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Temperament and Respiratory Sinus Arrhythmia as Contributors to Externalizing
Behavior Among Early Adolescents

Tyler Laney

A dissertation submitted in partial fulfillment

of the requirements for the degree of

Doctor of Philosophy

In

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Seattle Pacific University

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Abstract

The current study examines the relationship between temperament and physiological models of externalizing behavior to externalizing behavior in a community sample of early adolescents. The psychophysiological component of vagal tone, as measured by respirator sinus arrhythmia (RSA), is used with an emphasis placed on distinguishing between its function as a state versus trait measure of parasympathetic nervous system activity. Negative affectivity (NA) is proposed as a general risk factor for psychopathology. Emotion regulation, as indexed by effortful control (EC) and basal RSA, is hypothesized to function as a mediator between NA and externalizing behavior. A moderated mediation model is then proposed with physiological reactivity, as measured by mean stress RSA and RSA reactivity, moderating the β path. A total of 98 youth, 52% female, with a mean age of 12.89 ($SD = .82$) completed a laboratory task to measure their RSA at rest and while completing an unsolvable anagram stressor task. Temperament measures and externalizing behavior were assessed through self-report questionnaires. The direct effect of NA on externalizing behavior ($B = 2.75, t = 3.41, p < .001$), was significantly mediated by EC and decreased to ($B = 1.28, t = 1.40, p = .17$), while basal RSA did not ($B = 2.81, t = 3.43, p < .001$). Thus, individuals with high trait NA had lower EC and higher externalizing behaviors. Stress RSA did not function as moderator between EC or basal RSA to externalizing behavior. RSA reactivity did significantly act as moderator between EC and externalizing behavior ($B = 3.31, t = 2.65, p = .009$), and functioned in the full moderated mediation model with a significant conditional indirect effect (-1.65) through EC. The pattern of results suggests that at low

levels of RSA reactivity, the effect of NA and EC on externalizing behavior is the strongest. However, with greater RSA reactivity the effect NA and EC on externalizing behavior is disrupted. Results support the utility of differentiating between state versus trait and emotion regulation versus reactivity processes in theoretical and statistical models. Analyzing RSA as a moderator provides a framework for conceptualizing conflicting findings in the literature.

CHAPTER I

Introduction and Literature Review

Purpose

Externalizing behavior problems such as oppositional behavior, aggression, and rule violations are the most common and persistent form of childhood maladjustment (Campbell, 1995; Institute of Medicine, 1989). The current study examines the relationship between temperament and physiological models of externalizing behavior, with a focus on regulation and reactivity measures, to better understand engagement in this problem behavior for a community sample of youths. It is hypothesized that the link between trait negative affectivity (NA), as a general risk factor for psychopathology, and self-report of externalizing behavior will be mediated by temperament and physiological measures of emotion regulation capacity. The trait measures in this mediation model are additionally hypothesized to be moderated by state measures of physiological reactivity, in response to a stressor task. The effect of high trait NA on externalizing behavior is predicted to be mediated by emotion regulation, as indexed by trait effortful control (EC) or basal respiratory sinus arrhythmia (RSA). There is no a priori hypothesis for the potential direction of the effect of physiological reactivity as a moderator, also measured by RSA.

Externalizing behavior in adolescence is associated with a wide range of concurrent and prospective problems, including academic struggles, difficulties with peer relationships, engagement in criminal behaviors, mood disorders, and substance use (Johnson, McGue, & Iacono, 2006; Meyer-Bahlburg, Dolezal, & Sandberg, 2008; Reef, Diamantopoulou, van Meurs, Verhulst, & van der Ende, 2011). Theories on the

development of externalizing behavior focus on both environmental and experiential factors that contribute to externalizing behavior. However, individual differences in self-regulation of affect, behavior, and physiology are implicated in all major theoretical models of externalizing behavior (Frick & Morris, 2004). A construct that encapsulates components of emotion and regulation for an individual is temperament (Rothbart & Derryberry, 1981; Rothbart & Posner, 2006). Temperament is hypothesized to represent a trait with a strong genetic component, is relatively stable through life, and is heavily implicated in the development of psychopathology (De Pauw & Mervielde, 2010). This broad definition of temperament means that there are multiple theories relating this construct to externalizing behavior and approaches for measuring its specific components.

Contemporary theories of temperament have identified two affective reactivity factors (NA and positive affectivity (PA)) and a separate factor of general regulation (EC) (Rothbart & Derryberry, 1981; Rothbart & Posner, 2006). From this theory, NA is defined as a tendency to experience and express negative emotions, such as sadness or anger, particularly when faced with novel, stressful, or ambiguous situations. NA is hypothesized to be a broad risk factor for many forms of psychopathology in childhood, adolescence, and adulthood (Clark & Watson, 1991; De Bolle & De Fruyt, 2010; Watson & Clark, 1984). However, studies differentiating internalizing and externalizing behavior problems have noted that while both are associated with high NA, externalizing behavior is uniquely associated with low EC (Caspi, Henry, McGee, Moffitt, & Silva, 1995; Olson, Sameroff, Kerr, Lopez, & Wellman, 2005; Posner & Rothbart, 2000). EC is defined as an individual's capacity to inhibit reactive responses and to direct attention to

support the regulation of behavior to be adaptive in the current environment (Rothbart & Bates, 1998). Eisenberg and colleagues (2001) theorize that EC may help individuals regulate the expression of externalizing behavior even in emotionally elevated situations. These two components of temperament have been extensively associated concurrently and prospectively with externalizing behavior among children and adolescents (Eisenberg et al., 1995; Eisenberg et al., 2000; Eisenberg et al., 2009; Krueger, Caspi, Moffitt, Silva, & McGee, 1996; Krueger et al., 1994; Pitzer et al., 2009; Sher & Trull, 1994). However, the majority of research on NA and EC as predictors of externalizing behavior among youth has relied on self-report or parent-report measures of temperament. Additionally, as trait measures they do not take into account the actual response of an individual to a specific stressor.

Reactivity and regulation components of temperament may be more directly measured via physiological indices. A prominent theory of psychophysiology that is able to encapsulate the relationships between temperament, externalizing behavior, and physiology is Porges' (1995, 2001, 2007) polyvagal theory. This theory proposes that the expression of emotions and behaviors is related to and limited by hierarchically organized physiological systems. The most evolutionarily advanced and principal system for mammalian physiology is dependent on vagal tone. This system acts as a buffer to regulate the expression of more evolutionarily primitive and reactive systems, like the sympathetic nervous system, to allow for social communication and emotion regulation. A reliable and noninvasive measure of vagal tone is respiratory sinus arrhythmia (RSA). Basal (resting) RSA is hypothesized to represent an individual's capacity for emotion regulation, while RSA reactivity to stress is hypothesized to represent one component of

emotional reactivity (Beauchaine, 2001). Supporting the polyvagal theory, the literature has found that individuals with a higher basal RSA and those who have less withdrawal of RSA when faced with a stressor display lower rates of externalizing behavior (Beauchaine, 2001). Understanding the mechanisms that confer risk for the development and maintenance of externalizing behavior may inform prevention and intervention efforts.

Defining and Measuring Externalizing Behavior in Early Adolescence

Externalizing behavior is a broad construct encompassing many disruptive, hyperactive, or aggressive behaviors with a common theme of under-controlled emotions being expressed outwardly towards ones' environment or other individuals (Hinshaw, 1987). A more exhaustive list would include physical aggression, oppositionality, disruptiveness, property destruction, bullying, truancy and impulsivity. Synonymous terms for externalizing behavior in the research literature include antisocial behavior, conduct problems, and delinquency. Though not inherently maladaptive, externalizing behavior is generally subject to much cultural scrutiny and is diagnostically central to the DSM-IV diagnoses of disruptive behavior disorder, oppositional defiant disorder, conduct disorder, antisocial personality disorder, and attention deficit hyperactivity disorder. In the current study an empirically based definition of externalizing behavior is used based on Achenbach's youth self report (YSR, Achenbach, 1991a) and child behavior checklist (CBCL, Achenbach, 1991b). Each of the twenty-seven items on these measures relates to a unique behavior and is allocated to two subscales of either aggressive or delinquent behaviors. The aggressive subscale measures more overt externalizing behavior, such as physical altercations or yelling, while the delinquent

subscale focuses on covert behaviors, such as stealing or truancy (Stranger, Achenbach, & Verhulst, 1997). Achenbach's measures are one of the most common research and clinical indicators of externalizing behavior and have been found to be robust and valid (Achenbach & Rescorla, 2001; Rescorla et al., 2013).

A developmental perspective on externalizing behavior has been encouraged in the literature and puts focus on the trajectories of these behaviors across the life span (Costello & Angold, 2000). The large body of literature devoted to this subject has highlighted some important themes to keep in mind when collecting and interpreting results relating to externalizing behavior. A broad finding is that rates of externalizing behavior decrease with age (Keenan & Shaw, 1997; Silverthorn & Frick, 1999; Stanger & Verhulst, 1995). This finding has been found with a variety of measures including Achenbach's CBCL from childhood through adolescence (Bongers, Koot, van der Ende, & Verhulst, 2003; Leve, Kim, & Pears, 2005; Prinzie, Onghena, & Hellinckx, 2006). However, when disassembling the broad construct of externalizing behavior into more specific domains this steady downward trend is not found in all the relevant behaviors.

With regard to Achenbach's measures, the subscales for aggressive and delinquent behaviors have different developmental trajectories (Achenbach, 1991b; Bongers et al., 2003; Stanger, Achenbach, & Verhulst, 1997). Aggression seems to follow a similar downward trend to overall externalizing behavior peaking at age two, presumably when an individual first has the physical faculties to engage in such behaviors, and then steadily declines (Dishion & Patterson, 2006). Delinquent behaviors however have a u-shaped trajectory with a peak in early childhood followed by a decline, similar to aggression, but then increasing through adolescence. One potential theory

explaining these divergent trajectories can be found in Loeber and Schmalings's (1985) concept of overt and covert forms of externalizing behavior. Researchers suggest that as social norms become more salient with age and overt forms of externalizing behavior, such as aggression, more socially unacceptable, that individuals become more secretive and subtle in their use of these behaviors starting in middle childhood through early adolescence (Dishion & Patterson, 2006; Lahey et al., 2000; Poulin & Boivin, 2000). Achenbach's aggressive and delinquent behavior subscales are also conceptualized as measures of overt and covert externalizing behavior respectively (Stranger, Achenbach, & Verhulst, 1997). As overt aggressive behaviors decrease during the early adolescent and adolescent years, covert delinquent behaviors increase along with age appropriate increases in self-regulation skills and independence seeking (Bongers, Koot, van der Ende, & Verhulst, 2004; Lahey et al., 2000; Tremblay, 2000). This is the normative trajectory, but Moffit (1993) and other researchers have noted that there are a small proportion of youths who do not show declines in externalizing behavior, but rather continue with life-course-persistent externalizing behavior. Early adolescence is an important developmental period for externalizing behavior because it is a time of change and differentiation for these behaviors.

Though the externalizing literature has been skewed towards focusing on males, a clear picture of gender differences has emerged. A robust finding across measures, reporters, and samples indicates a gender difference with males having higher rates of externalizing behavior, particularly in relation to physical aggression (Lahey et al., 2000; McDermott, 1996; Roberts & Baird, 1972; Odgers et al., 2008; Tremblay et al., 1996). This finding is replicated in both the aggressive and delinquent subscales of Achenbach's

measures (Achenbach, 1991b; Bongers et al., 2003; Stranger, Achenbach, & Verhulst, 1997). These differences are most substantial at younger ages. Interestingly, however, there are no longer significant gender differences by the end of adolescence (Galambos, Baker, & Almeida, 2003; Odgers et al., 2008). Males and females also follow similar developmental trajectories regarding changes in rates of aggressive and delinquent behavior (Bongers et al., 2004).

The expression of externalizing behavior during childhood through adolescence is associated with a variety of concurrent and prospective negative outcomes. Many concurrent problems that start during childhood or adolescence do not resolve and persist through the lifespan. For instance, youths who engage in aggressive or delinquent acts are at greater risk to be the victim of a violent act and are arrested more often as perpetrators of illegal activities (CDC, 2013). Longitudinally, the presence of externalizing behavior as early as age eight was predictive of criminal offenses and other antisocial behavior in adulthood (Klinterberg, 1996; Bender & Lösel, 2011; Sourander et al., 2007). Rates of externalizing behavior in adolescence and childhood are associated with decreased academic achievement (Hinshaw, 1992; Johnson, McGue, & Iacono, 2006) and prospectively are predictive of lower educational and occupational attainment (Laub and Sampson 1994; Tanner, Davies, & O'Grady, 1999). Socially, youths engaging in externalizing behavior are at higher risk for peer rejection, to have deviant peer involvement, and to be asocial (Fanti & Henrich, 2010; Laird, Jordan, Dodge, Pettit, & Bates, 2001). Prospectively, this association is perpetuated with child and adolescent externalizing behavior predicting impaired social skills in adulthood (Bongers, Koot, van der Ende, & Verhulst, 2008). A similar pattern occurs with childhood externalizing

behavior predicting adolescent substance use and adolescent substance use predicting adult substance use issues for alcohol, cigarettes, and cannabis (Brook et al., 2008; Colder et al., 2012; Eschmann, Zimprich, Metzke, & Steinhausen, 2011; Korhonen et al., 2010). The mental health outcomes indicate concurrent comorbidity between externalizing and internalizing behaviors (Lee & Bukowski, 2012). Reef and colleagues (2011) have conducted a 24 yearlong longitudinal study of over 2,000 children predicting adult mental health outcomes based on externalizing behavior. All domains of externalizing behavior in childhood were associated with disruptive behavior disorders in adults, with some domains predicting mood disorders and anxiety disorder. The negative impact of externalizing behavior on those who employ these actions are not solely proximal and are indicative of long-term consequences in many areas of functioning. Early intervention is crucial to treating externalizing behavior and requires an understanding of the underlying factors influencing the expression of these behaviors.

Theoretical Models of Externalizing Behavior

Early theoretical models of externalizing behavior focused on aggression as the primary behavior. The longest standing theory of externalizing behavior is the frustration-aggression hypothesis from Dollard and colleagues (1939) and its later reformulation by Berkowitz (1989). The premise of this theory is that aggression, and potentially other components of externalizing behavior, are automatic responses to the emotional experience of frustration caused by perceived threats, blocking of goals, and unattained expectations. The roles of emotional and physiological arousal as well as emotion regulation in the modulation of externalizing behavioral responses were substantiated in this model. The theory has been criticized for its focus on the emotion of

frustration, limited generalizability to various functions of externalizing behavior, and lack of other contributing factors (Bandura, 1973; Fraczek, 1973). Though the frustration-aggression hypothesis is now viewed as a conceptual piece instead of an overarching theory, modern theories of externalizing behavior have built upon this framework through two research approaches. One avenue of research has focused on identifying associated factors and predictors of externalizing behavior, with an extended debate between the significance of biological versus environmental influences. The second area of research on models of externalizing behavior has focused on theorizing the underlying mechanisms at work when an individual is presented with a situation or stressor that leads to aggressive or delinquent behavior. The major theories in these two areas of research are reviewed.

Partially as a response to the frustration-aggression theory, much of the research on aggression and externalizing behavior in general, has focused on identifying factors that are associated with individuals who engaged in these behaviors. These factors could broadly be categorized as either biological or psychosocial and the resulting debate embodied the classic dichotomy of nature versus nurture. Lorenz (1966) portrayed humankind as innately inclined to use aggression to achieve goals and that only through socialization learned to inhibit this natural behavior. In contrast, Bandura's social learning theory (1973) proposed that aggressive behavior was not inherent and only emerged through observation of the aggressive behavior of others. These two theorists took extreme and opposing views in this argument, but research continues to find evidence for both theoretical perspectives.

Biological Factors. The evidence supporting a strong biological component for externalizing behavior can be seen concretely in genetic research. Sibling and twin adoptive pair studies allow researchers to compare similarity in upbringing and environment to a degree of genetic similarity to inform biological versus environmental loading. With a variety of measures and reporters, a moderate degree of heritability of aggression and delinquent behaviors is a common finding (Deater-Deckard & Plomin, 1999; Huizink, van den Berg, van der Ende, & Verhulst, 2006; Marceau et al., 2010). More specific genetic research has found the genes cholinergic muscarinic receptor 2 (CHRM2), Gamma-aminobutyric acid receptor subunit alpha 2 (GABRA2), and monoamine oxidase A (MAO A) to be associated with a variety of externalizing behaviors and relevant behavioral outcomes (Dick et al., 2009; Hendershot, Bryan, Ewing, Claus, & Hutchison, 2011, Bortolato et al., 2012). The hypothesized mechanism through which all three of these genes relate to externalizing behavior is through aspects of impulsivity or behavioral control. Though purely genetic components are the most obvious biological factors contributing to behavioral outcomes, there are other methods of measuring and accounting for this portion of predictive models for externalizing behavior.

Two constructs that are conceptualized to be genetically influenced and that are also related to aggressive and delinquent behavior are intelligence and temperament. Lower intelligence, as commonly measured as an intelligence quotient (IQ), has consistently been associated with and predictive of higher rates of criminality and externalizing behavior (Koenen et al., 2006; Stattin & Klackenber-Larsson, 1993). The directionality of this relationship had been heavily debated, but the relation of IQ

predicting aggressive and delinquent behavior is now firmly established (Lynam, Moffitt, & Stouthamer-Loeber, 1993). Events such as prenatal exposure to damaging substances (Liu, 2004), brain related injuries (Liu, 2011), and even lead poisoning during childhood can negatively impact IQ and cognitive functioning, subsequently putting children at higher risk for developing externalizing behavior (Needleman, Riess, Tobin, Biesecker, & Greenhouse, 1996). The predominant theory for how IQ relates to externalizing behavior points to the cognitive domain of executive functioning. This area of intellectual functioning involves the ability to plan, foresee consequences, and inhibit behavior and is necessary for an individual to effectively problem solve and avoid socially unacceptable behavior (Murray & Farrington, 2010).

The second genetically related trait that is present in many models of externalizing behavior is temperament. Traits of temperament are components of personality that are established early in life and remain relatively constant through development (Roberts & DelVecchio, 2000). The fact that individual differences in temperament emerge in infancy and that these early differences have been found to predict behavioral outcomes lends credence to the argument that there is genetic heritability of personality (Fox, Henderson, Pérez-Edgar, & White, 2008). Thomas, Chess, and Birch (1968) pioneered the hypothesis that temperament in infancy could be predictive of later behavior patterns and this line of research has continued with many competing theories and models. Mary Rothbart and her various colleagues (Rothbart & Derryberry, 1981; Rothbart & Posner, 2006) have been using a consistent definition for temperament for over thirty years:

We define temperament as constitutionally based individual differences in reactivity and self-regulation as observed in the domains of emotionality, motor activity, and attention. By reactivity, we mean characteristics of the individual's responsivity to changes in stimulation, as reflected in somatic, autonomic, and endocrine nervous systems. By self-regulation, we mean processes modulating this reactivity, including behavioral approach, avoidance, inhibition, and attentional self-regulation. In our view, individual differences in temperament constitute the earliest expression of personality and the substrate from which later personality develops. (Rothbart & Posner, 2006, p. 466)

Rothbart and other influential theorists have come to some consensus on three factors of temperament they find to be central to conceptualizing and even predicting psychopathology (Clark & Watson, 1991; Rothbart & Ahadi, 1994; Watson, Wiese, Vaidya, & Tellegen, 1999). NA, PA, and EC have been related to a wide variety of negative and positive mental health outcomes, though the terms and definitions to describe them vary somewhat between authors.

Shiner and Caspi (2003) have outlined five pathways through which temperament traits are hypothesized to influence psychopathology: spectrum association, vulnerability association, resilience association, pathoplastic association, and scarring association. The vulnerability association is the most popular, stating that aspects of personality can function as causal risk factors for the development of psychopathology. From a developmental perspective this underlying risk from temperament traits interacts with other biological and environmental factors through learning processes, environmental elicitation, environmental construal, social and temporal comparisons, environmental

selection, and environmental manipulation to contribute to the expression of psychopathology. In the modern literature there is a general consensus that the temperament traits that make individuals the most vulnerable to develop externalizing behavior are NA and EC (Clark, 2005; Eisenberg et al., 1997; Eisenberg et al., 2000; Rothbart & Bates, 1998; Sanson, Hemphill, & Smart, 2004; Sanson & Prior, 1999). NA is conceptualized as a tendency to react strongly with distressing emotions to internal and external stimuli. Initial parent reports of NA in early childhood have been associated with prospective measures of externalizing behavior through childhood and into adolescence (Lahey et al., 2008). The proposed mechanism for this relationship is that a strong emotional reaction, particularly of anger or irritability, provides the motivation for aggressive and delinquent acts. While NA represents an emotional state, trait EC has no emotional context and is conceptualized as an individual's ability to inhibit behavioral responses. The transactional model of antisocial personality development puts a focus on impulsivity, the conceptual opposite of EC, as the primary factor driving the expression of externalizing behavior across the lifespan (Beauchaine & Gatzke-Kopp, 2012; Beauchaine, Gatzke-Kopp, & Mead, 2007). The model posits that impulsivity, as an almost entirely biologically inherited trait, first emerges as hyperactive-impulsive behavior in early childhood, progresses to oppositional and delinquent acts in grade school, and culminates in criminal and antisocial behavior in adulthood (Beauchaine, Klein, Crowell, Derbidge, & Gatzke-Kopp, 2009). Similar to cognitive deficits, high trait impulsivity or low EC is hypothesized to impair an individual's ability to inhibit aggressive and delinquent impulses contributing to higher engagement in these behaviors. Biological factors are the foundation of the majority of modern models for externalizing

behavior, but environmental and socialization factors are equally important for a more full conceptualization.

Psychosocial Factors. The same studies that suggest a moderate genetic influence on the expression of externalizing behavior show an equal impact from environmental factors (Deater-Deckard & Plomin, 1999; Huizink et al., 2006; Marceau et al., 2010). One key theory underlying most psychosocial models of externalizing behavior is Bandura's (1973) social learning theory (Huesmann, 1994). The premise of social learning theory is that individuals learn and maintain behaviors through direct or observed interactions with their surroundings such that behaviors that are rewarded increase and those punished decrease (Bandura, 1978). This pattern was presented for externalizing behavior in Bandura's pivotal study involving children witnessing an adult committing violent acts against a blowup doll (Bandura, Ross, & Ross, 1961). Without specific direction, the children tended to imitate the violent behaviors of the adult role models regardless of the extremeness of the behaviors. Though the original social learning theory understated the importance of biological components, research continues to support the role that psychosocial factors such as parenting, peer influence, and environment have on the development of externalizing behavior.

The relationship and interaction of parent and child is the most influential on the development of a child. A model that uses the concepts behind Bandura's social learning theory and places a firm focus on this parental role related to externalizing behavior is coercion theory (Patterson, 1986; Snyder & Patterson, 1995). The basic premise of this theory is that parents who use harsh discipline or engage in coercive exchanges are inadvertently modeling and promoting similar behavior for their children. Specifically,

an approach for decreasing the behavior of others through punishment is modeled by the parent that the child experiences. When conflict occurs later the child attempts the modeled strategy for decreasing their parents behavior, leading to a coercive cycle where parent and child direct increasingly adverse behaviors at each other in attempts to force the other to a response through punishment. These interactions function to escalate and reinforce aggressive and delinquent behaviors (Crosswhite & Kerpelman, 2009). The literature has directly supported this theory finding that corporal punishment (Gershoff, Lansford, Sexton, Davis-Kean, & Sameroff, 2012; Lansford, Wager, Bates, Pettit, & Dodge, 2012), a lack of positive emotional interchange (Côté, Vaillancourt, LeBlanc, Nagin, & Tremblay, 2006), parent-child attachment (Smeeckens, Riksen-Walraven, & van Bakel, 2007), and behavioral monitoring (Patterson & Yoerger, 1997) are associated with increased externalizing behavior.

Ecological models of externalizing build off the importance of parenting and include factors affecting family dynamics that are associated with parenting and increased rates of externalizing behavior (Mason, Cauce, Gonzales, Hiraga, & Grove, 1994; White & Renk, 2011). Environmental factors such as low socioeconomic standing (Leventhal & Brooks-Gunn, 2000), neighborhood (Ingoldsby & Shaw, 2002; Kroneman, Loeber, & Hipwell, 2004), parental job satisfaction (Mason et al., 1994), high incidence of family stressors (Aguilar, Sroufe, Egeland, & Carlson, 2000), large family size, and parental discord (Hill, 2002) have been found to be risk factors for the development of externalizing factors. These environmental factors are hypothesized to have an indirect effect, as they are correlated with parents having the emotional stability and resources to engage in effective parenting, and are not as strongly related to externalizing behavior

outcomes as biological and parenting factors (Loeber & Dishion, 1983; White & Renk, 2011). Additionally, involvement with peers who engage in aggressive and delinquent acts is hypothesized to function under the basic social learning model where engagement in these behaviors is modeled and then socially reinforced (Kupersmidt, Burchinal, & Patterson, 1995). Authors have hypothesized that a common theme among these psychosocial factors, particularly related to parenting, is the socialization of emotion regulation skills (Crosswhite & Kerpelman, 2009; Eiden, Edwards, & Leonard, 2007). Through childhood and continuing into adolescence, children continue to develop emotion regulation by observing and interacting in the family context (Allen, Hauser, Eickholt, Bell, & O'Conner, 1994; Forgatch & Stoolmiller, 1994; Powers, Welsh, & Wright, 1994). Snyder and colleagues (2003) propose emotion regulation as a mediating mechanism between these individual risk factors and the development of externalizing behavior.

Emotion Regulation as a Key Component of Contemporary Theoretical Models. The culmination of this argument between nature versus nurture is that modern models emphasize both biological underpinnings and psychosocial influences in the development of externalizing behavior. However, the broad conceptualization of externalizing behavior means that the number of constructs empirically correlated with aggressive and delinquent behavior is so vast that developmental models cannot capture them all. Consequently, researchers typically either focus on longitudinal studies that are effective in identifying factors predictive of externalizing behavior but lack a firm theoretical conceptualization (Farrington, 2005; Moffitt, 1993; Moffitt, Caspi, Harrington, & Milne, 2002; Tremblay, 2000) or focus on particular constructs to the

detriment of other salient factors (Beauchaine & Gatzke-Kopp, 2012; Liu, 2004). Both approaches support that biological and psychosocial factors are at play, but do little to further the conceptualization of why individuals engage in externalizing behavior. This was the original goal of the frustration-aggression theory and modern researchers continue to propose more encompassing theories to explain these mechanisms. Though these researchers have different approaches, a common theme in the models is emotion regulation. Three theories of externalizing behavior that place emphasis on emotion regulation are the general theory of crime (Gottfredson & Hirschi, 1990), social information processing theory (Crick & Dodge, 1994; Dodge, Pettit, McClaskey, & Brown, 1986), and polyvagal theory (Porges, 2001).

The general theory of crime places self-control, the ability to direct motivation and inhibit impulsive behaviors, as the primary factor dictating the frequency and intensity of externalizing behavior associated with criminal offenses. Individuals low in self-control are hypothesized to be at higher risk due to their impulsivity, desire for immediate gratification, sensation-seeking, and lack of forethought or planning. The term self-control is synonymous with emotion regulation, and represents a mechanism for engagement in externalizing behavior. In this model self-control is believed to be developed at an early age, related to parenting practices, and is thus placed as a mediator between parenting influences and externalizing behavior. Research has generally supported the primary premises of the general theory of crime, and the relationship between self-control and externalizing behavior as a mediating mechanism has been established (Crosswhite & Kerpelman, 2009; Pratt & Cullens, 2000). Arguments against this theory propose that there are more mechanisms at play than simply self-control and

parenting, and that the construct of self-control itself is limited and poorly defined (Baker, 2011; Hay, 2001; Perrone et al., 2004). The general theory of crime lacked the biological and psychosocial interactions that are now widely accepted, but pointed to emotion regulation as a mechanism for how situations were processed and approached that could lead to externalizing behavior.

The second model looking at emotion regulation as a mechanism is Crick and Dodge's social information processing theory, which focuses on the cognitive aspects (Crick & Dodge, 1994). The theory states that when faced with a stressor, an individual relies on his or her learning history to attend to, interpret, and act on social information. Crick and Dodge (1994) hypothesized that this process occurs in the six sequential steps of encoding of cues, interpretation of cues, clarification of goals, response access of construction, response decision, and behavioral enactment. Children and adolescents who engage in higher rates of externalizing behavior show the following patterns in social information processing: attend to fewer social cues, recognize more threatening cues, make hostile attributions to the actions of others, have more instrumental versus relational goals, and view aggressive responses more positively (Coie & Dodge; Crick & Dodge, 1994; Crick & Dodge, 1996; Dodge, 2006). Though this theory deals primarily with attentional and cognitive processes, there are aspects of emotional regulation at play. The steps of social information processing do not occur in a vacuum, and strong negative emotions are likely to contribute some of these problematic patterns occurring (Frick & Morris, 2004). There is also a general acknowledgement that biological and temperamental predispositions may be present to explain behavior (Crick & Dodge, 1994; Dodge, 2006). Crosswhite and Kerpelman (2009) suggest that the trait of

impulsivity may impact an individual's ability to have effective processing when presented with a stressor. Specifically, impulsivity may contribute to less information being processed in step one and fewer potential behavioral responses being evaluated in step five (Dodge, 1993; Dodge & Schwartz, 1997). The social information processing theory highlights how aspects of a stressor uniquely interact with the learned behavior patterns of an individual to build an understanding of behavioral responses.

The third model incorporating emotion regulation is Porges' (1995; 2001; 2007) polyvagal theory. This model attempts to understand and measure the autonomic nervous systems (ANS) influence on the physiological changes in the body that either mobilize or inhibit an individual's biological and psychological resources to adapt to the current circumstances. Underlying this theory is the assumption that physiological states limit the range of emotional, behavioral, and psychological experience. Thus, primary emotions are inexorably linked to ANS functioning. Early models of psychophysiology were one-dimensional and focused on the presence or absence of excitatory physiological responses related the sympathetic nervous system (SNS) branch of the ANS. Traditional measures of greater SNS activation include higher heart rate, increased blood pressure, faster and shallower breathing, and sweat secretion to indicate arousal. Cannon's (1949) fight or flight theory embodies this theory, where a perceived stressor induces physiological arousal and appraisal of the stress dictates whether increased access to physical and mental resources are used to combat or escape the stressor. Porges built upon this theory to create a two-dimensional model to include the regulatory functions of the parasympathetic nervous system (PNS) based on evolutionary differences in ANS functioning. Porges (2007) theorizes that ANS regulation is comprised of three

evolutionary derived phylogenetic stages ordered from most evolutionarily advanced to least. The ventral vagal complex (VVC) as a structure of the PNS found in mammals controls emotion expression and communication, the SNS for fight or flight, and the dorsal vagal complex controls freeze responses. When faced with a stressor, layers are removed until the appropriate response is reached. The regulatory functions of the PNS, also known as the vagal tone, supersedes other stages and contributes to adaptive socially emotionally intelligent behavior when more activating responses are unnecessary. The two dimensions in this model are the SNS and PNS branches of the ANS that can be engaged or disengaged reciprocally, independently, or coactively to produce different degrees of physiological arousal. From this theoretical foundation, Porges and others propose that vagal tone at rest may directly correlate with an individual's capacity for emotion regulation (Beauchaine, 2009). This neurological activity is difficult to measure directly, instead measurement of physiological functions that can be traced back directly to vagal tone are used to estimate the engagement of the vagus nerve and consequently PNS activity. The primary measure of vagal tone is through respiratory sinus arrhythmia (RSA), which represents change in heart rate in relation to inhalation or exhalation of air.

There are two primary methods in polyvagal theory through which vagal tone is hypothesized to relate to externalizing behavior. The previously reviewed models incorporate emotion regulation as a trait measure, which is hypothesized to be predictive of an individual's likelihood to engage in externalizing behavior. Polyvagal is unique in that real time physiological data can be used to measure an individual's actual state responses to generate an index of reactivity. This is an important distinction, as the degree of reactivity to a stressor is assumed to be equivalent to emotion regulation but is

rarely actually measured. As a trait protective factor, individuals with a higher basal or baseline engagement of vagal tone are believed to have a greater degree of emotion regulation. This theory relates to externalizing behavior in that individuals with greater resting vagal tone may also have a greater capacity to inhibit socially unacceptable behavioral responses to provocation (Beauchaine & Gatzke-Kopp, 2012). Physiological reactivity is then the state changes in vagal tone in response to a stressor. This process of vagal tone reactivity is hypothesized by polyvagal theory to result in either continued engagement of vagal tone to inhibit SNS activity or to withdraw allowing for greater SNS, and consequently more emotional and behavioral, activation. The literature on the relationship between vagal tone reactivity and externalizing behavior is less developed and the findings are still mixed. Polyvagal theory proposes physiological mechanisms for the function of emotion regulation and reactivity, along with an objective measure for the construct in the form of RSA.

Models of externalizing behavior have focused on a variety of mechanisms and factors to better understand and predict individuals who engage in these forms of behavior. Though the diversity and complexity of these models points to the reciprocal nature of these factors, there also appears to be a common theme of emotion regulation. Biological factors such as temperament, impulsivity, and physiology are all hypothesized to relate to an individual's capacity for emotional regulation (Frick & Morris, 2004), while psychosocial factors such as parenting, peer influence, and cognitive processing are believed to inform the development of emotional regulation. Individual differences in emotion regulation, similarly to externalizing behavior as a whole, are likely influenced by a combination of biological and psychosocial factors. Thus emotion regulation may

represent a complex amalgamation of various factors and is an important mechanism for externalizing behavior. The current study seeks to further understand how temperamental and physiological factors are associated with externalizing behavior in a community sample of youths. In particular, the literature on vagal tone reactivity and its relationship to behavioral outcomes is still developing and in need of further investigation (Frick, 2012). The current study proposes a model of externalizing behavior focused on the predictive role of trait NA on externalizing behavior as mediated trait measures of emotion regulation and moderated by state measures of physiological reactivity. This conceptual model is shown in Figure 1.

Hypothesis Development

Negative Affectivity Predicts Externalizing Behavior. As discussed earlier, NA is a primarily inherited trait related to an individual's trait tendency to experience strong negative emotions such as frustration, fear, discomfort, and sadness. Individuals who are high in trait NA experience these negative emotions more often, more intensely, and for longer durations than typical. In the literature NA has also been referred to as neuroticism (Digman, 1990; Eysenck, 1959), negative emotionality (Tellegen, 1985), and negative temperament (Watson & Clark, 1993). Regardless of the term, when this propensity for distressing emotions is triggered, these individuals' ability to regulate behaviors and cognitions is likely compromised and emotionally driven. NA is considered a general risk factor for psychopathology including externalizing behavior (Krueger et al., 1996; Watson & Clark, 1984; Oldehinkel, Hartman, Ferdinand, Verhulst, & Ormel, 2007).

There is ample research supporting a direct relationship between NA and externalizing behavior. Longitudinal studies with early measures of trait NA predicting externalizing behavior throughout the lifespan are one of the strongest pieces of evidence of the association between these two constructs. There have been several studies that have used temperament measures of trait NA as young as infancy to predict externalizing behavior in adolescence. For instance, Lahey and colleagues (2008) used measures of fussiness and fearfulness in infancy of over 1,800 participants to predict maternal rating of externalizing behavior at multiple measurement points between the ages of 4-13. Belsky and Pluess (2011) had over 800 participant children who were initially evaluated at 6 months of age for mother report of trait NA. Participants then completed a self-report measure of externalizing behavior (YSR) at age 15 and the results indicated that the two constructs were significantly related. A similar result of difficult temperament measured at age two predicting increased rates of externalizing behavior at age 12 was found by Fanti and Henrich (2010). Honomichl and Donnellan (2011) found that maternal rating of NA at age four and a half was predictive of mother reported externalizing behavior (CBCL) at age 15. These findings at such young ages for temperament assessment support the hypotheses that trait NA has a strong biological component, that NA as a risk factor can be identified early, and provide some evidence for causality for trait NA proceeding and predicting externalizing behavior. This basic finding predictive relationship between trait NA and externalizing behavior has been found in many studies with varying ages, interval of measurement, and a variety of measures (Eisenberg et al., 2005; Eisenberg et al., 2009; Miner & Clarke-Stewart, 2008; Ormel et al., 2005; Schmitz et al., 1999).

This consistent association between trait NA and externalizing behavior has also been found in cross sectional research with adolescents. Muris, Meesters, and Blijlevens (2007) using self-report measures of trait NA and externalizing behavior in approximately 200 participants between the ages of 9-13 year olds found a significant correlation. Taylor, Allan, Mikolajewski, and Hart (2013) collected temperament and psychopathology data from the parents of nearly 700 same sexed twin pairs. The results from this unique sample suggested that temperament represents a risk factor for developing externalizing behavior with shared genetic and environmental components. The research suggests that cross sectional designs are able to detect meaningful relationships between these constructs. However, these results are not always consistent. Though Honomichl and Donnellan (2011) found NA to predict mother report of externalizing behavior, it did not predict self-report. Pitzer, Esser, Schmidt, and Laucht (2009) found that infant trait NA's ability to predict parent report externalizing behavior (CBCL) was minor once emotion regulation constructs were included in the model. Though there is considerable evidence for a predictive relationship between trait NA and externalizing behavior, this is a limited model and is rarely studied independent of other factors. As discussed earlier, emotion regulation is an aspect of many models of externalizing behavior that may mediate the relationship between these two constructs.

Hypothesis 1: Youth with higher trait NA will be reported to engage in higher rates of externalizing behavior.

Negative Affectivity and Emotion Regulation. Of the previously reviewed theories of externalizing behavior, the social learning theory best outlines a relationship between affect and regulation. High trait NA is theorized to influence emotion regulation

through enhancing the negative valiance of interpretation and inhibiting attentional and cognitive processes (Lonigan & Vasey, 2009; Verstraeten, Vasey, Raes, & Bijttebier, 2009). EC is the regulatory component of the tripartite model of temperament and is proposed as an index of emotional regulation. EC is defined as an individual's ability to inhibit, direct, and regulate attention and behavior. Similar constructs to EC in the literature include constraint and inhibition, while the opposing construct is impulsivity. Higher EC is conceptualized as being healthier and contributes to higher emotional regulation. (Clark, 2005). Though NA and EC are commonly statistically significantly inversely related (Rothbart, Ellis, & Posner, 2004), they are conceptually distinct (Oldehinkel et al., 2007).

Porges' (1995; 2001; 2007) polyvagal theory proposes vagal tone as a physiological index of emotional responding. An individual's basic capacity for emotion regulation as a trait is hypothesized to correlate to baseline measures of vagal tone. The basis of the theory is that the greater the engagement of vagal tone at rest, the more physiological regulatory resources the individual has to devote to maintaining higher order and adaptive social behaviors. Beauchaine (2001) proposes that basal vagal tone functions similarly to EC as an "indicator of self-regulatory processes such as attention, emotion, and cognition." While the relationship between NA and baseline vagal tone are established, there is limited evidence for this theory in the literature. The most direct support is from research in young children where trait resting vagal tone has been negatively correlated with negative temperament measures (Calkins, 1997; Porges, Doussard-Roosevelt, Portales, & Suess, 1994). Research linking temperament measures to basal vagal tone in adolescents has found that NA is not significantly associated,

though there are consistent positive associates to positive affectivity (Oveis et al., 2009; Wang, Lü, & Qin, 2013). In prospective research, higher basal RSA measurements at 9 months of age were predictive of lower ratings of temperamental reactivity at 3 years of age. While basal vagal tone and EC are conceptually quite distinct, they are both hypothesized to be within the overarching construct of trait emotion regulation.

Hypothesis 2a: High trait NA will be associated with less emotional regulation, as represented by self-report EC.

Hypothesis 2b: High trait NA will be associated with less emotional regulation, as represented by basal RSA.

Emotion Regulation and Externalizing Behavior. Emotion regulation effect on aggressive and delinquent behavior is a key component of the theories of externalizing behavior, such that individuals with lower trait emotion regulation are more likely to engage in these problem behaviors. Both EC and basal RSA have been extensively researched and consistently found to be negatively correlated to externalizing behavior. Effortful control is theorized to protect individuals from engaging in externalizing through their ability to focus their attention and inhibit behavioral impulses. This relationship is consistent through childhood and into adolescence in cross-sectional (Eisenberg et al., 2000; Eisenberg et al., 2001; Oldehinkel, Hartman, Ferdinand, Verhulst, & Ormel, 2007; Olson, Sameroff, Kerr, Lopez, & Wellman, 2005; Olson, Schilling, & Bates, 1999; Oosterlaan & Sergeant, 1996) and prospective research (Chang, Olson, Sameroff, & Sexton, 2010; Pitzer, Esser, Schmidt, & Laucht, 2009; Stifter, Putnam, & Jahromi, 2008; Zhou et al., 2007). A variety of measures been used to assess EC,

including observational and experimental, with consistent statistically significant results. The literature linking EC to externalizing behavior is robust and long established.

Vagal tone at rest, as measured by RSA, is hypothesized to represent an individual's capacity for emotion regulation (Porges, 2007). Polyvagal theory posits that greater vagal tone indicates stronger engagement of the PNS and its regulatory physiological functions. Though RSA varies according to environmental demands and behavior of the individual, as a trait measure at rest it is relatively stable across time. The following studies found a negative relationship with lower basal RSA associating with or predicting higher ratings of externalizing behavior (Beauchaine et al., 2007; Beauchaine et al 2001; El-Sheikh, Harger, & Whitson, 2001; El-Sheikh & Hinnant, 2011; El-Sheikh, Hinnant, & Erath, 2011; Mezzacappa et al., 1997). This finding is consistent across ages using a variety of measures of externalizing behavior.

Hypothesis 3a: A lower capacity for emotional regulation, as represented by lower self-reported EC, will be associated with higher rates of externalizing behavior.

Hypothesis 3b: A lower capacity for emotional regulation, as represented by lower basal RSA, will be associated with higher rates of externalizing behavior.

Emotion Regulation as a Mediator. NA, as a general risk factor for psychopathology, is associated with higher rates of externalizing behavior in children and adolescents. Emotion regulation, as measured by EC and basal RSA, is associated with both these constructs and may function as a mediator between the two. The finding that a combination of high NA and low EC contribute to higher rates of externalizing behavior is well established (Calkins & Fox, 2002; Oldehinkel, Hartman, De Winter, Veenstra, & Ormel, 2004; Oldehinkel, Hartman, Ferdinand, Verhulst, & Ormel, 2007; Lonigan &

Phillips, 2001). In the temperament literature the relationship has traditionally been conceptualized as EC functioning as a moderator (Posner & Rotherbart, 2000; Eisenberg et al., 1995; Eisenberg et al., 2005). However, such a model does not take into account the affect that NA has on EC and downplays the direct relationship that EC has to externalizing behavior (Oldehinkel et al., 2007). More recent research has noted that EC has a stronger direct relationship to externalizing behaviors than NA and that NAs proportion of the variance decreases even further once EC is accounted for (Olson, Sameroff, Kerr, Lopez, & Wellman, 2005; Pitzer, Esser, Schmidt, & Laucht, 2009; Rubin, Burgess, Dwyer, & Hastings, 2003). EC as a mediator to the dependent variable of psychopathology has been used successfully in general (Chang, Olson, Sameroff, Sexton, 2011, White & Turner, 2014) and specifically with NA (Pitzer, Esser, Schmidt, & Laucht, 2009; Tortella-Feliu & Sese, 2010). In a review of models utilizing NA and EC to predict psychopathology, Muris and Ollendick (2005) summarize that while a moderating model seems more intuitive that it is the mediation model that has more empirical evidence supporting it. Utilizing EC, as a measure of trait emotion regulation, as a mediator in statistical models also links more logically to theoretical conceptualizations of externalizing behaviors.

As a mediator, the association between basal RSA and externalizing behavior has been consistently found, but the path to NA has less evidence. In fact, basal RSA is frequently used in statistical models as a moderator suggesting that higher basal RSA acts as a protective factor against externalizing behavior (Eisenberg et al., 1995; El-Sheikh, Harger, & Whitson, 2001; Hinnant, Erath, & El-Sheikh, 2015; Keller & El-Sheikh, 2009). However, McLaughlin and colleagues (2015) had null results when testing basal

RSA as a moderator between psychosocial stressors and externalizing behavior in adolescents. Van der Graaff and colleagues (2015), again with adolescents predicting externalizing behavior, had inconsistent findings with RSA as a moderator with null results and low basal RSA acting as a protective factor against familial conflict. Additionally, the roles of basal RSA and RSA reactivity are often merged conceptually and used concurrently as moderators in these studies (El-Sheikh, Harger, & Whitson, 2001; El-Sheikh, Hinnant, & Erath, 2011; Leary & Katz, 2004; Morales, Beekman, Blandon, Stifter, & Buss, 2015). Given mixed findings and the developing nature of the literature (Frick, 2012), the current study is choosing to include basal RSA in the model as a mediator for three reasons. First, basal RSA is being conceptualized as a measure of emotion regulation, which theoretical models emphasis has a direct relationship to externalizing behavior. Second, while EC and basal RSA are both conceptualized as measures of emotion regulation it is a novel research methodology test to have the temperamental questionnaire and the physiological measure statistically tested as the same construct. Third, the vagal tone literature as a whole is still developing and has methodological and conceptual inconsistencies. The current study strives to contribute by making a clear delineation between trait and state measures. Thus, as trait measures EC and basal RSA are proposed as mediators, while the state measures of physiological reactivity are introduced into the model as moderators.

Hypothesis 4a: The relationship between trait NA and externalizing behavior will be mediated by emotion regulation as measured by EC.

Hypothesis 4b: The relationship between trait NA and externalizing behavior will be mediated by emotion regulation as measured by basal RSA.

Physiological Reactivity as a Moderator

Porges' (1995; 2001; 2007) polyvagal theory proposes vagal tone as a physiological index of emotional responding. While an individual's basic capacity for emotion regulation can be established from baseline measures of vagal tone, the primary role of vagal tone is to flexibly engage or withdraw to regulate SNS activity to appropriately respond to environmental demands. By measuring this process of vagal reactivity to a concurrent stressor it is hypothesized that an individual's arousal or emotionality, and subsequently their ability to participate in either prosocial behavior or fight and flight responses, can be inferred. Vagal tone reactivity responses are not necessarily adaptive or maladaptive, and primarily depend on what is an appropriate response to the given stressor. For instance, an adaptive reactivity response to seeing a tiger in a jungle would be vagal tone withdrawal to decrease PNS activity and allow the SNS to activate physiological arousal functions to support the behavioral response of yelling and fleeing. However, a more socially advanced stressor of a verbally teasing peer during school is best served by the more evolutionary advanced response of continued engagement of vagal tone to support the use of affiliative social behavior to ignore the peer or ask for support. However, the literature on vagal reactivity is still emerging and research related to behavioral outcomes has been inconsistent. The following review of research linking vagal reactivity and externalizing behavior focuses on early adolescence as the age group of interest for this study.

In relation to externalizing behavior, there are two common yet contradictory findings on vagal reactivity. In all the following studies RSA is used as an estimate of vagal tone and cite polyvagal theory as a justifying model. The first common empirical

finding is that greater RSA withdrawal to stress is associated with externalizing behavior. The justification for these results from polyvagal theory is that withdrawal of vagal tone allows for the mobilization of fight or flight SNS activity; thus, greater RSA withdrawal represents a strong emotional response to stress. This is in line with the conceptualization of vagal tone as a measure of reactivity such that excessive withdrawal may be a general indicator of emotion dysregulation and thus contributing to maladaptive behavior (Beauchaine, 2001; Berntson, Cacioppo, & Quigley, 1991; Berntson and Cacioppo, 2004). This finding has been consistently found in diverse samples ranging in age from late childhood to adolescence. Beauchaine and colleagues (2001) and Mead and colleagues (2004), looking at adolescent and late childhood samples respectively, found that participants with higher externalizing behavior and the control group both had RSA withdrawal associated with a mood induction. An important distinction was that the externalizing behavior groups also had lower basal RSA, indicating that their total withdrawal of RSA resulted in less overall vagal tone engagement. Though El-Sheikh and Hinnant (2011) did not relate RSA withdrawal to externalizing behavior specifically in a community sample, they did find that withdrawal at age eight predicted decreases in basal RSA prospectively through age eleven, suggesting that strong emotional and physiological reactivity may impede later emotion regulation. Supporting the theory that RSA withdrawal is a risk factor is that the opposite response of RSA engagement has also been found to be a protective moderator between marital conflict and child externalizing behavior (El-Sheikh, Harger, & Whitson, 2001; El-Sheikh, Hinnant, & Erath, 2011; Leary & Katz, 2004). Prospectively, RSA engagement to two different stressor tasks was

associated with less externalizing behavior at the first time point and predictive of continued lower rates of these behaviors (Keller & El-Sheikh, 2009).

The second common and inverse result for vagal reactivity is that instead of RSA withdrawal being associated with externalizing behavior, that RSA engagement and staying at the same level was more strongly associated with these problem behaviors (Hinnant & El-Sheikh, 2009; El-Sheikh, Hinnant, & Erath, 2011). Polyvagal theory is related to this finding pointing to the potentially adaptive functions of mild or moderate arousal to support attention and processing speed (Porges, 2007). El-Sheikh and colleagues (2011) comment on the need for vagal tone to be flexible to adjust to a variety of situations and that lacking the ability to withdraw vagal tone when needed could be particularly impacting. This finding may also relate to often replicated findings that individuals with persistent externalizing behavior problems have lower sympathetic nervous system arousal, which would be consistent with RSA engagement as representing a lack of change, as RSA is indexing parasympathetic nervous system engagement (Dietrich et al., 2007; Frick et al., 2003). Hinnant and El-Sheikh (2009) in a laboratory stressor found RSA engagement in combination with lower basal RSA to be the best predictive combination of vagal tone measurements to externalizing behavior. In fact, RSA withdrawal was found to be a protective factor. This general pattern of results has been found with several community sample studies of children and adolescents (Calkins, Graziano, & Keane, 2007; Calkins & Keane, 2004; Graziano, Keane, & Calkins, 2007; Katz, 2007).

The literature is still mixed on the role of RSA reactivity as an indicator of emotionality and arousal. Beauchaine and colleagues (2007) note the implications of

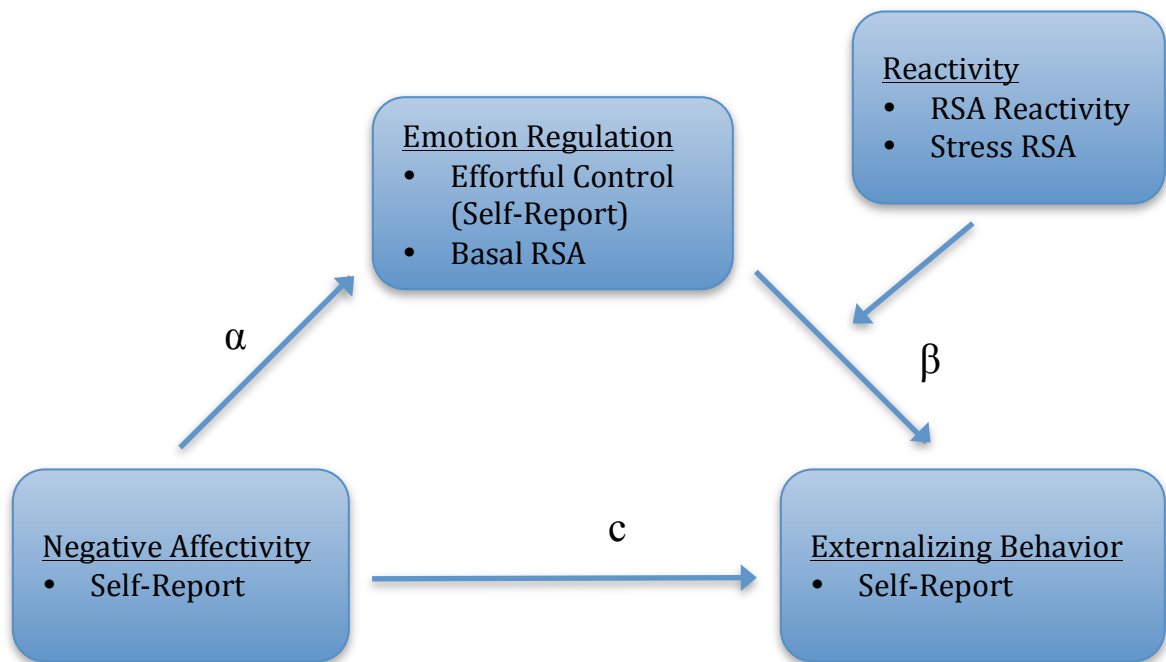
measuring reactivity as a change score for individuals who are known to already have low basal RSA. Engagement or withdrawal responses may not be particularly informative, if the state measurement of RSA during the stressor continues to be lower for the individuals engaging in externalizing behavior. El-Sheikh and colleagues (2011) also note that some withdrawal of RSA is adaptive, but that at the extremes it is maladaptive. Along the same lines of thought, Frick and Morris (2004) propose that to avoid maladaptive behavior problems that individuals who can respond flexibly may be best equipped to respond to a variety of different stressors appropriately and at less risk for psychopathology. The current study proposes that RSA reactivity, as a state measure of physiological reactivity to a specific stressor, functions broadly as a moderator between psychosocial factors and externalizing behavior.

Hypothesis 5a: The relationship between emotional regulation capacity and externalizing behavior will be moderated by physiological reactivity as mean RSA during a stress induction, stress RSA.

Hypothesis 5b: The relationship between emotional regulation capacity and externalizing behavior will be moderated by physiological reactivity as measured by the change in RSA from baseline to stress induction, RSA reactivity.

Hypothesis 6: Physiological reactivity will act as a moderator on the β path of the mediation model supporting the moderated mediation model pictured in Figure 1.

Figure 1. Conceptual Model.



CHAPTER II

Methods

Eligibility. For the current study a community sample of never depressed youth was desired as part of a larger federally funded research study. Youth were initially recruited from public and private middle school classrooms in a metropolitan area in the Pacific Northwest. The ages of eligibility for participating youth was between 10 and 14 years of age and were recruited through brief in-class presentations from study staff and through emails and newsletters directed at the parents of the students. Youth participants completed an initial screening, before being invited for full participation and the laboratory visit, to assess current depression symptoms. Current depressive symptoms were assessed from child report on the Children's Depression Inventory 2nd Edition (CDI; Kovacs, 2011). Youth who were above the clinical cutoff for depression on the CDI, a score of fourteen or higher, received reimbursement for their completion of the initial screener but did not participate in further data collection. If the youth had a CDI score of thirteen or lower, their parents were contacted by phone to be interviewed about the youth's current medications. Some forms of psychiatric medications can interfere with physiological measurement and excluded the youth from participating. If these criteria were all met, participants were invited to complete the laboratory visit portion of the study.

Power Analysis. From my review I could find no standardized methods for a priori estimates of sample size for moderated mediation models. To insure that the analyses are not underpowered, the statistical technique of bootstrapping was utilized. Bootstrapping uses the available data to take thousands of random sample observations to

create an approximate sampling distribution. This method is non parametric, not requiring normally distributed data, and increases power to detect moderate effect sizes with smaller samples (Fritz & MacKinnon, 2007; Mallinckrodt, Abraham, Wei, & Russell, 2006). Efron and Tibshirani (1993) have found bootstrapping to be useful for studies utilizing small or moderate sample sizes ranging between 20 to 80 participants. Rucker and colleagues (2011) recommend that when using bootstrapping, moderate sample sizes are preferable. Simulations have found that, with power set at 0.8, a sample size of 71 is sufficient to find significant mediation when the α and β paths are moderately related (Fritz & MacKinnon, 2007). Based on this information, the current study aimed to recruit 60 or greater participants.

Final Sample

A total of 259 youths completed the screening phase of the study. Of this group, 40 of the child participants exceeded the clinical cut-off for depression on the self-report CDI and were not eligible for the remainder of the study. From the pool of 219 potential participants, 104 were invited to and participated in the next phase of data collection. An additional six youth were removed from this pool. Specifically, there were two incidents of youth feeling lightheaded after being hooked-up to the physiological equipment and their study visit was halted. On two occasion errors in collection of physiological data resulted in data that was unable to be interpreted. In one instance the participating youth had disabilities that made full participation in the study unfeasible. Lastly, one youth was identified as an outlier and is described in detail below. All youths received equal compensation regardless of their degree of participation.

There were minimal instances of missing data on the screening measures for depression and the temperament constructs of NA and EC. Across all measures, to be considered a valid scale score no more than three items could be omitted from a specific scale. There were no instances where this occurred on any measure and all participants had complete data. The final sample size for all analyses was 98 youth.

All measures were reviewed for potential outliers along with tests of skewness and kurtosis. Initial review of the primary measures, the YSR had a concerning skewness of 1.08 and kurtosis of 1.62. Closer inspection of this measure revealed a sole outlier over three standard deviations above the mean. Removal of the participant with this outlier data point resulted in both skewness and kurtosis falling within acceptable limits for the YSR. Table 1 contains the final summary of the tests of skewness and kurtosis, along with the means and standard deviations of the study variables. Though some concerning values remain, suggesting data that is not normally distributed, the bootstrapping method employed in the Preacher, Rucker, and Hayes (2007) moderated mediation analyses is a nonparametric test that does not require assumptions of normality.

Table 1

Descriptive Statistics of Study Variables

Variable	Mean	SD	Minimum	Maximum	Skewness	Kurtosis
1. Baseline RSA	7.14	0.99	4.12	9.97	0.07	0.30
2. Stressor RSA	6.40	0.99	2.81	9.18	-0.13	1.58
3. RSA Reactivity	0.77	0.67	-0.70	2.63	0.38	0.30
4. YSR Ext	5.13	4.05	0.00	17.00	0.67	-0.27
5. Youth-Report NA	2.74	0.48	1.36	3.88	-0.36	0.33
6. Youth-Report EC	3.57	0.42	2.85	4.59	0.28	-0.76

The final sample size for this study was 98 youth, which was maintained across all analyses. Ages of participating youth ranged from 11.40 to 14.55 years with a mean age of 12.89 years old and a standard deviation of 0.82 at the time of the lab visit. Gender was relatively evenly split with 51 (52%) of the youth participants being female and the remaining 47 (48%) being male. The ethnicity of participants was similar to the demographics of the area with 73.5% identifying as Caucasian, 5.1% as Asian, 1% as Hispanic/Latino, 8.2% as multiethnic, and the remainder declining to identify their ethnicity. A correlation matrix of the relevant variables can be found in Table 2.

Table 2

Correlation Matrix of Study Variables

Variable	1	2	3	4	5
1. Baseline RSA	--				
2. Stressor RSA	0.77***	--			
3. RSA Reactivity	0.35***	-0.33***	--		
4. YSR Ext	-0.00	0.03	-0.04	--	
5. Youth-Report NA	-0.15	-0.14	-0.04	0.33***	--
6. Youth-Report EC	-0.02	-0.06	0.05	-0.41***	-0.54***

Note: N = 98. * $p < .05$, ** $p < .01$, *** $p < .001$.

Several additional variables were also examined as potential control variables in the model. The choice of these variables was based on the previously discussed literature review. Age and gender have traditionally been related to the development of externalizing behavior. The physical health measures of height, weight, and Body Mass Index (BMI) are included for their potential effect on physiology. Though youth are screened out if they have clinically significant depression, the remaining variation in self-reported symptomatology may still be meaningful. Table 3 contains a correlation matrix

of these variables to the measures already in the theoretical model. None of the proposed control variables had a significant relationship to any of the physiological variables. Self-report of depressive symptoms on the CDI was strongly correlated with the questionnaire measures of externalizing behavior and temperament. However, given the lack of correlation to the physiological measures depression was not entered in as a control variable. Adding additional variables to an already complex model would also decrease the power of the statistical analyses to find significant results. Of note, there was a significant difference between basal RSA and stress RSA conditions ($t = 11.06, p < .001$).

Table 3

Correlation Matrix of Control Variables

Variable	Age	Gender	Height	Weight	BMI	CDI
1. Baseline RSA	0.11	-0.02	0.08	0.06	0.02	-0.02
2. Stressor RSA	0.09	-0.05	0.04	0.11	0.13	0.06
3. RSA Reactivity	0.05	0.04	0.07	-0.08	-0.16	-0.12
4. YSR Ext	0.10	-0.09	0.01	0.05	-0.05	0.50***
5. Youth-Report NA	-0.01	0.09	-0.28***	-0.28***	-0.18	0.28***
6. Youth-Report EC	-0.11	0.13	0.09	0.20*	0.21*	-0.37***

Note: N = 98. * $p < .05$, ** $p < .01$, *** $p < .001$.

Procedure

Participants were recruited via in-class presentations and emails to parents of 5th – 8th grade children attending participating schools. Once the youth had assented and parents consented to screening, the youth completed screening questionnaires including youth report of NA, EC, and depression. Researchers working directly with the participants were blinded to the results of these initial screening measures. Once

participants were found eligible for participation in the full study, they were scheduled for a laboratory visit. At this visit, youth completed the YSR self-report of externalizing behavior. The participating youth were hooked up to physiological measuring equipment by a same sexed experimenter and run through a paced computerized paradigm.

Participants were told that the purpose of the experiment was to monitor their body's reactions while their problem-solving abilities are tested through a computerized word activity. Before physiological measurement began, the participants were requested to avoid unnecessary movement and talking during the experiment to reduce interference on physiological measurements. Participants also received some instruction on and practice of anagrams to insure that they understood the instructions for the computerized word activity, which functioned as the stressor task. The paradigm included a two-minute baseline measurement period, and a five-minute stressor task. The baseline measurement period involved the youth sitting quietly at the computer as neutral nature scenes are presented; the basal RSA measurement was collected during this time. For the stressor task twenty anagrams were presented with a timer at the top of the screen counting down from five minutes. Of the twenty anagrams, only five of them were solvable and the other fifteen were designed to be unsolvable. Unsolvable anagrams are a common task used for stress induction in studies of physiological reactivity of vagal tone (Mezulis & Rudolph, 2012; Reynard, Gevirtz, Berlow, Brown, & Boutelle, 2011; Zuroff, Mongrain, & Santor, 2004). RSA data continued to be collected during the stressor task time period. After completing these tasks the participant were debriefed about the true purpose of the study, to observe their response to a stressful situation, and informed that not all of the anagrams were solvable. Participants were observed by experimenters throughout the

study and were allowed to request to discontinue the study at anytime. If a participant appeared overly distressed during the study, experimenters evaluated whether the youth should continue with the study. No participants discontinued the study for this reason.

Measures

Negative Affectivity and Effortful Control. Trait temperament measures of NA and EC of the participating youth were measured by self-report using the Negative Affectivity and Effortful Control subscales of the Early Adolescent Temperament Questionnaire - Revised (EATQ-R, Ellis & Rothbart, 2001). The EATQ-R is designed after Rothbart and Bates' (1998) three-factor model of temperament specifically for the age group of 9 to 16 year olds. Both subscales contain items rated on a 5-point Likert scale from 1 = *almost never true* to 5 = *almost always true*. The NA subscale consists of 22 items focused on the youth's expression of fear, sadness, and frustration including prompts such as "I get very frustrated when I make a mistake in my school work" and "I worry about getting into trouble". The EC subscale contains 26 items related to attention, inhibition, and activation with content such as "I pay close attention when someone tells me how to do something." and "It's easy for me to keep a secret". The self-report version of the EATQ-R has been found to have good retest reliability, supporting the theory that the measure is capturing stable temperament traits (Ellis & Rothbart, 2001; Muris & Meesters, 2009; Whittle et al., 2008). In addition, the measure has been found to have good internal consistency, construct validity, and parent-child agreement in community samples (Krause, Mendelson, & Lynch, 2003). The internal consistency of the self-reported EC and NA subscales ranged from 0.79 to 0.88 (Ellis, 2003). The Cronbach's alpha was 0.76 for NA and 0.85 for EC in the current study.

Depressive Symptoms. The CDI 2nd edition is a 27-item self-report measure of current depressive symptoms designed for age 7 through 17 years old (Kovacs, 2011). The measure instructs participants to rate using a 3-point Likert scale the severity of their symptoms of depression from 0, indicating no symptoms, to 2 indicating definite symptoms. A total score is then produced with a possible range of 0 to 54, with a score of 14 or greater as the recommended clinical cutoff (Kovacs, 2011). As described earlier, the CDI was used only as a screening measure to establish eligibility to participate in the study and was not part of any of the analyses used in the current study. The Cronbach's alpha was 0.82 for the CDI in the current study.

Vagal Tone Basal and Reactivity. Basal vagal tone and vagal tone reactivity were collected through electrocardiogram (ECG) at 1000 Hz using a Biopac MP150 Data Acquisition System. A Lead II configuration was used for the electrodes, with one below the right collarbone and the other on the left ribcage. Signals were collected through AcqKnowledge 4.1 software and analyzed in Mindware software using the age appropriate respiratory range of 0.15 to 0.50 Hz with spectral analysis and normalized with logarithmic transformations to commute RSA data. This physiological RSA data was quantified in 30-second epochs, time intervals, and then all epochs for that measurement period were combined to produce a mean. Thus, basal vagal tone is represented by a mean of the RSA scores across the 4 epochs during the two-minute baseline time period and vagal tone reactivity is a mean of the 10 epochs during the five-minute stressor task. Basal RSA is then the physiological measure of emotion regulation capacity used in analyses. Physiological reactivity is indexed by two measures. Stress

RSA is simply the mean RSA across the five-minute stressor task. RSA reactivity is the difference score of basal RSA minus stress RSA.

Externalizing Behavior. The externalizing behavior of the youths was measured through self-report on the externalizing behavior subscale on the YSR (Achenbach, 1991a). The YSR can be used with participants ages 11 and up and the externalizing behavior subscale is comprised of items related to aggressive and delinquent behaviors. Items are scored on a 3-point Likert scale with possible responses of 0 = *not true*, 1 = *somewhat or sometimes true*, 2 = *very true or often true*. Content of the items on this measure include “I swear or use dirty language” and “I threaten to hurt people”. The YSR is one of the most common measures of behavior problems and has good reliability and an internal consistency as high as 0.89 (Achenbach & Rescorla, 2001; Ebesutani, Bernstein, Martinez, Chorpita, & Weisz, 2011). In the current study self-report on externalizing behavior was chosen over parent-report because findings suggest that youths report a higher rate of engaging in problem behaviors than their parents do (Bongers et al., 2004; Moffitt, Caspi, Dickson, Silva, & Stanton, 1996; Rescorla et al., 2013). The Cronbach’s alpha was 0.80 for the YSR in the current study.

CHAPTER III

Results

Analyses

Main effect of NA on externalizing. Traditional methods of testing mediation (Baron & Kenny, 1986) suggested that a significant relationship between the predictor and outcome variable was the initial required step in establishing mediation. The Preacher, Rucker, and Hayes (2007) approach to mediation, and moderated mediation, along with other modern approaches (Kenny, Kashy, & Bolger, 1998; MacKinnon, Krull, & Lockwood, 2000; Shrout & Bolger, 2002) do not require this step and instead focus on the role of the indirect effect through the proposed mediator. However, this initial relationship is still meaningful along with the other relationships represented by the other paths of the model and will thus be discussed in iterative steps despite not being a requirement of these analyses. The PROCESS macro was used to conduct tests of mediation use statistical Model 4 as outlined in Hayes' (2013) book related to the methodology. Though some hypotheses have predictions as to the direction of relationships, only two-tailed tests were available using the PROCESS macro. Prior to introducing additional variables to the model, there was a significant relationship between the independent variable of NA and the dependent variable of externalizing behavior based on self-report measures. This total effect ($B = 2.75, t = 3.41, p < .001$) is denoted as the c path in Table 3 and 4. The direction of the relationship indicates that individuals who report having high trait NA also report engaging in higher rates of externalizing behavior. Hypothesis 1 is thus supported.

Self-reported EC as a mediator. With this foundational relationship established, EC and Basal RSA were run in separate models as potential mediators on the significant positive relationship between trait NA and externalizing behavior. The results for EC are summarized in Table 3. Hypothesis 2a is supported with a negative relationship between self-report trait NA and trait EC found as indicated by a significant unstandardized regression coefficient ($B = -0.47, t = -6.23, p < .001$). Hypothesis 3a is also supported with a significant negative relationship of trait EC to self-reported externalizing behavior, ($B = -3.91, t = -4.9, p < .001$). The predicted relationships on the α and β paths contribute to an unstandardized indirect effect of 1.46. The bootstrapped 95% confidence interval around the indirect effect does not contain zero and with the mediator of EC in the model the direct effect of NA on externalizing behavior is no longer significant, both of which support that hypothesis 4a. The direction of this relation suggests that individuals higher in trait NA are likely to have lower trait EC and ultimately higher rates of engaging in externalizing behaviors. Thus, trait EC as a measure of emotional regulation significantly mediates the relationship between trait NA and externalizing behavior.

Table 4

Effortful Control as a Mediator

Path	Variables	<i>B</i>	<i>SE</i>	<i>t</i>	<i>p</i>
α	Negative Affectivity to Effortful Control	-0.47	0.08	-6.23	< .001
β	Effortful Control to Externalizing Behavior	-3.12	1.05	-2.97	.004
<i>c</i>	Total Effect	2.75	0.81	3.41	.001
<i>c'</i>	Direct Effect	1.28	0.92	1.40	.17
		<i>M</i>	<i>SE</i>	<i>LL 95% CI</i>	<i>UL 95% CI</i>
$\alpha*\beta$	Indirect Effect	1.46	0.48	0.57	2.49

Note. LL = lower limit; CI= confidence interval; UL = upper limit.

Basal RSA as a mediator. Analyses relevant to basal RSA as a mediator are summarized in Table 4. Neither the direct relationship of NA to basal RSA ($B = -0.33$, $t = -1.63$, $p = .11$) nor basal RSA to externalizing behavior ($B = -0.02$, $t = -0.03$, $p = .971$) for this model are significant. Higher trait NA is not associated with less vagal tone engagement at rest, as measured by basal RSA. Hypothesis 2b is thus not supported, however the relationship is in the correct direction and is approaching significance. Hypothesis 3b is also not supported, as the relationship between basal RSA and self-report externalizing behavior is in the opposite direction and not significant. The indirect effect accounts for little of the variance in the relationship between trait NA and externalizing behavior, and the direct effect remains significant. The 95% confidence interval for the indirect effect includes zero, and thus basal RSA as a measure of emotional regulation is not a mediator. The results do not support hypothesis 4b.

Table 5

Basal RSA as a Mediator

Path	Variables	<i>B</i>	<i>SE</i>	<i>t</i>	<i>p</i>
α	Negative Affectivity to Basal RSA	-0.33	0.21	-1.63	.11
β	Basal RSA to Externalizing Behavior	0.21	0.40	0.53	.60
<i>c</i>	Total Effect	2.75	0.81	3.41	.001
<i>c'</i>	Direct Effect	2.81	0.82	3.43	<.001
		<i>M</i>	<i>SE</i>	<i>LL 95% CI</i>	<i>UL 95% CI</i>
$\alpha*\beta$	Indirect Effect	-0.01	0.18	-0.71	0.12

Note. LL = lower limit; CI= confidence interval; UL = upper limit.

Stress RSA as a moderator. Model 1 of the PROCESS macro was used to run four models testing mean stress RSA and RSA reactivity as separate moderators. The

results for mean stress RSA are summarized below in Table 5. The interaction for mean stress RSA and EC is not significant ($B = 0.49, t = -0.57, p = .57$), indicating that the relationship between EC and externalizing behavior is not influenced by mean RSA during stress. Hypothesis 5a is thus not supported.

Table 6

Stress RSA as a Moderator between EC and Externalizing Behavior

Path	Variables	<i>B</i>	<i>SE</i>	<i>t</i>	<i>p</i>
β	Stress RSA to Externalizing Behavior	1.70	3.00	0.57	.57
	Effortful Control to Externalizing Behavior	-0.80	5.54	-0.14	.89
	Interaction of Stress RSA* EC	-0.49	0.85	-0.57	.57
Stress RSA		<i>Effect</i>	<i>SE</i>	<i>t</i>	<i>p</i>
-1 SD	5.41	-3.43	1.24	-2.77	.007
Mean	6.40	-3.91	0.90	-4.33	<.001
+1 SD	7.38	-4.39	1.23	-3.57	<.001

RSA reactivity as a moderator. The effect of RSA reactivity on the relationship between EC and externalizing behavior is summarized in Table 6. The interaction term is significant ($B = 3.31, t = 2.65, p = .009$), supporting RSA reactivity as a moderator as predicted in Hypothesis 5b. To better understand the pattern and direction of this relationship at different values of the moderator, the simple slope of the conditional effect is graphed at one standard deviation below the mean, one standard deviation above and the mean of RSA reactivity (Figure 2). In addition to these values, the second half of Table 6 lists effect sizes and significant tests through a greater range of values for the moderator utilizing the Johnson-Neyman technique. For low values of RSA reactivity, individuals having minimal changes in their RSA from the baseline to the stress portion of the laboratory task, higher ratings of EC are significantly related to lower rates of

externalizing behavior. As individuals have greater RSA reactivity, or more RSA withdrawal during the stressor, the negative association becomes increasingly more positive and is eventually no longer significant. Though not significant at all values of the moderator, the next step is to place this measure of physiological reactivity into the greater moderated mediation model to see if it continues to exert influence.

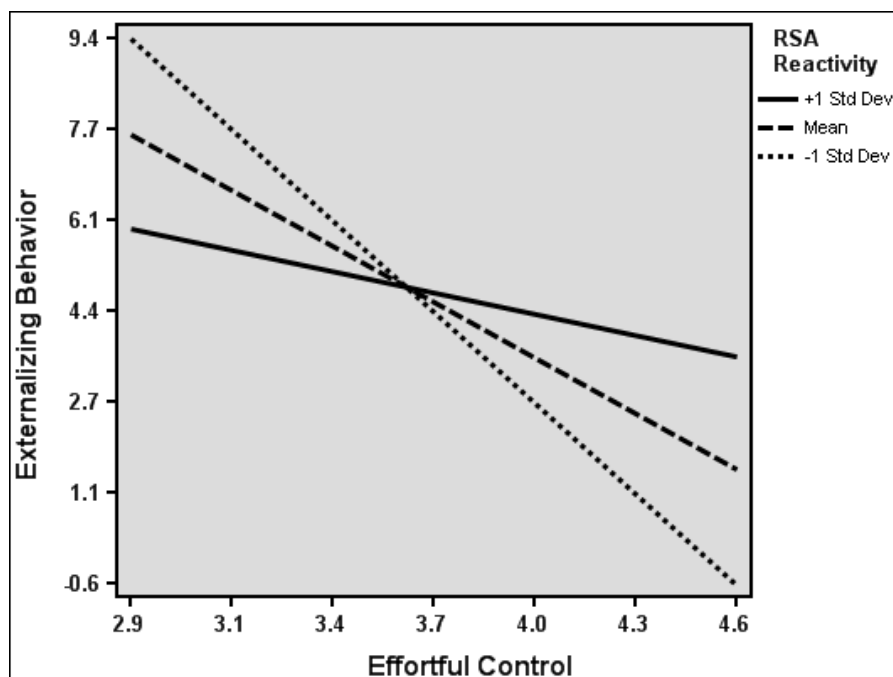
Table 7

RSA Reactivity as a Moderator between EC and Externalizing Behavior

Path	Variables	<i>B</i>	<i>SE</i>	<i>t</i>	<i>p</i>
β	RSA Reactivity to Externalizing Behavior	-12.03	4.52	-2.66	.009
	Effortful Control to Externalizing Behavior	-6.01	1.18	-5.10	<.001
	Interaction of RSA Reactivity * EC	3.31	1.25	2.65	.009
RSA Reactivity		<i>Effect</i>	<i>SE</i>	<i>t</i>	<i>p</i>
-1 SD	.08	-5.75	1.12	-5.16	<.001
Mean	.75	-3.55	0.88	-4.03	<.001
+1 SD	1.41	-1.34	1.30	-1.04	.30
	-0.70	-8.32	1.88	-4.43	<.001
	-0.53	-7.77	1.70	-4.57	<.001
	-0.37	-7.22	1.52	-4.74	<.001
	-0.20	-6.67	1.36	-4.91	<.001
	-0.03	-6.12	1.21	-5.07	<.001
	0.13	-5.57	1.07	-5.19	<.001
	0.30	-5.02	0.97	-5.19	<.001
	0.47	-4.47	0.90	-4.98	<.001
	0.63	-3.92	0.87	-4.50	<.001
	0.80	-3.37	0.89	-3.77	<.001
	0.97	-2.82	0.96	-2.93	<.001
	1.13	-2.26	1.07	-2.12	.04
	1.16	-2.16	1.09	-1.99	.05
	1.30	-1.71	1.20	-1.43	.16
	1.47	-1.16	1.35	-0.86	.39
	1.63	-0.61	1.51	-0.40	.69

1.80	-0.06	1.69	-0.04	.97
1.97	0.49	1.87	0.26	.79
2.13	1.04	2.06	0.51	.61
2.30	1.59	2.24	0.71	.48
2.47	2.14	2.44	0.88	.38
2.63	2.69	2.63	1.02	.31

Figure 2. Physiological Reactivity as a Moderator.



Though a significant direct effect was not found between basal RSA and externalizing behavior, it may be that the relationship is conditional on the involvement of other variables. Thus, the two indices of physiological reactivity were tested separately as potential moderators. The results of these analyses are presented in Table 7 and Table 8 for mean stress RSA and RSA reactivity respectively as moderators. Neither mean stress RSA ($B = -0.01, t = -0.03, p = .97$) or RSA reactivity ($B = -0.89, t = -1.57, p = .12$) had a significant interaction, and did not moderate the effect of basal RSA on externalizing behavior. The only evidence for conditional effects was for RSA reactivity

moderating the direct effect between EC and externalizing behavior. Hypothesis 5a was not supported. Hypothesis 5b was supported, but only for EC as the measure of emotion regulation.

Table 8

Stress RSA as a Moderator between Basal RSA and Externalizing Behavior

Path	Variables	<i>B</i>	<i>SE</i>	<i>t</i>	<i>p</i>
β	Stress RSA to Externalizing Behavior	0.36	2.04	0.17	.86
	Basal RSA to Externalizing Behavior	-0.17	1.88	-0.09	.93
	Interaction of Stress RSA* Basal RSA	-0.01	0.28	-0.03	.97
Stress RSA		<i>Effect</i>	<i>SE</i>	<i>t</i>	<i>p</i>
-1 SD	5.41	-0.23	0.72	-0.32	.75
Mean	6.40	-0.24	0.66	-0.36	.72
+1 SD	7.38	-0.25	0.72	-0.34	.73

Table 9

RSA Reactivity as a Moderator between Basal RSA and Externalizing Behavior

Path	Variables	<i>B</i>	<i>SE</i>	<i>t</i>	<i>p</i>
β	RSA Reactivity to Externalizing Behavior	6.27	4.22	1.49	.14
	Basal RSA to Externalizing Behavior	0.80	0.65	1.23	.22
	Interaction of RSA Reactivity * Basal RSA	-0.89	0.57	-1.57	.12
RSA Reactivity		<i>Effect</i>	<i>SE</i>	<i>t</i>	<i>p</i>
-1 SD	.08	0.74	0.62	1.19	.24
Mean	.75	0.14	0.45	0.32	.75
+1 SD	1.41	-0.45	0.55	-0.83	.41

Moderated mediation. Only one measure of emotional regulation, EC, and one measure of physiological reactivity, RSA reactivity, functioned as predicted in their

respective roles as mediator and moderator. These measures are used to test hypothesis 6 positing that physiological reactivity will moderate the indirect effect of NA, through emotion regulation, on externalizing behavior as illustrated in Figure 1. The results of Haye's (2013) test of moderated mediation, using Model 14 with moderation occurring on the β path, are summarized in Table 9. The interaction of self-report EC and RSA reactivity on self-report externalizing behavior continues to be significant ($B = 3.51, t = 2.83, p = .006$), indicating meaningful moderation by physiological reactivity on the β path. Though not a requirement for moderation mediation, the direct effect of self-report NA on externalizing behavior is no longer significant ($B = 1.53, t = 1.7, p = .09$) with the other variables accounted for in the model. Lastly, the index of moderated mediation also indicates that the conditional indirect effect (-1.65) is statistically different from zero, the lower limit and upper limit 95% confidence intervals do not contain zero, supporting hypothesis 6.

To better understand the results of the moderated mediation, the second half of Table 9 displays the conditional indirect effect and significance for a range of values of the moderator, physiological reactivity. The output from the Johnson-Neyman technique indicates regions of significance, where a value for RSA reactivity and corresponding conditional indirect effect is statistically significant at p equals 0.05 or lower. This region encompasses smaller values and ends just past the mean where the change in RSA from baseline to stressor task is greater than 0.80. Correspondingly, the underlying mediation relationship is strongest when RSA reactivity is low. At greater values of RSA reactivity the direction of the indirect effect reverses, however this relationship is not significant. Figure 3 illustrates the changing value of the indirect effect, conditional on

the value of the moderator, compared to the basic direct effect with corresponding error bars.

Table 10

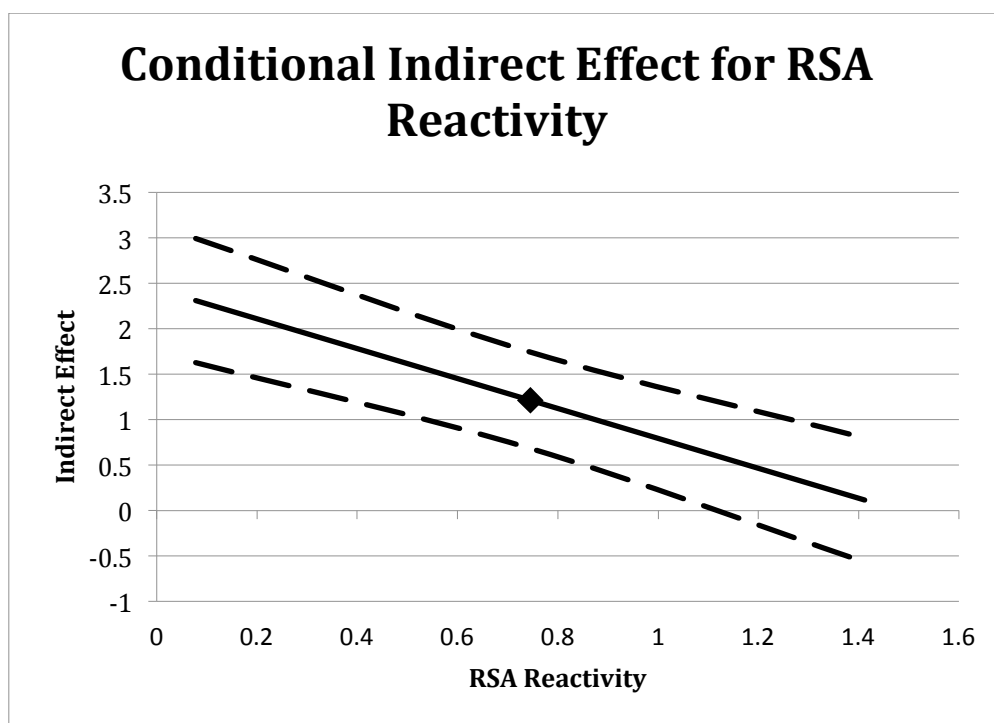
Final Moderated Mediation Analyses

Path	Variables	<i>B</i>	<i>SE</i>	<i>t</i>	<i>p</i>
α	Constant to Effortful Control	4.86	0.21	23.20	<.001
	Negative Affectivity to Effortful Control	-0.47	0.08	-6.23	<.001
β	Constant to Externalizing Behavior	19.65	5.90	3.33	.001
	Effortful Control to Externalizing Behavior	-5.20	1.26	-4.13	<.001
c'	Direct Effect	1.53	0.90	1.70	.09
	RSA Reactivity to Externalizing Behavior	-12.75	4.49	-2.84	.006
	Interaction of RSA Reactivity * EC	3.51	1.24	2.83	.006
Index of Moderated Mediation		<i>Index</i>	<i>Boot SE</i>	<i>LL 95% CI</i>	<i>UL 95% CI</i>
		-1.65	0.65	-2.99	-0.44
RSA Reactivity		<i>Indirect Effect</i>	<i>Boot SE</i>	<i>LL 95% CI</i>	<i>UL 95% CI</i>
-1 SD	.08	2.31	0.52	1.39	3.56
Mean	.75	1.21	0.50	0.23	2.23
+1 SD	1.41	0.12	0.79	-1.57	1.51
RSA Reactivity		<i>Indirect Effect</i>	<i>SE</i>	<i>z</i>	<i>p</i>
		-0.70	1.07	3.35	<.001
		-0.53	0.98	3.39	<.001
		-0.37	0.89	3.42	<.001
		-0.20	0.81	3.43	<.001
		-0.03	0.73	3.42	<.001
		0.13	0.66	3.36	<.001
		0.30	0.60	3.23	.001
		0.47	0.56	2.99	.002
		0.63	0.53	2.61	.01
		0.80	0.53	2.12	.03
		0.85	0.53	1.96	.05

0.97	0.85	0.55	1.55	.12
1.13	0.58	0.59	0.98	.33
1.30	0.30	0.64	0.47	.64
1.47	0.03	0.71	0.04	.97
1.63	-0.25	0.78	-0.32	.75
1.80	-0.52	0.86	-0.60	.55
1.97	-0.80	0.95	-0.84	.40
2.13	-1.07	1.04	-1.03	.30
2.30	-1.34	1.13	-1.18	.24
2.47	-1.62	1.23	-1.31	.19
2.63	-1.89	1.33	-1.42	.15

Note. LL = lower limit; CI= confidence interval; UL = upper limit.

Figure 3. Effects of Moderated Mediation Model with Error Bars



CHAPTER IV

Discussion

Interpretation of Results

The goal of the study was to incorporate temperamental and physiological factors of emotion regulation and reactivity into a coherent theoretical model of externalizing behavior, with a clear distinction between trait and state measures. Temperament research is older, with more consistent findings, and was used as the foundation into which polyvagal theory was incorporated. The model used can be seen in Figure 1. I hypothesized that the direct relationship between NA and externalizing behaviors would be mediated by the trait emotion regulation measures of EC and basal RSA.

Additionally, I hypothesized that the resulting indirect effect would be moderated on the β path by the state physiological reactivity measures of mean stress RSA and RSA reactivity. Statistically testing EC and basal RSA as measures of emotion regulation and distinguishing state measures of RSA as physiological reactivity from basal RSA are some of the more novel contributions of the current study. While the results provide support for the proposed theoretical model in the expected directions, not all measures functioned as predicted. The significant and null results both provide clues to how theory, research, and clinical practice, particularly related to psychophysiology, can continue to develop.

The self-reported temperament measures of NA and EC had significant correlations with externalizing behaviors in the expected directions and support well established findings in the literature. NA as a general risk factor for psychopathology was supported through significant associations with the emotion regulation measure of

EC and the dependent variable of externalizing behavior. The direction and magnitude indicate that individuals with greater trait NA have a decreased ability to inhibit their behavior and are more likely to engage in higher rates of aggressive and delinquent behavior. EC directly negatively related to externalizing behaviors in such a way that individuals with lower EC were also more likely to engage in aggressive and delinquent behavior. When EC is placed as a mediator between NA and externalizing behavior, the strength of the direct effect decreases and is no longer significant. This mediation finding suggests that NA's relationship to externalizing behavior may be largely accounted for by poor EC.

The second measure of trait emotion regulation, basal RSA, did not have a direct relationship to NA or externalizing behavior and thus did not function as a mediator between the two. This null result is not entirely surprising as basal RSA has inconsistently been associated with both constructs. Additionally, though basal RSA and EC are both widely conceptualized as measures of emotional regulation in the literature they were not correlated in the current study ($r = -0.02, p = 0.85$). Again, competing models of basal RSA have placed it as a moderator rather than a mediator. Though basal RSA is not directly correlated to the independent or dependent variable, it also does not significantly interact with NA ($B = -0.12, t = -0.19, p = .85$) and a moderation model is not a feasible alternative in the current data set. The current study did not generate support for basal RSA as an index of emotion regulation in the prediction of externalizing behaviors, particularly in relation to self-report questionnaire measures with early adolescents.

The next set of results focus on the role of physiological reactivity measures as moderators of the relationship between emotion regulation measures and externalizing behavior. Though basal RSA did not have a direct effect on externalizing behavior, the moderating role of physiological reactivity was tested to investigate the potential for conditional effects. However, there was not a significant interaction between basal RSA and either of the physiological reactivity measures. Again, absolute measures of RSA, even during stress induction, appear to have limited utility in relation to questionnaire measures of regulation and behavior.

RSA reactivity represents a relative measure of state physiological reactivity and controls for individual variation in baseline RSA inherently as a change score from mean RSA while at rest to stress induction. RSA reactivity did moderate the direct relationship between self-reported EC and externalizing behavior. The direction and magnitude of the interaction of EC and RSA reactivity on externalizing behavior is as follows, see Table 6. Individuals with little withdrawal, reduction in RSA from baseline to stressor, have an amplified negative relationship between EC and externalizing behavior. This indicates that those high in EC and low in RSA reactivity are the least likely to engage in aggressive and delinquent acts, while those with low EC and the same amount of reactivity are the most likely to engage in these problem behaviors. Thus, individuals with little state RSA reactivity may be more dependent on EC to modulate their behavior. However, as RSA reactivity increased, greater withdrawal, the significant role of EC decreased. For RSA reactivity, values above the mean and greater the moderation, interaction was no longer significant, and therefore no longer predictable, and the effect of EC on externalizing behavior approached zero. This pattern of results suggests that

the moderating role of RSA reactivity is potentially nonlinear and/or there is an additional variable unaccounted in the model at play. The implications of this finding are discussed below.

When testing the full moderated mediation model, as depicted in Figure 1, EC was used as the measure of emotion regulation mediator and RSA reactivity as the measure of physiological reactivity moderator as the other measures were not significant. Please see Table 9 for specific effect sizes, significance, and other values. As this is a moderated mediation analysis, it is now the indirect effect of NA through EC on externalizing behavior that is conditional on the value of RSA reactivity. At low values of RSA reactivity, minimal withdrawal, the positive indirect effect is stronger. Such that individuals with high NA are more likely to have low EC, and do not have a meaningful change in RSA from baseline to stressor, are estimated to engage in the highest rates of externalizing behavior. However, the reverse is also true that individuals with low NA are more likely to have high EC, and if having minimal withdrawal of RSA, are predicted to have the lowest rates of externalizing behavior. Again, the strength of the indirect effect decreases as RSA reactivity increases and just past the mean is no longer significant. The moderator has a significant conditional effect on the indirect effect for the majority of the values and the full moderated mediation model is considered to be supported. The implications of these findings on theory, research, clinical work, and the limitations of the current study are discussed below.

Implications for Theory Development

Temperament. Findings of the current study are largely consistent with the established literature on temperament related to NA and EC. EC functioning as a

mediator of NA to externalizing behavior is an established finding (Muris & Ollendick, 2005; Pitzer, Esser, Schmidt, & Laucht, 2009; Tortella-Feliu & Sese, 2010); though there is also a strong body of literature supporting it functioning as a moderator instead (Posner & Rotherbart, 2000; Eisenberg et al., 1995; Eisenberg et al., 2005). Distinguishing mediation from moderation conceptually is important. In the currently study, EC functioning as a mediator would suggest that NA's effect on externalizing behavior is due to shared variance between NA and EC, such that NA affects externalizing behavior through its relationship to EC, and has a less substantial direct affect on externalizing behavior. As a moderator, EC is thought to interact with NA in such a way that the direction or strength of the direct relationship between NA and externalizing behavior would change depending on the value of EC. As a competing model with the current data set, EC as a moderator does not result in a significant interaction ($B = -1.08$, $t = -0.65$, $p = .52$) and is not supported. The theoretical conceptualization of an interactive relationship between NA and EC on psychopathology is potentially sound, however in the current study EC was strongly and significantly correlated with NA ($r = -0.54$, $p < .001$) and externalizing behavior ($r = -0.41$, $p < .001$). It is these large direct correlations that made a moderating relationship unlikely, but lend support to the mediation model.

Psychophysiology. The current study has larger implications for the psychophysiological literature. Basal and stress RSA did not function in the model, did not work under other common competing statistical approaches, and were not significantly correlated with any other variables in the study. While psychological research focuses on RSA as a potential indicator of emotional states and arousal, physical medicine emphasizes the general health implications and associations of the measure.

Girls have consistently been found to have higher RSA than boys (Eisenberg et al., 1995; Fabes Eisenberg, & Eisenbud, 1993), and RSA decreases with age across the lifespan, is higher in physical active individuals, and is lower in individuals with diabetes and hypertension (Masi, Hawkley, Rickett, & Cacioppo, 2007). While it is important to note that polyvagal theory makes hypotheses about vagal tone, of which RSA is only an imperfect measure (Grossman, Karemaker, & Wieling, 1991; Grossman & Kollai, 1993); there continue to be inconsistent findings for RSA as an absolute measure (Morales et al., 2015).

The literature relating RSA reactivity to externalizing behavior is quite divided. Porges' (1995; 2001; 2007) polyvagal theory proposes that less withdrawal, lower reactivity in the current study, represents engagement of the PNS and suppression on SNS contributing to more socially adaptive and regulated responses to stressors. Conversely, withdrawal of RSA and PNS activity allows for SNS engagement and fight or flight responses. However, there is a seemingly competing body of research that has repeatedly related a lack of withdrawal to higher rates of externalizing behavior and greater withdrawal as a protective factor (Hinnant & El-Sheikh, 2009; El-Sheikh, Hinnant, & Erath, 2011). I believe that the results of the current study, by taking into account trait measures of temperament and analyzing RSA reactivity as a moderator, help explain how these patterns of results are not contradictory.

In the current study low RSA reactivity moderated the indirect effect of NA and EC such that the highest and lowest rates of externalizing behaviors could occur. Porges' theory for individuals with low reactivity would thus be supported as long as those individuals also had low NA and high EC. However, if those individuals had high NA

and low EC then low reactivity would be associated with the highest rates of externalizing behavior and match the results of El-Sheikh's repeated finding.

The role of NA and EC changes as physiological reactivity, and the amount of RSA withdrawal, increases. Primarily, the strength of the effect of these temperament traits on predicting externalizing behavior decreased and at the greatest degree of reactivity was no longer distinguishable from zero. High RSA reactivity then disrupts the positive and negative affects that NA and EC have on engaging in externalizing behavior. For individuals whose temperamental traits of high NA and low EC put them at risk for externalizing behavior, this is a protective factor. For individuals with low NA and EC, their rates of externalizing behavior continue to be relatively low. Analyzing direct relationships of RSA measures to temperamental and externalizing behavior was not supported in the current study. Additionally, the complexity of previous results in the literature appears to be better explained when analyzing RSA reactivity as a state measure and moderator of relationships between other variables. Of note, the disrupted predictive ability of NA and EC at high levels of RSA reactivity suggests that other sources of information are needed to predict externalizing behavior.

There are other methodological considerations to take into account when interpreting the results of this study and others that look at RSA reactivity and externalizing behaviors. This study, along with similar studies using stress induction tasks (Beauchaine et al., 2001; Keller & El-Sheikh, 2009; Mead et al., 2004; Wang, Lü, & Qin, 2013), are making an intrinsic assumption that an individual's physiological response to an induced stressor is going to provide insight into that individual's response to real world stressors prior to engaging in aggressive or delinquent acts. Bush and

colleagues (2011) tested changes in RSA across social, cognitive, sensory, and emotional challenge tasks. They found that individuals reacted significantly differently depending on the type of task. The type of stressor task may alter findings across studies.

Beauchaine (2009) identifies the divide in the research relating RSA reactivity to externalizing behavior as between research analyzing psychophysiology from a developmental versus psychopathological perspectives. In samples of individuals with clinically significant histories of conduct problems, there is a theory of a callous-unemotional pathway to aggression. Within this literature a lack of RSA reactivity to stressors is a common finding and is posited to be a sign of desensitization to high arousal associated with violence (Frick & Morris, 2004; Nigg, 2006). For these high-risk groups externalizing behavior is presumed to be more instrumental in nature, and regulatory and reactivity components are assumed to have minimal effect. Developmental research investigating community samples having findings more in line with polyvagal theory where physiological reactivity is conceived as a risk factor and emotion regulation is considered to have an important role (Beauchaine et al., 2001; Mead et al., 2004). The findings of the current study would suggest that these callous-unemotional individuals with low physiological reactivity also have high NA and low EC. While such speculation must be made with caution given the low rates of externalizing behavior observed in the current community sample, this more complex understanding of physiological reactivity is gaining support in the literature.

An important conclusion of this study is that engagement or withdrawal of the PNS is not by default always an adaptive response. It is dependent on the temperamental and emotional regulation traits of the individual. This finding matches the broader

literature suggesting that flexible responding to match the stressor is emphasized as the healthiest functioning of the PNS (Frick & Morris, 2004) and some researchers have even suggested that a moderate degree of withdrawal is actually ideal (Beauchaine, 2001). This causes complications for researchers as RSA reactivity no longer functions in a linear manner, an assumption of the majority of statistical tests. Looking at RSA reactivity alone without taking into account temperamental and regulatory traits of the individual does not adequately capture their propensity to engage in externalizing behavior.

While RSA reactivity at low levels was a statistically significant moderator of the indirect effect of NA and EC on externalizing behavior, as reactivity increased the relationship became non-significant. PNS functioning is only a piece of ANS activity. Polyvagal theory proposes that the PNS is more phylogenetically advanced and supersedes SNS activity, but once vagal tone has been withdrawn it is the degree of SNS activation that then determines physiological reactivity. I would suggest that this might be the reason why, in the current study, the moderating role of RSA reactivity became less significant the greater the withdrawal. When RSA reactivity is small and the PNS is assumed to be engaged, it is theoretically the primary physiological indicator of physiological reactivity, the necessary variables are in the model to make a prediction, and the resulting moderation is significant. However, when there is withdrawal there are then two physiological factors involved in determining physiological, SNS activity is not accounted into the calculations, and thus the model's ability to accurately predict externalizing behavior is compromised. Introducing measures of SNS activity may help

explain how NA and EC may continue to predict externalizing behavior once engagement of the PNS has been withdrawn.

Clinical Implications

The results of the current study have implications for how temperament and physiological reactivity can be utilized in clinical practice. The following is prefaced with the understanding that the design of this study does not allow for causal inferences and generalizations are made in the context of the measures and stressor used. The temperament factors of NA and EC are easily identified risk factors for engaging in aggressive and delinquent behaviors. As EC functioned as a mediator, targeting interventions to address this specific deficit may be particularly helpful. Additionally, as RSA reactivity functioned as a moderator it can also be used to evaluate risk. In particular, individuals with low physiological reactivity are either the most at risk for engaging in externalizing behavior if they have high NA and low EC, or the most protected if they have the opposite temperament. An assessment of RSA reactivity using a relatively mundane stressor task appears to have some validity as a measure of risk. While increasing an individual's physiological regulation seems like an intuitive recommendation, this is not suggested by the findings of the current study. Based on RSA reactivity alone, reducing physiological reactivity only adds additional protection if the temperament factors are already well developed. For individuals with high NA and low EC decreasing their RSA reactivity may actually increase their risk for externalizing behavior. Lastly, the null results for basal RSA do not provide evidence that it is an informative measure related to temperament and externalizing behavior.

Limitations of the Current Study

A variety of factors limit the generalizability of the results. The data was essentially collected at a single time point in relation to the dependent variable and causality is unable to be assumed. The variability in externalizing behavior was also quite limited, likely due to using a community sample, and the mode was zero. The study is also overly reliant on questionnaire measures. While questionnaire measures are easily administered and widely established in the social sciences, they contain weaknesses related to reporter bias and issues of validity. In general, there is conceptual and measurement enmeshment in the constructs related to reactivity and regulation. For instance, Rothbart and Posner (2006) conceptualize NA as a measure of “reactivity,” while simultaneously proposing it as a trait measure of general risk of psychopathology. Basal RSA and RSA reactivity are commonly used interchangeably as measures of reactivity and regulation conceptually and statistically (Sulik, Eisenberg, Silva, Spinrad & Kupfer 2012). The construct overlap, lack of methodological sequencing, and competing statistical models, and conflicting findings in the literature mean that the theoretical model used in the current study is likely imperfect. This is not to diminish the findings of this study or others, but it must be emphasized that these findings are not immutable and there is still great growth potential in these areas of study.

Future Research

Analyzing physiological reactivity solely through vagal tone is innately limiting. ANS functioning is a two-factor system, where the PNS and SNS can engage and/or withdraw independently based on the present environmental and internal conditions (Berntson, Cacioppo, Quigley, & Fabro, 1994). I hypothesize that this was potentially

apparent in the current study. Modeling SNS and PNS functioning statistically is difficult and has been attempted in a limited number of studies (Beauchaine, Hong, & Marsh, 2008; El-Sheikh et al., 2009). Given the greater utility of relative measures over absolute value measures as moderators, a double moderating model or structural equation modeling with change scores of PNS and SNS activity may be advisable. If research continues to focus on RSA reactivity alone, using statistical methods that can account for curvilinear relationships may be essential. In addition to physiological reactivity, physiological recovery also offers new opportunities for understand and individuals responses to stress. State measure of reactivity need not be limited to physiological, tasks or questionnaires related to cognitive processes and attention may also provide insight.

The conceptual overlap between reactivity, regulation, and affectivity in the broader literature is concerning and that does not take into account the synonyms for these constructs. This is an issue that has been brought up in the temperament (Oldehinkel, Hartman, Ferdinand, Verhulst, & Ormel, 2007) and psychophysiological literature (Beauchaine, 2001). I attempted to make a clear distinction by differentiating between state emotion regulation and trait physiological reactivity measures. While conflicting viewpoints are to be expected in a broad field such as psychology and overlap is appropriate, research that continues to merge and test the conceptualization of diverse perspectives is needed. Another way to approach this problem is to use more experimental and observational measures. The current study would have greatly benefited from a task to measure aggressive behaviors or impulses after the stressor task instead of relying on a nonspecific questionnaire measure. Such methodology also allows causality to be inferred.

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