics for the Unconditional Models*

Variable	Model Fit	Parameter	Mean Estimate (SE)	Variance Estimate (SE)
Fear	$\chi^2 = \text{N.S.}$ RMSEA = 0.00 CFI = 1.00 SRMR = 0.02	Intercept	2.23 (0.21)**	1.37 (0.52)**
		Linear Slope	0.39 (0.17)*	N.S. ^a
Frustration	$\chi^2 = \text{N.S.}$ RMSEA = 0.03 CFI = 0.96 SRMR = 0.02	Intercept	4.41 (0.35)**	4.43 (5.57)
		Linear Slope	1.00 (0.26)**	0.70 (2.99)
Effortful Control	$\chi^2 = \text{N.S.}$ RMSEA = 0.00 CFI = 1.00 SRMR = 0.01	Intercept	0.29 (0.01)**	0.02 (0.003)**
		Linear Slope	0.20 (0.01)**	0.01 (0.001)**
Internalizing ^b	$\chi^2 = \text{N.S.}$ RMSEA = 0.00 CFI = 1.00 SRMR = 0.004	Status	5.10 (0.26)**	19.26 (2.96)**
		Linear Slope	0.15 (0.25)	11.04 (3.10)**
		Quadratic Slope	0.004 (0.08)	0.67 (0.20)**
Externalizing	$\chi^2 = \text{N.S.}$ RMSEA = 0.06 CFI = 0.99 SRMR = 0.02	Status	5.22 (0.23)**	13.04 (1.34)**
		Linear Slope	-0.25 (0.07)**	0.73 (0.16)**

Note. ** $p < .01$. ^a Estimation of the variance in the linear slope of fear reactivity resulted in a Heywood case for slope variance. As the variance was very small and not significant, it was fixed to zero and not estimated. ^b The unconditional growth model for internalizing demonstrated better fit including quadratic growth. However, covariance between the linear and quadratic slopes was extremely high ($r = .98$) leading to instability in the models when predictors were added. Therefore, in conditional models, only the linear slope was used as an outcome.

Table 5. *Descriptive Statistics of Physiological Indices at Baseline and during Emotion Eliciting Tasks*

	N	Baseline		Emotion Task		Reactivity Score	
		Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
Frustration							
Time 1	234	105.47 (8.76)	86.07-137.01	109.97 (8.42)	87.37-140.57	4.56 (5.13)	-7.84-21.43
Time 2	250	100.39 (9.66)	73.10-125.78	105.27 (9.87)	81.20-130.12	5.07 (6.14)	-14.60-25.12
Time 3	267	96.27 (9.53)	66.89-125.51	102.93 (9.32)	77.03-144.09	6.56 (6.46)	-12.61-35.55
Average	287	-	-	-	-	5.50 (4.56)	-7.33-17.05
Fear							
Time 1	99	4.56 (3.99)	0.11-20.62	6.88 (5.79)	0.14-32.80	2.30 (2.45)	-1.32-12.18
Time 2	223	4.32 (4.11)	0.04-20.72	6.98 (6.11)	0.06-27.28	2.62 (2.87)	-0.66-18.71
Time 3	252	4.89 (4.41)	0.07-18.53	7.96 (7.43)	0.10-39.22	3.09 (4.17)	-1.87-29.47
Average	290	-	-	-	-	2.67 (2.50)	-1.32-17.11

Table 6. Comparison of Physiological Indices at High and Low Levels of Reactivity

	Fear Reactivity				Frustration Reactivity			
	<i>Baseline</i>		<i>Emotion Eliciting</i>		<i>Baseline</i>		<i>Emotion Eliciting</i>	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
Low	26	1.78 (2.60)	26	1.58 (2.45)	42	104.79 (8.22)	37	103.17 (7.94)
Mean	58	5.50 (3.67)	58	8.18 (3.77)	59	100.36 (6.93)	57	105.99 (6.98)
High	37	7.22 (3.27)	37	15.04 (4.23)	39	98.21 (7.74)	34	109.67 (8.17)

Note: Mean and standard deviation of physiological index at baseline and during emotion eliciting task calculated at or below -1SD (low), at or above +1SD (high), and between -1/4 to +1/4 SD (mean) of reactivity scores.

Table 7. Parameters from Conditional Growth Models Testing Internalizing Symptoms

Interactions with Frustration Reactivity						
Variable	Status			Slope		
	<i>B</i>	<i>SE</i>	<i>Z</i>	<i>B</i>	<i>SE</i>	<i>Z</i>
Income	-0.16	0.08	-1.97*	-0.06	0.03	-2.11*
Gender	-0.27	0.50	-0.55	-0.13	0.15	-0.88
Cognitive Ability	5.13	3.95	1.30	0.53	1.24	0.43
Direct Effects:						
Fear	0.06	0.10	0.56	0.02	0.03	0.67
Frustration	-0.06	0.14	-0.44	0.002	0.05	0.04
Effortful Control:						
Intercept	-1.05	2.72	-0.39	0.60	2.16	0.28
Slope	-2.45	4.01	-0.61	1.72	4.07	0.42
Interaction Effects:						
Frustr. x EC Intercept	-0.29	0.46	-0.63	-0.41	0.16	-2.53**
Frustr. x EC Slope	0.32	0.61	0.53	-0.17	0.19	-0.89
Interactions with Fear Reactivity						
Variable	Status			Slope		
	<i>B</i>	<i>SE</i>	<i>Z</i>	<i>B</i>	<i>SE</i>	<i>Z</i>
Income	<i>-0.16</i>	<i>0.08</i>	<i>-1.88t</i>	-0.05	0.03	-1.94*
Gender	-0.14	0.49	-0.29	-0.08	0.15	-0.51
Cognitive Ability	5.15	4.01	1.28	0.87	1.24	0.70
Direct Effects:						
Fear	-0.36	0.28	-1.30	-0.03	0.07	-0.46
Frustration	0.03	0.06	0.44	0.02	0.02	0.89
Effortful Control:						
Intercept	-0.82	2.55	-0.32	0.21	2.05	0.10
Slope	-1.56	3.76	-0.41	2.47	3.28	0.75
Interaction Effects:						
Fear x EC Intercept	0.17	0.90	0.19	0.03	0.23	0.14
Fear x EC Slope	2.22	1.50	1.48	0.30	0.41	0.73

Note. ^t $p < .06$; * $p < .05$; ** $p < .01$. Frustr. = frustration reactivity; EC = effortful control. Status is coded as final time point.

Table 8. *Parameters from Conditional Growth Models Testing Externalizing Symptoms*

Interactions with Frustration Reactivity						
Variable	Status			Slope		
	<i>B</i>	<i>SE</i>	<i>Z</i>	<i>B</i>	<i>SE</i>	<i>Z</i>
Income	-0.19	0.08	-2.47*	-0.05	0.02	-2.18*
Gender	0.96	0.46	2.06*	-0.02	0.14	-0.15
Cognitive Ability	-0.21	3.80	-0.06	0.10	1.06	0.09
Direct Effects:						
Fear	0.06	0.08	0.77	-0.004	0.03	-0.16
Frustration	-0.06	0.13	-0.46	0.01	0.03	0.21
Effortful Control:						
Intercept	-0.37	2.34	-0.16	0.63	0.76	0.83
Slope	-1.80	3.39	-0.53	-0.08	1.11	-0.08
Interaction Effects:						
Frust. x EC Intercept	-0.69	0.39	-1.75 ^t	-0.21	0.10	-2.16*
Frust. x EC Slope	-0.21	0.61	-0.35	-0.17	0.16	-1.02
Interactions with Fear Reactivity						
Variable	Status			Slope		
	<i>B</i>	<i>SE</i>	<i>Z</i>	<i>B</i>	<i>SE</i>	<i>Z</i>
Income	-0.17	0.08	-2.26*	-0.05	0.02	-2.00*
Gender	1.13	0.46	2.47*	0.03	0.14	0.20
Cognitive Ability	0.10	3.89	0.03	0.03	1.05	0.03
Direct Effects:						
Fear	-0.43	0.27	-1.58	-0.11	0.11	-1.02
Frustration	-0.03	0.05	-0.49	0.00	0.02	0.003
Effortful Control:						
Intercept	-0.46	2.26	-0.20	0.64	0.77	0.83
Slope	0.09	3.51	0.03	0.54	1.23	0.44
Interaction Effects:						
Fear x EC Intercept	0.48	0.60	0.80	0.41	0.20	2.00*
Fear x EC Slope	2.75	1.29	2.13*	0.71	0.54	1.31

Note. ^t $p < .08$; * $p < .05$; ** $p < .01$. Frust. = frustration reactivity; EC = effortful control. Status is coded as final time point.

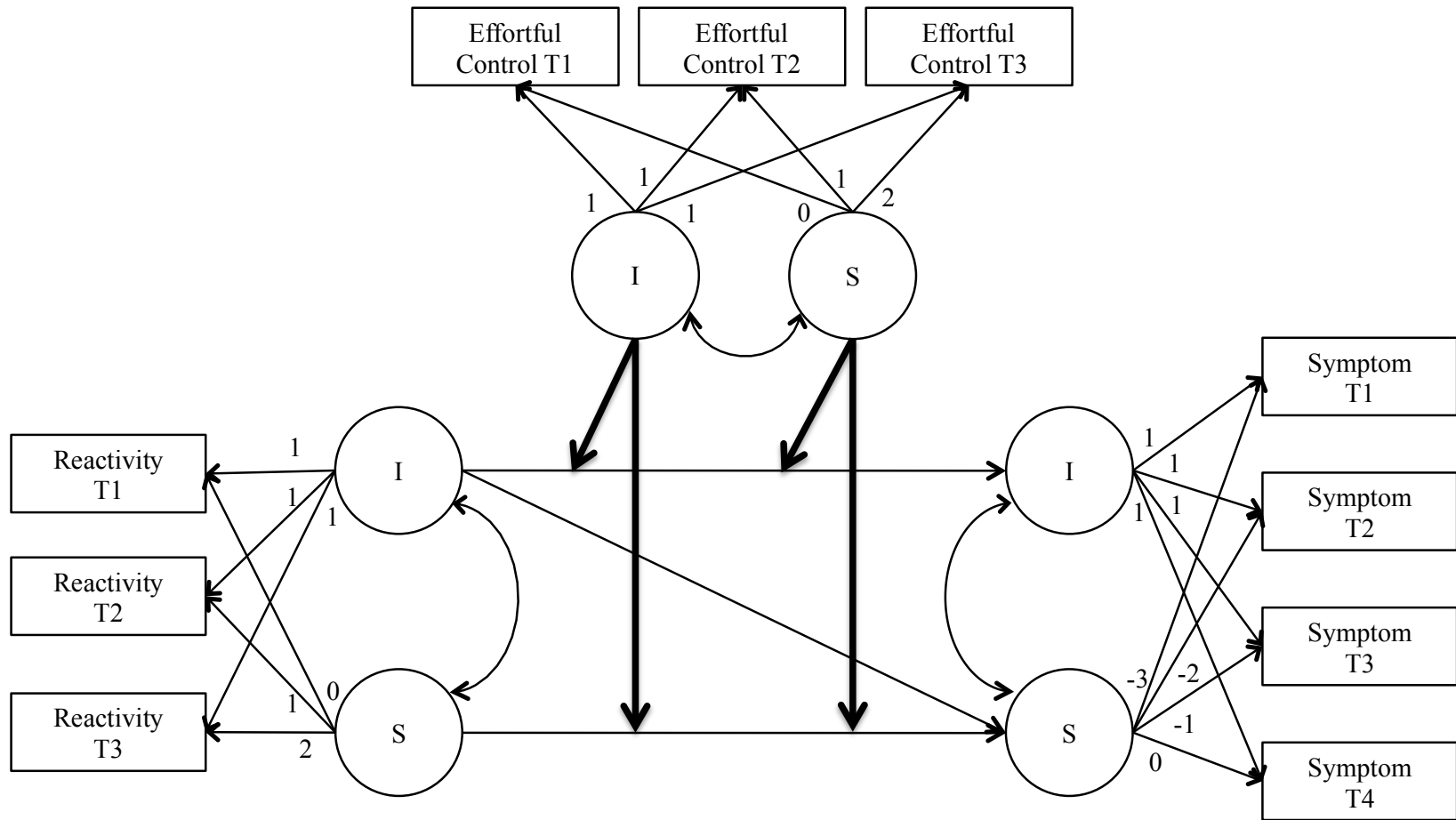


Figure 1. *Full theoretical model.*

The full model to be explored includes latent growth curves of effortful control, reactivity, and symptoms with direct effects and moderation (bolded lines represent interactions). Four models tested fear and frustration reactivity each predicting internalizing and externalizing symptoms.

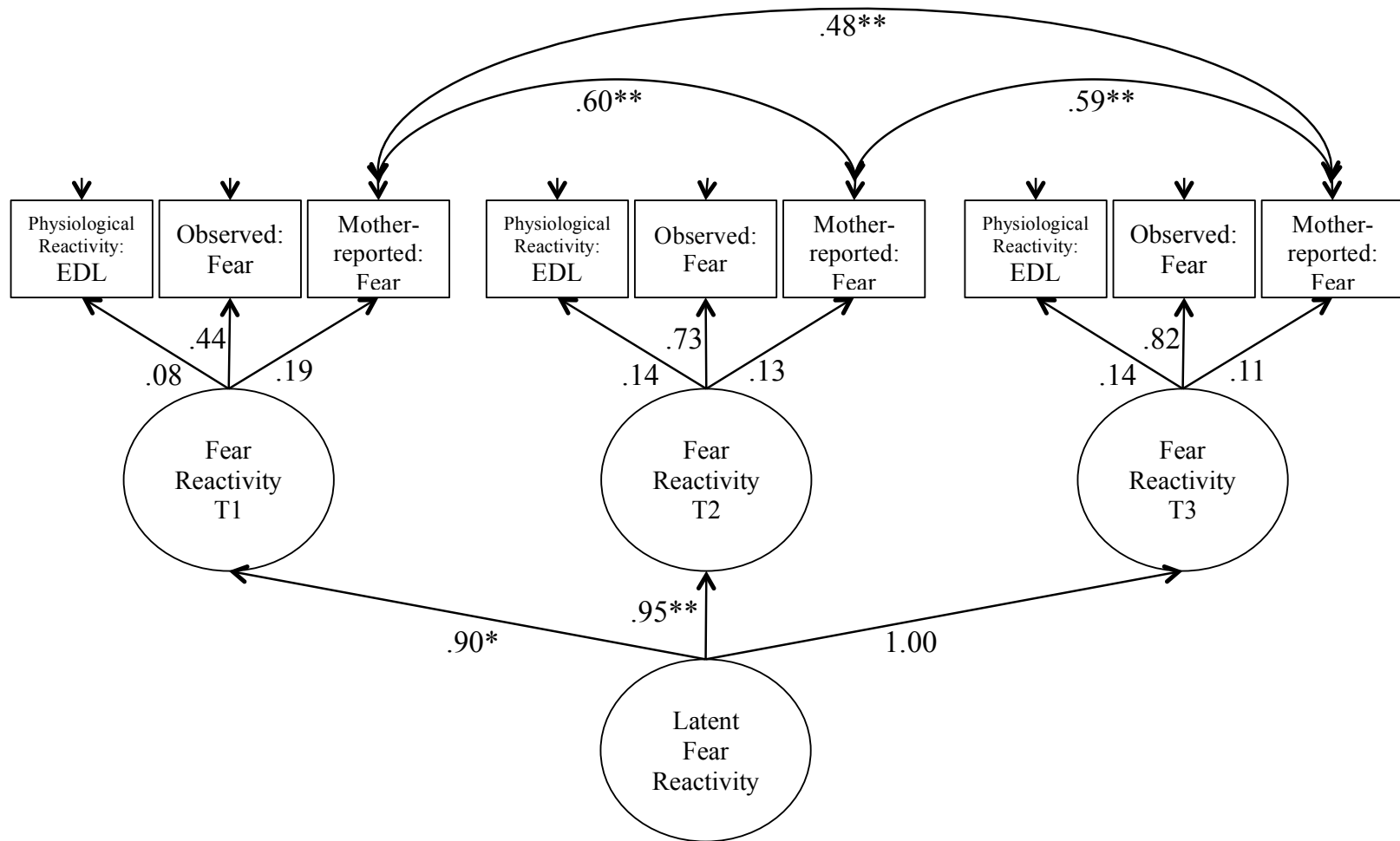


Figure 2. *Confirmatory factor analysis: Measurement of fear reactivity.*

Standardized loadings are reported. All correlations between identical methods were modeled, but only significant correlations are included in the figure. The model for frustration reactivity failed to converge. *Note:* * $p < .05$; ** $p < .01$.

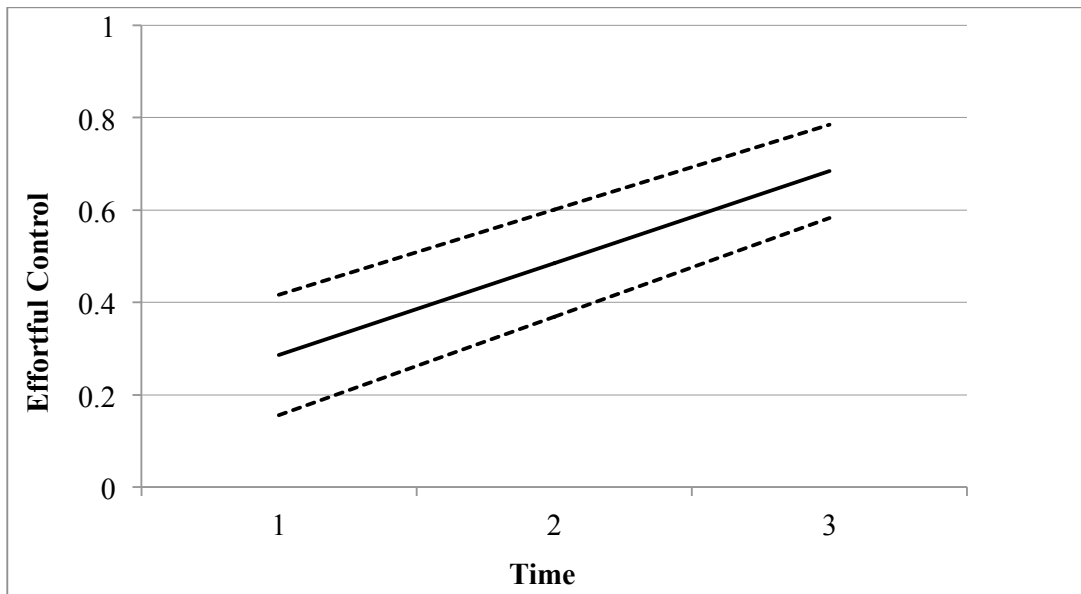


Figure 3. *Unconditional growth of effortful control.*

Growth trajectory plotted across 18 months at mean intercept and slope (bolded line) and at +/- 1 SD of the mean intercept and slope (dashed lines) while accounting for correlation between intercept and slope ($r = -.21$). Scores on effortful control are proportion of total possible score and thus range from 0-1.

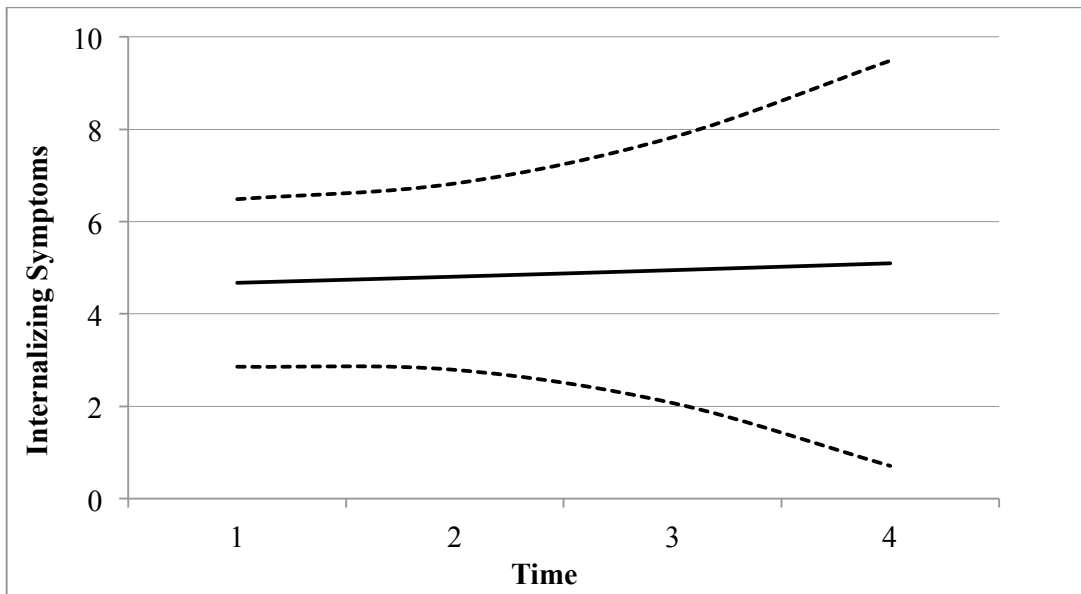


Figure 4. *Unconditional growth of internalizing symptoms.*

Quadratic growth more accurately fit the data for internalizing symptoms thus a quadratic factor was included in all models. Growth trajectory was plotted across 27 months at mean intercept, linear, and quadratic slope (bolded line) and at +/- 1 SD of the mean intercept, linear, and quadratic slope (dashed lines) while accounting for correlation between intercept and both slope factors (linear: $r = .55$; quadratic: $r = .40$). Possible range of scores on the internalizing scale can range from 0 to 48.

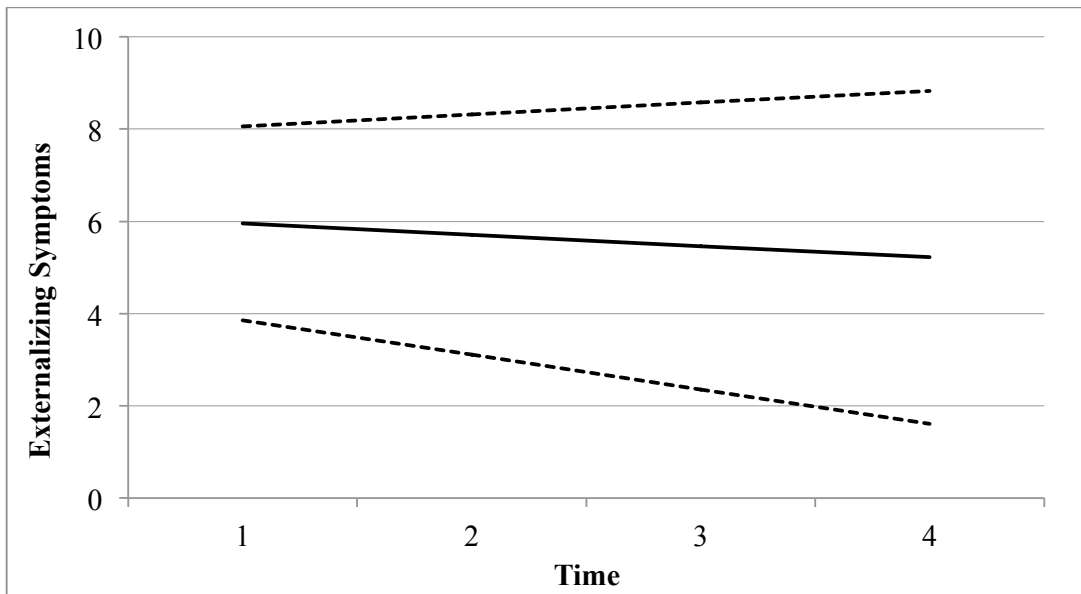


Figure 5. *Unconditional growth of externalizing symptoms.*

Growth trajectory was plotted across 27 months at mean intercept and linear slope (bolded line) and at +/- 1 SD of the mean intercept linear slope (dashed lines) while accounting for correlation between intercept and slope factors ($r = .59$). Possible range of scores on the externalizing scale can range from 0 to 42.

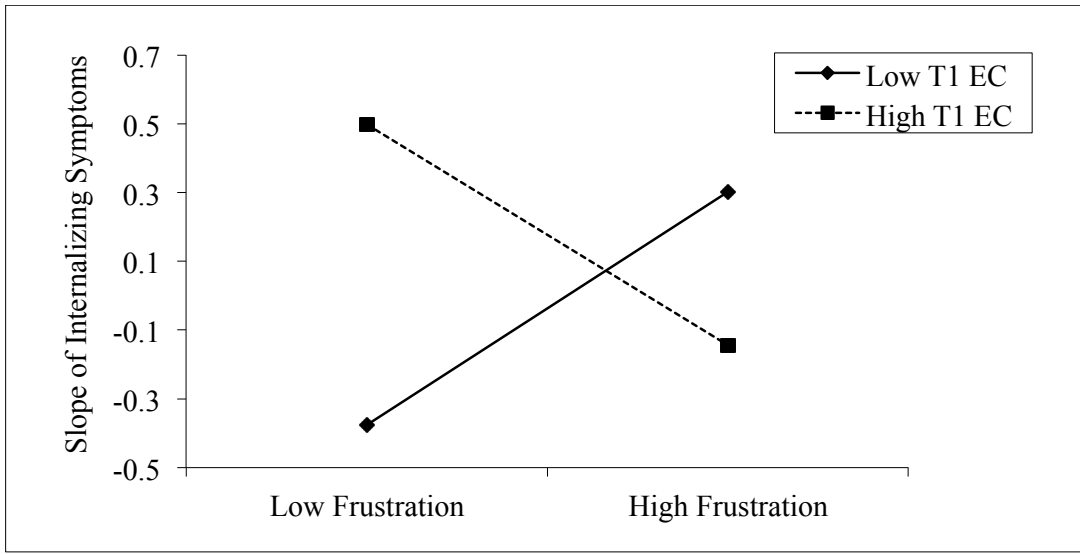


Figure 6. *Interaction between frustration and intercept of effortful control on slope of internalizing symptoms.*

Predictors were plotted at ± 1 SD from the mean. Y-axis represents slope of internalizing symptoms. Positive values reflect increasing symptom levels, whereas negative values reflect decreasing symptoms.

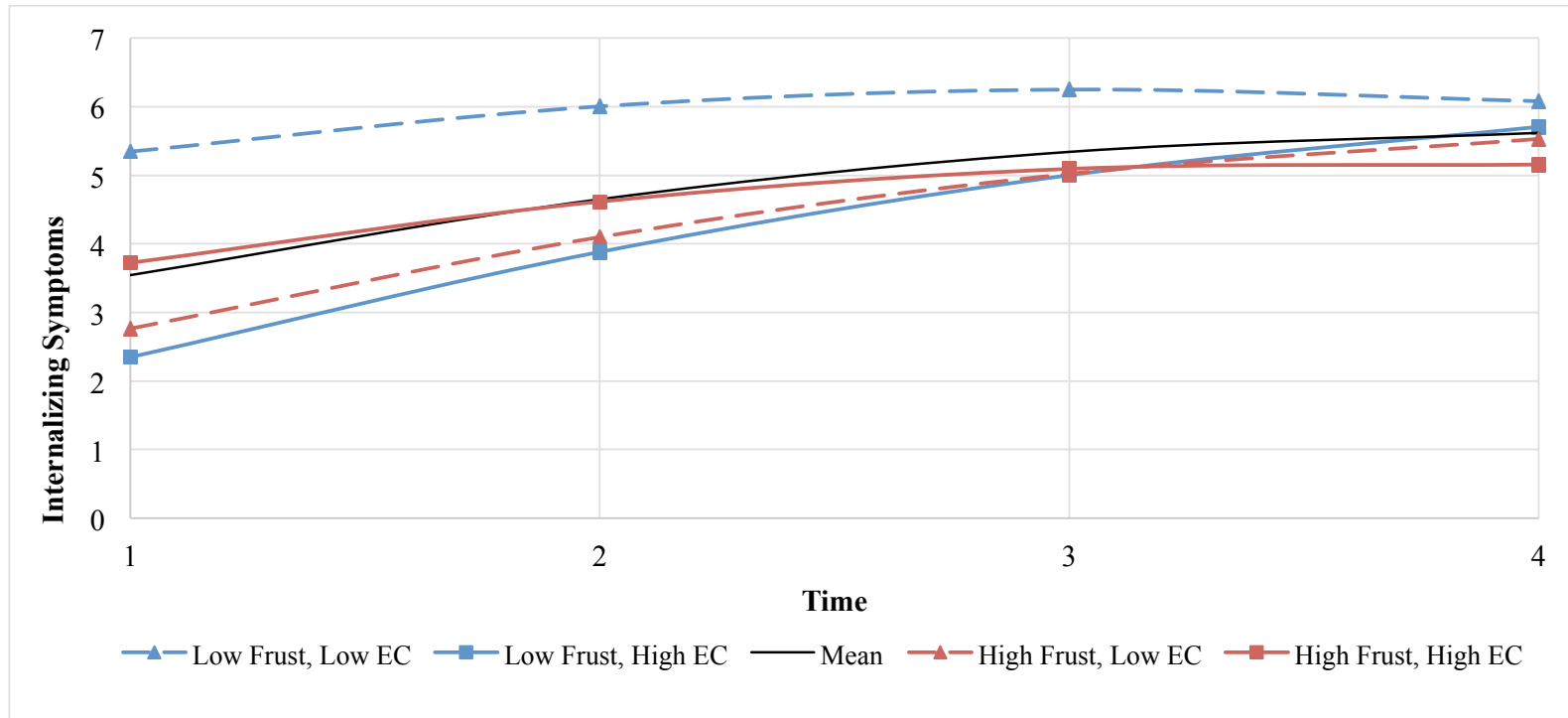


Figure 7. *Conditional latent growth curve modeling interaction between frustration and intercept of effortful control on internalizing symptoms.*

Regression equations included direct effects of frustration and effortful control intercept on both status and linear slope factors, as well as interaction effect on the linear slope factor only. Predictors were plotted at ± 1 SD from the mean. Average trajectory (black line) was plotted at the average level of predictors, which, as frustration and effortful control were mean centered, is zero for both in this case.

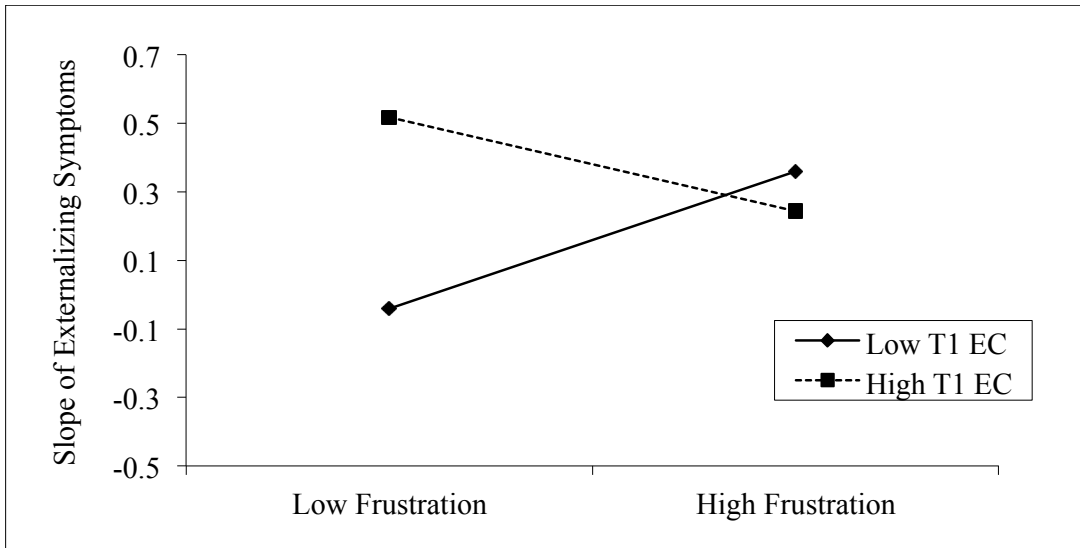


Figure 8. *Interaction between frustration and intercept of effortful control on slope of externalizing symptoms.*

Predictors were plotted at ± 1 SD from the mean. Y-axis represents slope of externalizing symptoms. Positive values reflect increasing symptom levels, whereas negative values reflect decreasing symptoms.

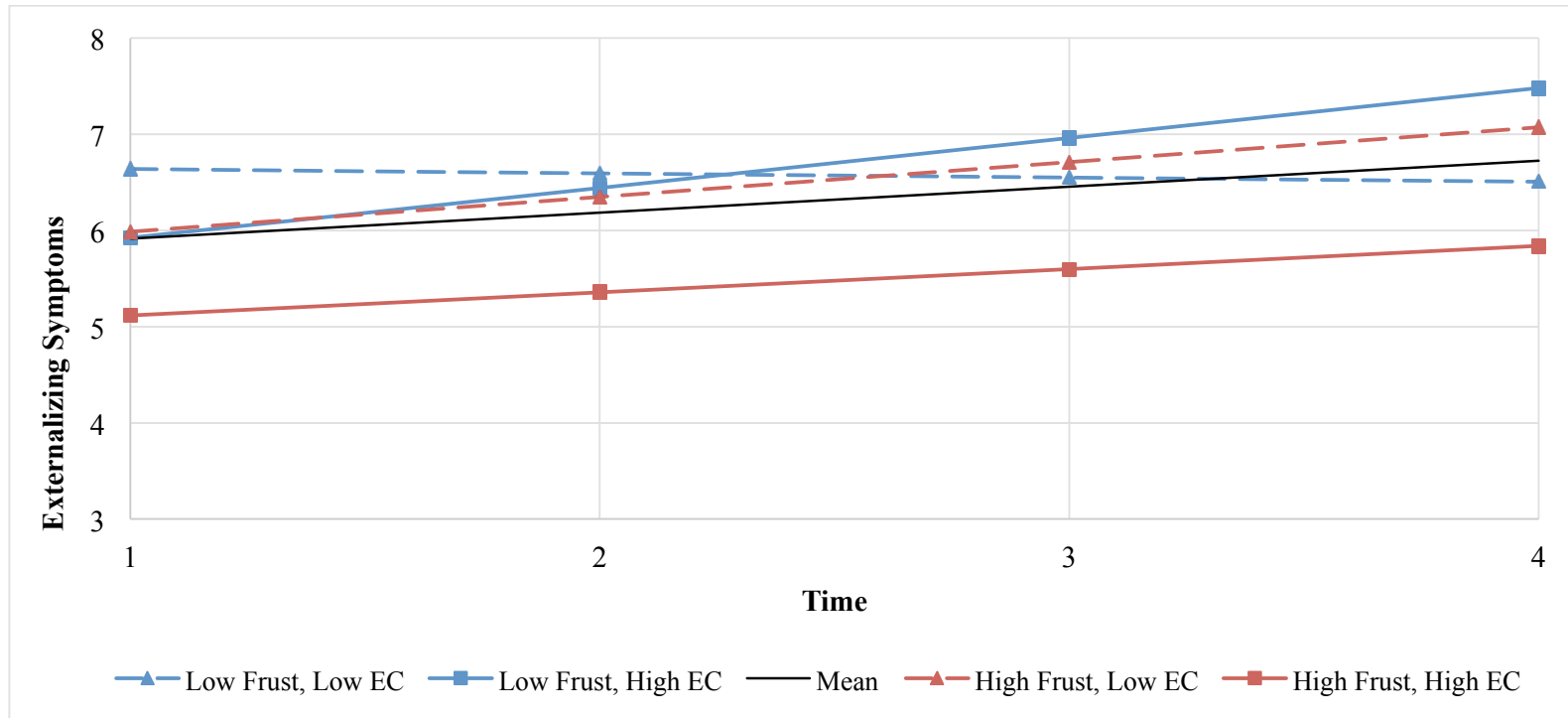


Figure 9. *Conditional latent growth curve modeling interaction between frustration and intercept of effortful control on externalizing symptoms.*

Regression equations included direct effects of frustration and effortful control intercept on both status and linear slope factors, as well as interaction effect on the slope factor only. Predictors were plotted at ± 1 SD from the mean. Average trajectory (black line) was plotted at the average level of predictors, which, as frustration and effortful control were mean centered, is zero for both in this case.

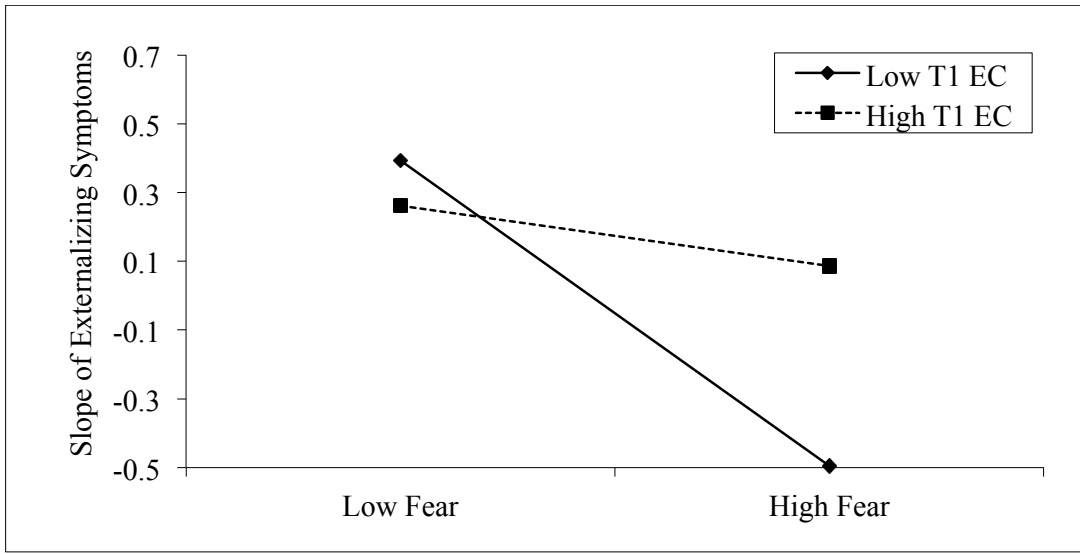


Figure 10. *Interaction between fear and intercept of effortful control on slope of externalizing symptoms.*

Predictors were plotted at ± 1 SD from the mean. Y-axis represents slope of externalizing symptoms. Positive values reflect increasing symptom levels, whereas negative values reflect decreasing symptoms.

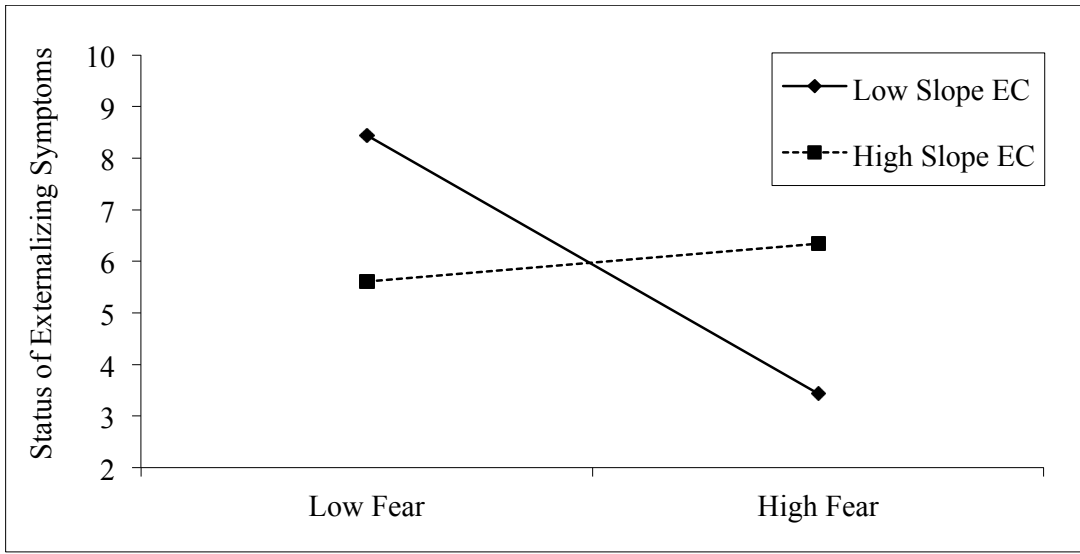


Figure 11. *Interaction between fear and slope of effortful control on status of externalizing symptoms.*

Predictors were plotted at ± 1 SD from the mean. Y-axis represents status, or final level, of externalizing symptoms. Possible range of externalizing scale spans 0 to 42 points. Effortful control slope was negatively correlated with effortful control intercept ($r = -.21$), suggesting that children with high initial effortful control were more likely to have smaller slopes.

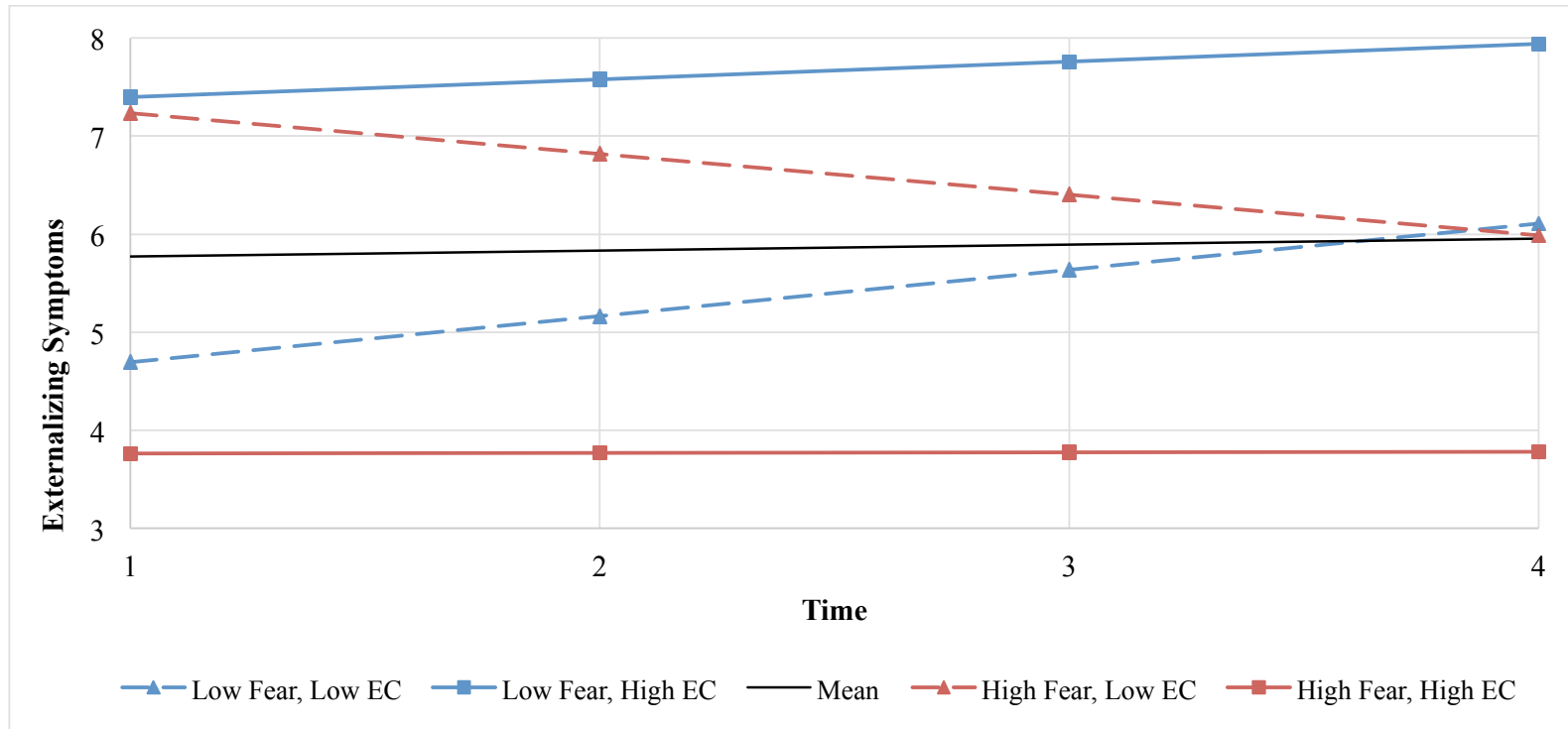


Figure 12. *Conditional latent growth curve modeling effects of fear and effortful control on externalizing symptoms.*

Regression equations included direct effects of fear and effortful control intercept and slope on both status and linear slope factors, as well as two interaction effects: fear x effortful control slope on status of externalizing only and fear x effortful control intercept on slope of externalizing only. Fear was plotted at ± 1 SD from the mean. Effortful control was plotted ± 1 SD from the mean of the intercept while tempering effects of effortful control slope by accounting for intercept-slope correlation. Average trajectory (black line) was plotted at average level of predictors, which, as fear and effortful control were mean centered, is zero for both.

VITA

Lyndsey Moran completed her undergraduate degree at Dartmouth College in 2007, majoring in psychology and minoring in neuroscience. After completing her bachelor's degree, she worked as a research coordinator for multiple neuroimaging studies exploring neurobiological correlates of infant temperament in relation to adolescent psychopathology at the Martinos Neuroimaging Center at Massachusetts General Hospital in Boston, MA. It was here that she was introduced to research in temperament and became interested in relations between temperament, child development, and adolescent psychopathology. She went on to pursue her doctorate at the University of Washington in 2009, where she developed a research program examining factors related to risk and resiliency in the development of psychopathology with particular interest in the role of effortful control in children's adjustment. In 2016, she earned her Doctorate in Child Clinical Psychology with a minor in Quantitative Psychology at the University of Washington. She completed a one-year clinical internship at McLean Hospital/Harvard Medical School in Belmont, MA.