ABSTRACT

Title: INTERNALIZING AND EXTERNALIZING BEHAVIORS IN PRESCHOOLERS: PHYSIOLOGICAL MECHANISMS, PARENTAL RATINGS AND LUNCHTIME OBSERVATIONS

Myriah Koledin, M.A., 2005

Directed By: Professor, Nathan Fox, Department of Human Development

Physiological reactivity and regulation, via measures of vagal tone(a physiological measure), and heart period, and their relation to social behavior as witnessed during lunchtime were examined in preschoolers. Participants included 100 children, 3-6 years of age from a day care center. Vagal tone and heart period were collected during a 25-minute protocol including baseline, challenge task, video watching, and post-baseline. Parent ratings of their child's behavior were collected using the Child Behavior Checklist. Results indicated that for a group of withdrawn children as evidenced from lunchtime observations, significant correlations were found for heart period recovery from a challenge task with total problems, and stability of heart period was correlated with internalizing, externalizing and total problems. The stability measure for vagal tone in the HWD group was significantly correlated with externalizing and total problems. It is concluded that children high in withdrawn behavior exhibit a different physiology than those exhibiting low withdrawn behaviors as witnessed during lunchtime observations.

INTERNALIZING AND EXTERNALIZING BEHAVIORS IN PRESCHOOLERS: PHYSIOLOGICAL MECHANISMS, PARENTAL RATINGS AND LUNCHTIME OBSERVATIONS

By

Myriah Koledin

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Advisory Committee:
Professor Dr. Nathan Fox, Chair
Professor Dr. Roger Azevedo
Professor Dr. Jane Doussard-Roosevelt

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Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

Background

Self-regulation has been defined as the ability to fulfill a request, to initiate and end activities according to situational demands, to modulate the intensity, frequency and duration of verbal and motor acts in social and educational settings, to postpone acting on a desired goal or object, and to generate socially approved behavior in the absence of external monitors. Self-regulation has implications for understanding and influencing the nature of transitions from sensorimotor levels of functioning, to those organized around reflective thought, task-oriented behaviors, as well as cognitive performance, and social interactions (Kopp, 1982).

In connection with self-regulation are the constructs of reactivity and emotion expression. Reactivity refers to emotional, attentional, and motoric responses that are elicited by external stimuli, and which often manifest themselves in the emotional expression of individuals (Huffman, et al., 1998). It is posited that reactivity, regulation and expression of emotion interact with one another consequently affecting social behavior. For example, Fox and Calkins (1993) argue that the characteristic influence of the child's emotional arousal or reactivity on social behavior will depend on the degree to which the child engages in behaviors that allow him or her to manage their reactivity in a beneficial way. However, children who experience extreme arousal or emotional reactivity may have problems regulating those experiences, regardless of the strategies they may try to use.

Regulatory control may be linked closely with behavior problems in later childhood. In the research literature maladaptive behavior problems have been categorized or described along two broad dimensions, externalizing and internalizing. Externalizing behavior problems are characterized by difficulties with attention, aggression, conduct, and under-socialization, while internalizing problems include withdrawal, anxiety, fearfulness, and depression. These dimensions provide a distinction between aggressive, antisocial, undercontrolled behavior and fearful, inhibited, overcontrolled behavior (Rapport, Denney, Chung & Hustace, 2001).

The relation between maladaptive behavior and self control has been made explicit by researchers such as Block and Block (1980). They argued that children with externalizing problems are undercontrolled, while those with internalizing problems are overly controlled or constrained in their behavior. There is in fact a growing body of literature that links externalizing problems to insufficient regulation, including inadequate ability to inhibit behavior and to control attention and cognitive processing, and to future behavior problems (Rubin, Burgess, Dwyer, & Hastings, 2003; Eisenberg et al., 2000; Fagot, & Leve, 1998). However, the relations between measures of regulation and internalizing problems are less clear. Studies show mixed results, with some reporting that early preschool internalizing problems can predict later internalizing problems (Lavigne et al., 1998), and others not confirming these findings (Fischer, Rolf, Hasazi, & Cummings, 1984).

In considering the dimensions of early behavior that may be relevant to externalizing or internalizing problems and their developmental bases, it is useful to consider how such behavior is often defined and explained in young children. For example, when characterizing early externalizing behavior problems in children, there is often reference to a lack of control, under-control, or poor regulation. By the time the child has reached the end of the toddler period, he or she is expected to be capable of emotional, behavioral, and physiological regulation that supports an emergent independent identity and self-sufficient behavior (Kopp, 1982). However, although there is an identifiable developmental progression in the attainment of self-regulatory skills and abilities within these domains, individual differences may affect how a child demonstrates proficient regulation. These individual differences have been shown to have important implications for psychosocial adaptation and the gain of important developmental achievements (Sroufe, 1996). Consequently, regulatory functioning in the physiological domain should be attended to when examining the early correlates of self-regulation, externalizing, and internalizing difficulties.

In the physiological domain, self-regulation in relation to internalizing and externalizing behaviors, along with emotion expression and reactivity, may all share a common neurophysiological mechanism. Aspects of cardiac activity that reflect dimensions of physiological or behavioral regulation have been investigated in studies of early behavior problems in young children. Heart rate variability, one specific dimension of cardiac activity, has been linked to regulation in young children. Although there are numerous ways to measure this variability, Porges (1991) and colleagues have developed a method that measures the amplitude and the period of the oscillations linked with inhaling and exhaling. Therefore, this measure refers to the variability in heart rate that occurs at the frequency of breathing, termed respiratory sinus arrhythmia (RSA), and is believed to reflect the parasympathetic influence on heart rate variability by way of the vagus nerve. Porges has termed this measure of heart rate variability vagal tone (Porges, 1996).

It has been proposed that baseline measures of cardiac vagal tone, computed as the amplitude of respiratory sinus arrhythmia (RSA) will give a sensitive measure of an individual's homeostasis, and change in vagal tone indexes an individual's ability to cope with disruption to homeostasis and therefore should be related to behavioral dimensions of reactivity, expressiveness, and self-regulation (Porges, Doussard-Roosevelt, & Maiti, 1994). Porges and colleagues (e.g., Doussard-Roosevelt & Porges, 1999; Porges & Doussard-Roosevelt, 1997a, 1997b; Porges, Doussard-Roosevelt, Portales, & Suess, 1994) propose a hierarchical model in which complex behaviors are built on a foundation of physiological regulation, leading to a relation between measures of vagal tone and more complex behaviors, including social behaviors, emotion regulation and attention regulation.

Porges has speculated that vagal tone reflects reactivity to, and awareness of, one's environment. High vagal tone is one index of autonomic functioning that may be associated with better behavioral and neural reactivity (Porges, 1991). For example, Stifter and Fox (1990) found that infants who cried to an arm restraint procedure were displaying appropriate behavioral reactivity, and also showed high base level vagal tone. Higher baseline measures of vagal tone have also been linked with good attentional ability (Suess, Porges, & Plude, 1994). Therefore, observed differences among individuals in terms of resting vagal tone may reflect differences in one or more stable and biologically based traits, such as the ability of the individual to attend and react appropriately to environmental stimuli (Porges, 1991).

Being able to regulate ones emotions, reactions, and expressions is often vital for everyday functioning and learning, and understanding the underlying mechanisms involved in these processes is helpful in determining the etiologies of certain behavioral problems and other issues that may interfere with cognitive, social, and personal performance. The purpose of the current thesis is to examine physiological reactivity and regulation (via measures of vagal tone/RSA) and their relation to complex social behavior in a sample of preschoolers. Observations of social behavior during the lunchtime period as well as parent ratings of internalizing and externalizing behavior were examined.

Chapter 2: Review of Literature

Peer Interaction and Social Competence

Increased attention has been given to identifying the roles that emotionality plays in children's social competence. Socially competent children display emotions that are responsive to group norms and obtain a balance between their own desires and interests and those of other children. A child's ability to identify and express emotions and emotional intentions is related to their social competence and is also reflected in the quality of children's emotional states (Fabes et al., 1999).

Optimal regulation is thought to be linked with positive, adaptive behavior, the strength of this relation varying according to the intensity that various emotions are experienced. In contrast, individuals who experience intense levels of negative emotionality may become overwhelmed and therefore behave more negatively, impulsively, and less constructively than do less emotionally aroused individuals. Consequently, regulation and emotional reactivity are viewed as interrelated and are thought to contribute jointly to children's social functioning (Eisenberg & Fabes, 1992; Fox, 1989). For example, Fabes and colleagues (1999) found that when observing intense interaction or when negative emotions were elicited between interacting peers, that socially competent responding was less likely to be seen. Moreover, when the interactions were of high intensity, highly regulated children were likely to show socially competent responses.

Disruptive behavior problems in toddlerhood are highly stable across childhood, and predictive of other more serious levels of behavior and conduct problems, and also place children at risk for peer rejection and associated problems (Calkins & Dedmon, 2000). Evidence supports the importance of regulation of emotion to children's social competence and adjustment. For example, Stocker and Dunn (1990) found moody or emotionally negative children to experience more peer rejection. Eisenberg and colleagues (1993) have found that individuals who are highly emotional in response to anger-inducing events and poor at regulation are likely to show aggression in social situations. Strategies such as attentional control (focusing on an object other than the arousing stimulus), avoidance (turning away from stimulus), and instrumental coping (working with the situation) may be helpful in dealing with anger. Children who fail to implement these strategies tend to vent their emotions and may become aggressive. These findings lead to important implications of anger display and the regulation of anger for peer relationships. Highly emotional children who were low on regulatory skills were found to have poorer social skills and lower sociometric status. These finding indicate that the ability to cope with anger allows the child to maintain social relationships with peers even when conflict and disagreement occur, an outcome that contributes to the development of social competence (Eisenberg et al., 1993).

Similarly, Rubin and colleagues (2003) examined whether observed toddler initiations of conflict and aggression, along with toddlers' ability to regulate emotions and inhibit undesired behaviors, and the extent to which the child's mothers interact with them in a negative way would predict aggressive and conduct behavior problems by preschool age. They found that the display of early conflict initiations and aggressive behavior in combination bodes poorly for subsequent adjustment. Furthermore, considering toddlers who were least able to regulate their behaviors and emotions, a significant relation existed between conflict-aggression and preschool-age externalizing difficulties. The same was not true for those toddlers whose emotional and behavioral regulatory skills were average or above average. These results indicate the importance of individual and social interaction risk factors when investigating the interaction of individual differences, temperament, and peer relations, as well as parenting.

With regard to intrapersonal factors, certain dispositional characteristics have been associated with, and predictive of, behavioral maladjustment. A difficult temperament among infants and toddlers often becomes visible through high activity level and anger proneness, or high emotional reactivity and poor regulatory control (Rubin, Burgess, & Hastings, 2002). Difficult temperament has been linked with behavioral undercontrol, aggression, and interpersonal conflict, characteristic of externalizing problems (Rubin, Hastings, Chen, Stewart, & McNichol, 1998). On the other hand, an inhibited, fearful temperament may be an early precursor of internalizing behavior problems such as anxious and depressive symptoms (Fox, Calkins, Schmidt, Rubin, & Coplan, 1996). Behavioral inhibition, which is possibly biologically based, has been defined as a pattern of responding or behaving with signs of anxiety, distress, or wariness when unfamiliar or challenging situations are encountered (Kagan, 1989). Behavioral inhibition is marked by the toddler's latency to speak to an unfamiliar adult, latency to approach the stranger or unfamiliar objects, and time spent near or away from the mother.

Rubin and colleagues (2002) examined whether different types of behavioral inhibition were stable from toddler to preschool age, and whether inhibited temperament and/or parenting style would predict children's later social and behavioral problems. They found that from the first observation at around age 2, until their second observation at age 4, meaningful connections were found between toddler inhibition, maternal intrusive control and derision, and nonsocial behaviors at age 4. Toddler inhibition also predicted socially reticent behavior during a free play episode at 4 years. Mothers who showed relatively high occurrences of intrusive control and/or derisive comments, had toddlers who showed a significant and positive association between peer inhibition and 4-year social reticence; whereas if mothers were neither intrusive nor derisive, then toddler's peer inhibition and 4-year reticence were not significantly linked. It appears therefore that maternal behaviors moderated the relation between toddlers' peer inhibition and preschoolers' social reticence (Rubin, Burgess, & Hastings, 2002).

Similarly, Eisenberg and colleagues (1998) examined a various form of inhibition called social inhibition in relation to regulation, emotionality and coping in children through teacher and parent report. Social inhibition varies from behavioral inhibition in that social inhibition involves emotion and/or inhibited behaviors solely in social situations, whereas behavioral inhibition involves wariness in novel contexts, including unfamiliar nonsocial as well as social situations (Eisenberg, Shepard, Fabes, Murphy, & Guthrie, 1998). The findings reveal that social inhibition was positively related to internalizing negative emotion, and avoidant coping. For parent ratings, social inhibition was positively related to behavioral inhibition and non-impulsivity, attention focusing and avoidant coping, and was negatively related to positive emotionality, instrumental coping and for seeking teacher support. Overall, the findings support the idea that social inhibition is related to individual differences in regulation, internalizing emotionality and coping style, and that children susceptible to internalizing negative emotions and unable to shift attention from negative emotion are especially likely to be socially inhibited years later.

A child who develops coping strategies for external social and nonsocial demands over the first few years of life is likely assembling a range of behaviors that will assist with the development of socially appropriate behaviors (Calkins, 1997). Kagan's (1989) conceptualization of inhibition and disinhibition to the unfamiliar as a temperamental characteristic has served as a foundation for the exploration of the development of later externalizing and internalizing problems. Following are several studies that examine links between emotional and behavioral regulation and adaptive and maladaptive social behaviors.

Externalizing Behaviors

Regulation or control of emotion has been shown to be linked closely to externalizing behaviors. One reason for concern over externalizing behaviors is that children who are rated higher on this scale also have other problems. They show poor achievement in school, poor peer relations, and disrupted parent relations, and are at risk for future delinquency (Fagot & Leve, 1998). The transition from early preschool years (2-3 years) to school entry (4-5 years) poses a significant shift in behavioral patterns in order to meet a variety of social demands that are represented by principal developmental tasks such as making friends and learning certain social skills required by the school setting. Children's ability to adapt successfully to these social demands is thought to be crucial to their further development. In contrast, the development of externalizing behaviors at this age is predictive of dysfunction in later childhood (Mesman, Bongers, & Koot, 2001).

There is a growing body of literature that links externalizing problems to insufficient regulation, including inadequate ability to inhibit behavior in order to control attention and cognitive processing, as well as exhibiting under-controlled emotions (e.g., Eisenberg et al, 2000; Andersson & Sommerfelt, 2001; Eisenberg et al., 2001; Fagot, & Leve, 1998). For example, Eisenberg and colleagues (Eisenberg et al., 2000) examined the moderating role of individual differences in negative emotionality in the relation of behavioral and attentional/emotional regulation to externalizing problem behaviors. Results indicated that behavioral dysregulation predicted externalizing problems for children classified as both high and low in negative emotionality. However, prediction of problem behavior from emotional control was significant only for the children who exhibited negative emotionality. One explanation put forth by the authors for the results is that children low in negative emotionality were simply low in externalizing behaviors, therefore individual differences in attentional/emotional control did not predict externalizing behavior for this group of children. However, children high in negative emotionality exhibited greater levels of problem behavior. Due to the fact that attentional regulation is likely to play a role in the regulation of internal emotional experiences, it appears that a lack in emotion regulation is what accounted for the difference in externalizing behavior between children more susceptible to intense and frequent negative emotions as opposed to those less susceptible (Eisenberg et al., 2000).

Evidence also supports the importance of emotion regulation to children's social competence and adjustment. For example, Eisenberg and colleagues (1993) similarly found that the combination of high emotional intensity and low attentional regulation was associated with low social skills and sociometric status. When taken together, measures of children’s emotionality, attentional control, and coping accounted for over half of the variance in boys’ and girls’ social skills, respectively. Similarly, Fabes et al. (1999) looked at the relation of regulatory emotional processes to the quality of children’s social competence, which they defined as the ability to realize social goals effectively, in everyday peer interactions. Results indicated that for moderate to high intense interactions, children who were high in effortful control were unlikely to experience high levels of negative emotional arousal in response to peer interactions. Furthermore, when the interactions were of high intensity, children who were highly regulated were likely to show socially competent responses. Overall, results support the idea that regulatory processes interact with situational factors to influence how children respond to social relations with other children in their everyday lives.

Internalizing Behaviors

Internalizing problems include withdrawal, anxiety, fearfulness, and depression. Consistent with externalizing behaviors, internalizing behaviors are closely linked with regulation or control of emotion and self, however the relations are less clear. Due to the fact that internalizing problems often involve the inability to control negative emotionality, which is reflected in high levels of sadness, anxiety, and depression, it can be expected that people with internalizing problems have low attentional control, a type of regulation that has been linked to low levels of negative emotionality (Derryberry & Rothbart, 1988; Eisenberg et al., 2001).

For example Eisenberg and colleagues (Eisenberg et al., 2001) conducted a study examining the relation of different types of negative emotion, regulation and control to internalizing and externalizing problem behaviors. They defined internalizing problems as social withdrawal, anxiety, depression, and psychosomatic complaints. Results indicated that children with internalizing symptoms were prone to sadness, low attentional regulation, and low impulsivity. Findings suggest that emotion and regulation are linked in methodical ways with adjustment and that there is an important difference between effortful control and less voluntary modes of control. The finding that internalizing children were low in attentional regulation is consistent with the concept that they have particular difficulty regulating internal emotions such as sadness and anxiety.

Internalizing behaviors appear to increase with age and place children who are affected at risk for a variety of later difficulties including learning problems, academic underachievement, conduct problems, and deficient social skills (Rapport, Denney, Chung, & Hustace, 2001; Kohn & Rosman, 1972; Normandeau & Guay, 1998). For example, Rapport and colleagues (2001) conducted a study looking at dual pathways that may mediate the relation between internalizing behavior problems and later academic achievement. Overall the model implies that internalizing behavior problems are associated with risk for impaired classroom performance and concentration or memory difficulties, which over time, are thought to adversely affect children’s long-term academic achievement. Results revealed several conclusions: individual differences in measured intelligence of children are linked with differences in classroom performance and cognitive functioning; classroom performance and cognitive functioning make individual contributions to the prediction of later achievement over the influence of intelligence; and anxiety and depression or withdrawal contribute to the prediction of classroom performance and cognitive functioning over the effects of intelligence.

Overall, the results show that classroom performance and cognitive functioning appear to mediate the effects of internalizing behaviors as well as intelligence.

These results are consistent with other studies as well. For example, Kohn and Rosman (1972) found that preschoolers rated by teachers as high on apathy/withdrawal, as opposed to interest/participation, received lower academic ratings in the first and second grade. Another study examined the relation between anxious-withdrawn behavior problems and later school achievement, based on grades, in children followed from kindergarten to first grade (Normadeau & Guay, 1998). It was found that a direct link existed between anxious-withdrawn behavior problems and later school achievement, but only accounted for a small amount (10%) of the variance in school achievement. The absence of cognitive and classroom performance variables as mediators may have contributed to the relatively large proportion of unexplained variance in the model. In general these collective findings are important as it appears that classroom performance and cognitive functioning do impact the effects of internalizing behaviors, which could lead to impairment in the child's functioning (Normandeau & Guay, 1998).

Physiological Bases

Situating self-regulation and the constructs of internalizing and externalizing behaviors in a theoretical framework of physiology brings into consideration the Polyvagal Theory (Porges, 1995). It is posited that by understanding the mechanisms involved in individual and developmental differences in emotion expression and regulation, it may provide a way to identify individuals whose ability to regulate emotions varies. Therefore, there is the possibility that individual differences in the nervous system might map onto individual differences in the expression and regulation of emotion. The theory rests on the assumption that individual differences in parasympathetic tone are related to the regulation of emotion. Parasympathetic tone is indexed by the vagal tone measure of RSA.

The autonomic nervous system regulates homeostatic function and is composed of two subsystems, the parasympathetic and sympathetic nervous systems. These systems represent structures that originate in the brain stem and aid in the regulation of many organs, including the eyes, salivary glands, blood vessels, heart, larynx, trachea, lungs, stomach, adrenal glands, kidneys, intestines, and bladder. The peripheral nervous system generally promotes functions linked with growth and restorative process, and the sympathetic nervous system helps with increased metabolic output to deal with external challenges. The vagus nerve, which is the tenth cranial nerve, originates in the brain stem and leads to many organs in the body including the heart and the digestive system. Vagal stimulation of the sino-atrial node of the heart, which is the primary internal pacemaker of the heart, slows heart rate, and vagal withdrawal speeds heart rate. While the sympathetic nervous system is involved in large shifts in heart rate (i.e., the fight-flight response), the parasympathetic nervous system, via vagal pathways, provides for subtle increases and decreases in heart rate. These brief fluctuations in vagal tone act like the removal and reengagement of a “vagal brake.” The vagal system is a complex bi-directional scheme which encompasses neural pathways that allow direct and express communication between brain structures and specific organs. The vagus contains both motor and sensory fibers, which allow the promotion of dynamic feedback from organs to various brain centers, in turn allowing the regulation of homeostasis (Doussard-Roosevelt, Porges, & Maiti, 1994).

Porges (1995) also outlines a four level hierarchical model of neurobehavioral organization, which describes the foundational basis for behaviors that are provided by physiological processes and systems. The first level involves the regulation of internal processes successfully by way of neural feedback systems. Baseline vagal tone is a measure of the organization in one of these feedback systems. The vagal tone index is a measure originating from the electrocardiographic (ECG) signal and represents the variability in heart rate that is associated with respiration, known as respiratory sinus arrhythmia (RSA). Vagal tone measures address the neural influence of the brain on the rhythm of the heart by way of the vagus nerve. The "vagal brake" is a concept used to understand the regulation of vagal influence on heart rate as changes in environmental context require changes in behavior states.

The second level of the hierarchy represents the coordination of physiological systems. Change in vagal tone in response to stressors represents one reflection of this coordination. The vagal brake may be engaged or disengaged, dependent on the situation, in turn causing heart rate to decrease or increase. The third level involves overt behaviors such as talking, listening, and maintaining eye contact. The fourth level reflects social interactions related to behavior regulation. Each level serves as the foundation for the coordination of complex behaviors such as emotion regulation and attention regulation at the higher levels of the model. In response to mild or challenging stressors, the behavioral response of the individual is predicted by the underlying physiological reactivity and regulation patterns (Doussard-Roosevelt, & Porges, 1999).

Vagal Tone and Emotion Regulation

Research on relations between behavioral measures of emotion regulation and vagal tone have consistently found relations to behavioral measures. Eisenberg et al. (1995) refer to emotion regulation in terms of modulating internal reactivity, specifically attentional and behavioral responses to emotional and physiological internal reactions that result from the processing of external stimuli.

Related studies have looked at emotion regulation and underlying physiology in relation to early behavior problems (Cole, Zahn-Waxler, Fox, Usher, & Welsh, 1996; Eisenberg et al., 1995; Eisenberg et al., 1996; Rubin, Burgess, Dwyer, & Hastings, 2003). For example Eisenberg and colleagues (1995) conducted a study examining the joint and unique contributions of regulation and emotionality to normal children's socially appropriate, non-aggressive behavior at school, pro-social behavior and sociability at school, and problem behaviors at home as assessed through teacher and parent report, and measures of physiology. Depending on the gender of the child, results differed as to the index of physiological regulation in relation to measures of social functioning. They found that for boys, vagal tone was associated with pro-social/sociable behavior, as well as low levels of father-reported problem behavior, and to some degree high regulation and low emotionality. In contrast, girls with high vagal tone were viewed by teachers as low in socially appropriate behavior, and as high in emotionality and low in regulation/coping. Vagal tone was unrelated to parents' reports of girls' behaviors and characteristics. Consistent with these findings, Eisenberg and colleagues (1996) report a similar study in which girls' vagal tone was negatively related to their reception of peer nominations of pro-social behavior, whereas the opposite was found for boys.

One explanation for these discrepant findings is that uninhibited assertive girls and boys are viewed differently. Possibly due to gender stereotypes and differing expectations for boys and girls, boys' uninhibited, assertive behavior is viewed as more positive than the same behavior in girls. High vagal tone (greater heart rate variability) has been linked to uninhibited rather than inhibited behavior. Due to gender stereotypes and therefore differing expectations for boys and girls, it is possible that girls' uninhibited, assertive behavior is viewed by others as an indication of low social and pro-social functioning (Eisenberg et al., 1996).

Consistent with this view is Buck's (1975) finding that girls who clearly displayed spontaneous emotional reactions were viewed by teachers as impulsive, dominating, and difficult to get along with, while this was not true for boys. Therefore, it is possible that the uninhibited style of girls with high vagal tone reduces their involvement in routine everyday pro-social actions and/or affects peer perceptions. Cole, Zahn-Waxler, Fox, Usher and Welsh (1996) examined expressive and physiological aspects of emotion regulation during a negative mood task in preschoolers with varying degrees of behavior problems. Similar to the previous studies, the researchers found that the group labeled highly expressive showed higher vagal tone than the other two identified groups (modulated, inexpressive). Looking collectively at the results, it appears that higher vagal tone is associated with greater sociability, self-regulation, and adaptive functioning in children.

Chapter 3: Methods

Proposed Study

The current study examined physiological reactivity and regulation (via measures of vagal tone/RSA) and their relation to complex social behavior in a sample of preschoolers. Observations of social behavior during the lunchtime period, specifically, near the end of the semester in which the child participated in the research study, the child was videotaped from behind a two-way mirrored observation booth for 5 minutes on three different days, yielding a total of 15 minutes of observational data per child. The lunchtime setting was used as a way to provide a controlled environment since the children can be unobtrusively observed from a rather close distance. Also during this time, interaction with classmates is encouraged in a naturalistic way, due to the seating arrangements, but it is not mandatory. During this time, adult intervention is limited, which allows the children space to interact with their peers in a semi-supervised way. Parent ratings of their child's behavior overall were also collected. There have been limited studies that have examined the relation of internalizing and externalizing behaviors specifically to measures of vagal tone in a sample of preschool children, and few which have been conducted recently. Social competence is related to children's ability to identify and express emotions and emotional intentions (Fabes et al., 1999).

In lieu of the current research, it has become increasingly important to determine the links between broadband behavior problems and other areas of the child's life, as well as how behavior regulation and control are influenced by physiology, specifically measures of vagal tone. If externalizing and internalizing behaviors are predictive of later problems in social competence and school success, as many studies show (Rapport, Denney, Chung, & Hustace, 2001; Mesman, Bongers, & Koot, 2001; Fagot & Leve, 1998), then perhaps evaluating the underlying physiological mechanisms which may drive and predict these behaviors that interfere with the development of social skills and successful school behaviors, could provide more evidence for an important link between regulation, behavior and physiology in preschool children.

Utilizing the Polyvagal theory as a framework, and addressing individual differences in underlying physiology, it could be theorized that children's externalizing and/or internalizing behaviors can be predicted by the numerous effects of individual differences in emotionality and regulation, and that behavioral regulation, as witnessed in a social interaction such as lunchtime, would be a predictor of broadband problem behaviors for children with varying physiological regulatory abilities.

Hypotheses

The current study examined relations between measures of physiological regulation (vagal tone and heart period), measures of externalizing and internalizing behaviors as rated by parents, and social behavior during lunchtime in a sample of preschool children. The first set of hypotheses refer to relations among baseline measures of vagal tone and heart period (HP) and measures of maladaptive behavior as reported on the CBCL and measures of social competence as observed and coded during the lunchtime period.

Hypothesis 1A: Baseline measures of vagal tone and heart period will be related to parent report of externalizing and internalizing problems in young children. Specifically, children evidencing high vagal tone will be less likely to have parents report high symptoms in internalizing or externalizing. Children evidencing low vagal tone will be more likely to have parents rating symptoms of both internalizing and externalizing. This hypothesis will be examined by computing a correlation matrix between the baseline measure of vagal tone and heart periodand the CBCL measures of internalizing and externalizing problems.

Hypothesis 1B: Baseline measures of vagal tone and heart period will be related to measures of social competence during lunchtime such that children exhibiting high vagal tone will be observed to exhibit greater social competence than those with low vagal tone. This hypothesis will be examined by computing a correlation matrix between the baseline measure of vagal tone and heart periodand observed behaviors during lunchtime.

The second set of hypotheses involves relations among measures of vagal and heart period response to a challenge and parent report of maladaptive behavior and observed social competence during lunchtime.

Hypothesis 2A: Children showing greater vagal response (defined as lower vagal tone to challenge) will exhibit lower levels of externalizing and internalizing problems as reported by their parent. Children showing lower vagal response (evidenced by higher vagal tone to challenge) will display higher levels of internalizing and externalizing symptoms as reported by their parent. This hypothesis will be analyzed by looking at correlations between change scores of vagal tone and heart period in response to a stressor and CBCL measures of internalizing and externalizing behaviors.

Hypothesis 2B: Children showing greater vagal response will exhibit greater social competence during lunchtime. Conversely, children exhibiting lower vagal response will demonstrate reduced social competence during lunchtime. Analysis of this hypothesis will be conducted by examining correlations between change scores and observed behaviors.

Hypothesis 3A: Children showing higher difference scores from pre-baseline to post-baseline will reveal higher ratings of internalizing and externalizing problems by their parent. On the other hand, children showing lower difference scores form pre-baseline to post-baseline (good recovery), will be more likely to have low parent report of internalizing and externalizing symptoms. A correlation matrix will be computed examining the recovery score in relation to CBCL measures of internalizing and externalizing behaviors in order to analyze this hypothesis.

Hypothesis 3B: Children who exhibit higher difference scores from pre-baseline to post-baseline, will show evidence of more reduced social competence during lunchtime than children who display lower difference scores from pre-baseline to post-baseline. This hypothesis will be analyzed by looking at correlations between the recovery scores and observed social behaviors during lunchtime.

Participants

Participants included 100 children, 3-6 years of age (*mean age*= 4.3, *sd* = .73), attending a University-based Center for Young Children. The majority of children were Caucasian (46 Caucasian, 8 African American, 6 Hispanic, 15 Asian American, 12 Mixed, and 10 were unknown) and were from two-parent middle income families. There are 44 males and 56 females. Children were tested in individual sessions in a research room in the preschool. ECG data were recorded during a 25-minutes session that included four conditions (quiet baseline, video, maze task, and quiet post baseline).

Measures of RSA and heart period for each condition were derived from the ECG data. In addition, children were observed during lunchtime sessions in their classrooms.

Procedures

Session

Before testing began, each class was introduced to the experimenters and the procedures were described. To describe the way the experimenter would monitor their heart rate, a teddy bear with sticker electrodes was used in a demonstration. Consent forms were sent home to parents (See Appendix 2). Children whose parents returned signed consent forms were approached for participation in the research. When the child entered the research room with the researcher, they were reminded about the study and shown the monitor that would be collecting their heart beats. The sticker electrodes were attached to leads and placed on the child's chest. After making sure the child was comfortable, they were told that after sitting quietly for 4 minutes, they will get to watch a video and then do some mazes.

The video consisted of one of two Disney sing-along songs which lasted for 4 minutes. The challenge task included 4 different, semi-challenging mazes, and 2 more mazes with increasing difficulty, which the child was to attempt to complete to the best of their abilities. These mazes were chosen to assess how the child reacted to a challenge situation, if a child finished the first 4 before the time was up, they were given the next 2 in order to increase the challenge. Following the maze task, children again sat quietly for 4 minutes, and were then given a certificate and sticker to take home with them. From these procedures, RSA measures were obtained for each of the four conditions.

Measures

Heart Rate

Heart rate recordings were collected by monitoring ECG with three Ag/AgCl disposable sticker electrodes that were placed on the child's chest. The ECG signal was amplified and input to a Vagal Tone Monitor-II (Delta Biometrics, Inc.), which detected the peak of the R–wave to the nearest msec and timed sequential heart periods (interbeat intervals). MXedit software (Delta Biometrics, Inc.) was used to display visually the heart period data, to edit outliers, and to quantify heart period and the cardiac vagal tone index using the Porges method (Porges, 1985). The sampling interval was set at 250 msec and a bandpass filter was used to extract the variability within the frequency band of respiration for young children (.24-1.04 Hz). Heart period and RSA were calculated and averaged across sequential 30-sec epochs for the four conditions.

Parent Measures

Behavior ratings by parents were collected using the Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2000; Appendix 3), and were sent home with the consent form at the beginning of each recruitment period. The CBCL consists of two broad-band behavior problem groupings, reflecting a distinction between fearful, inhibited, over-controlled behavior (internalizing), and aggressive, antisocial, under-controlled behavior (externalizing). To determine a child's behavior problems, all internalizing items and externalizing items were summed individually and *t* scores were provided for each. A child with a CBCL score of 63 or above for either of the two subscales of internalzing or externalzing behaviors is considered at clinical risk. There were 3 children who had *t* scores above the clinical range.

Lunchtime Observation and Coding

Each 5 minute section of collected lunchtime observations were analyzed in 5 second epochs, coding for the following various behavior groupings: engaged talking, engaged listening, onlooker/watching, withdrawn, away from table, control problems, and eating. There was a range of possible scores from 0-180. Engaged talking was marked if the child was clearly talking to another person, either another classmate or a teacher. If the child appears to be talking to him or herself, without engaging another person during their dialogue, it was not coded in this category (see: withdrawn). Engaged listening was coded if the child was looking at another classmate or teacher while that person was talking, and not simply glancing around. Onlooker/watching was marked if the child was not clearly engaged in a conversation (either talking or listening), and was simply glancing around the room. Withdrawn was coded if the child was not clearly engaged in a conversation (either talking or listening), was not glancing around the room, and was either looking down, absorbed in him or herself, or staring into space. If the child got up from his or her seat for any reason, whether they stayed next to their seat, or wandered away from the table, they were coded as away from the table. Control problems were coded if the child acted out in any way, whether or not the behavior was directed at another person (e.g., yelling, fighting, spilling liquid, hitting table). Finally, eating was coded if the child was chewing or drinking liquid. The observed variables yielded a proportion of the time the child engaged in each behavior. Interrater reliability was calculated with 30 participants using the total amount of time that the child engaged in each behavior (α values: talking $\alpha = .97$, listening $\alpha = .82$, onlooker/watching $\alpha = .93$, away from table α = .99, eating α = .96, withdrawn α = .98, and no incidents of control problems were coded by either rater for the 30 participants, which resulted in an α of 1.0).

Chapter 4: Results

Overall Findings

First, measures of vagal tone and heart period (HP) at each time period (baseline, video, maze, and post-baseline) as well as response, defined as baseline to task change (the difference in HP and vagal tone measured during a resting state and during task, i.e. maze minus baseline), recovery, defined as task to post-baseline change (the difference in HP and vagal tone measured during the task and during a resting period at the end of the session, i.e. maze minus post-baseline) and change scores (post-baseline minus baseline) were correlated with internalizing, externalizing, total problems (combined internalizing and externalizing), and all lunch observations (talking, listening, watching, away from table, control problems, eating, and withdrawn). The only significant correlations were the change scores for HP from baseline to post-baseline with internalizing (r (78) =- .250, p = .027), and total problems (r (78) = -.234, p = .039), and the recovery score for HP with lunchtime withdrawn behavior (r (90) =- .240, p = .023).

Paired samples t-tests were then run on response, recovery and change score measures for HP and vagal tone. HP significantly decreased from baseline to maze (mean change = 12.51, t = 5.61, p = .00), and decreased from baseline to post-baseline (mean change = 11.88, t = 5.39, p = .00). However, there was no significant change from maze to post-baseline (mean change = -.63, t = -.25, p = .807). A similar pattern emerges for the vagal tone data. Namely, a significant decrease from baseline to maze (mean change = .36, t = 6.79, p = .00), a decrease from baseline to post-baseline (mean change =

.272, *t* = 5.17, p = .00), and a non-significant increase from maze to post-baseline (mean change = -.092, *t* = -1.64, p = .10).

Baseline Vagal Tone/Heart Period and CBCL

No significant correlations were found between baseline vagal tone or HP and parent report of externalizing (HP: *r* (79) = .10, *p* = .38; vagal tone: *r* (79) = .07, *p* = .53) and internalizing problems behaviors (HP: *r* (79) = .14, *p* = .22; vagal tone: *r* (79) = .05, *p* = .64). As internalizing and externalizing scores were highly correlated (*r* (79) = .729, *p* = .00), the two dimensions were grouped together to create a category of total problems, which also did not relate significantly to baseline measures of HP or vagal tone (HP: *r* (79) = .067, *p* = .559; vagal tone: *r* (79) = .067, *p* = .56).

BaselineVagal Tone/Heart Period and Lunch

Baseline measures of vagal tone and HP show no significant relation to social behaviors during the lunchtime observations (HP: *r*'s < .16, p > .129; vagal tone: *r*'s < .083, *p* > .27).

Vagal Tone/Heart Period Response and CBCL

There were no significant correlations found between vagal response or HP response to a challenge (the maze) and parent report of internalizing (HP: *r* (78) = -.084, *p* = .46; vagal tone (*r* (78) = -.12, p = .32) and externalizing behaviors (HP: *r* (78) = -.084, *p* = .465; vagal tone: *r* (78) = -.185, *p* = .106).

Vagal Tone/Heart Period Response and Lunch

There were no significant correlations found between vagal response or HP response to a challenge (the maze) and lunchtime observations of behavior (HP: *r*'s < .126, *p* > .082; vagal tone: *r*'s < .139, *p* > .172).

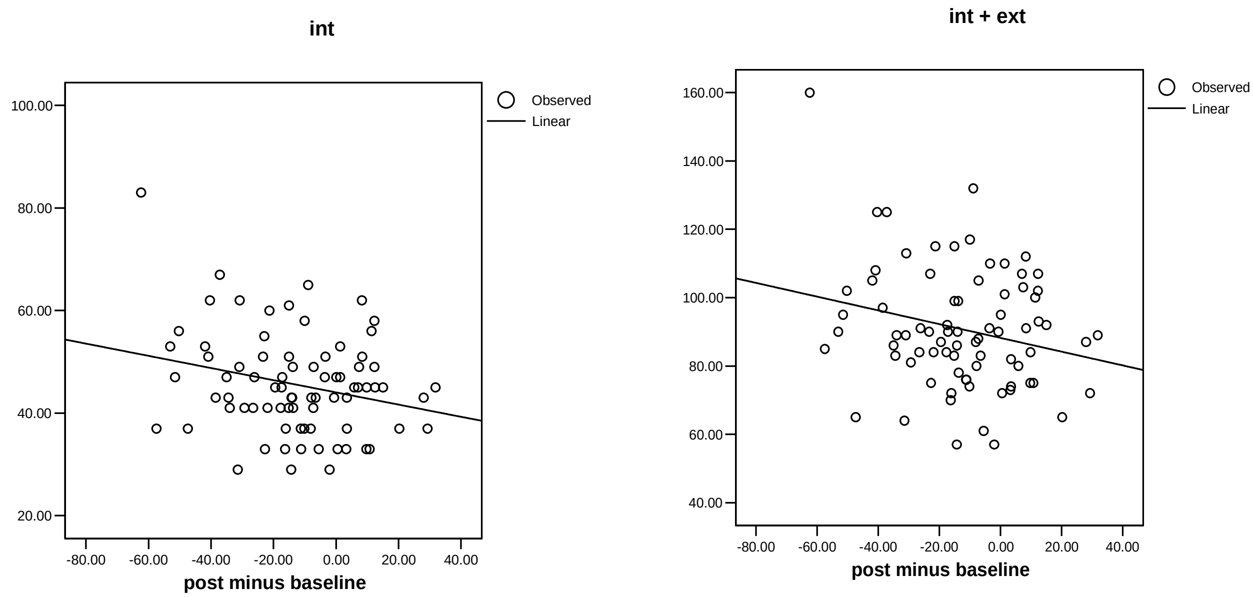
Vagal Tone/Heart Period Stability and CBCL

When difference scores from baseline to post-baseline were examined, significant correlations were found for HP and internalizing scores (*r* (78) =- .250, *p* = .027), and HP and total problem behavior (internalizing and externalizing combined; *r* (78) =- .234, *p* = .039) (See Figure 1). Although there were no significant correlations between vagal tone, internalizing, externalizing, or total problem behavior, these measures did approach significance for externalizing (*r* (78) =- .197, *p* = .084), and total problem behavior (*r* (78)= -.195, *p* = .087), and were in the same direction as the correlations for HP.

Figure 1.

<u>HP Change Scores from Baseline to Post-Baseline and Internalizing (A) and Total Scores (B)</u>

A. B.



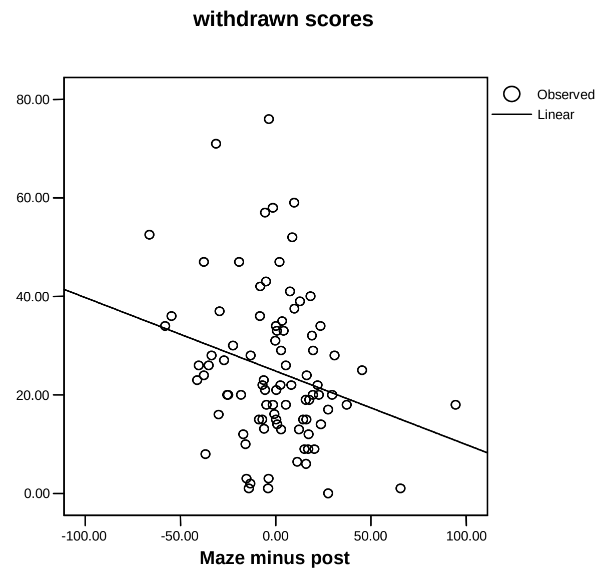
The the less recovery to post-baseline (more negative) the more internalizing and total problems observed.

Vagal Tone/Heart Period Change Scores/Recovery and Lunch

There were no significant correlations for change score measures of baseline to post-baseline measures of HP or vagal tone with lunchtime behaviors (HP: *r*'s < .143, *p* > .178; vagal tone: *r*'s < .08, *p* > .456). However, recovery scores for HP from the maze task to the post-baseline were negatively correlated to withdrawn behavior during lunchtime (*r* (90) = -.240, *p* = .023). Here, a large recovery score was associated with lower withdrawal ratings. Although the correlation did not reach significance for vagal tone (*r* (90) = -.150, *p* = .158), it too was in the negative direction (See Figure 2).

Figure 2

<u>HP Recovery Scores from Maze Task to Post-Baseline and Withdrawn Scores During Lunchtime</u>



The more negative the score is, the more recovery there is from the challenge to the post-baseline, the higher withdrawn behavior that is observed, and vice versa.

High Withdrawn and Low Withdrawn Groups and CBCL

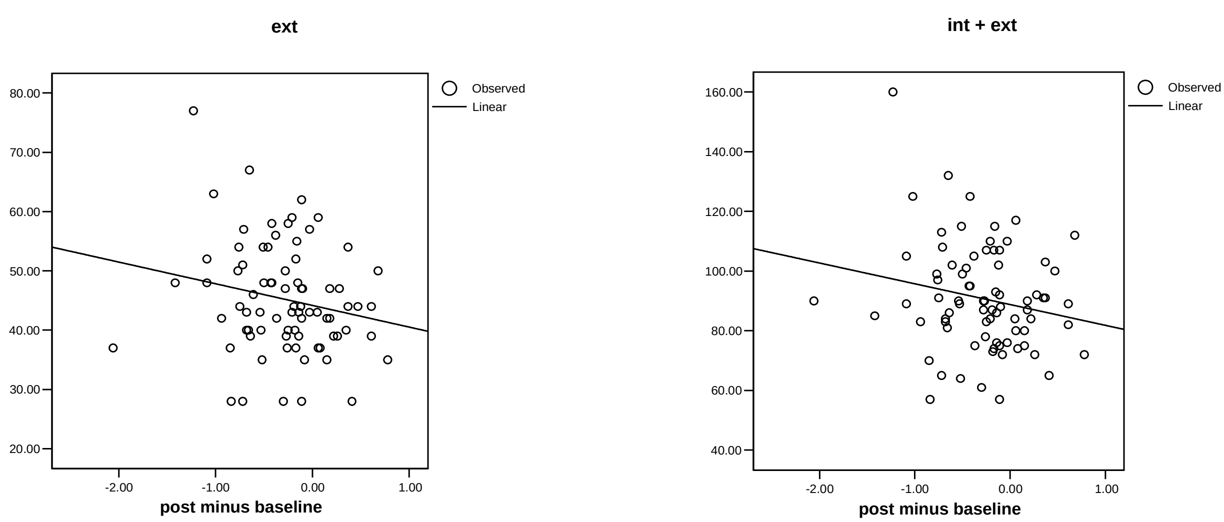
A median split of children based on their withdrawn scores during lunchtime resulted in two groups: group 1 included participants with low withdrawn (LWD) behaviors, and group 2 included participants with high withdrawn (HWD) behaviors. For the HWD group, the HP recovery score from maze to post-baseline was significantly correlated with total problems (*r* (42) = .314, *p* = .043). The change score measure from baseline to post-baseline was significantly correlated with internalizing (*r* (42) =- .310, *p* = .046), externalizing (*r* (42) = -.374, *p* = .015), and total problems (*r* (42) =- .361, *p* = .019). As such, high difference scores (poor recovery to post-baseline, the more negative the number) were associated with higher levels of internalizing, externalizing and total problems.

The only vagal tone measure that reached significance was the overall measure based on the difference scores between baseline and post-baseline. These analyses were significant for externalizing (r (42) = -.455, p = .002), and total problems (r (42) = -.392, p = .010) (see Figure 3), and approached significance for internalizing (r (42) = -.3287, p = .066). The LWD group showed no significant correlations with internalizing, externalizing or total problems for any of the measures (r's < .12, p's > .195).

Figure 3

<u>Vagal Tone from Baseline to Post-Baseline and Externalizing (A) and Total Problems (B)</u>

A. B.



The larger the drop in vagal tone from baseline to post-baseline, the more externalizing and total problems; the less the change in vagal tone from baseline to post-baseline, the fewer problems.

A 3 x 2 repeated measures ANOVA of HP was then run with Time (baseline, maze, post-baseline) as the within subjects factor and withdrawal level (Low/High) as the between subjects factor. Results indicated that there was a main effect for time of collection [F (2, 176) = 18.73, p = .00, ε = .97], and a two-way interaction effect between time and level of withdrawal [F (2, 176) = 3.93, p = .02, ε = .97] (see Figure 5). There was no main effect of group [F (1, 88) = .975, p = .33]. Post-hoc analysis revealed significantly higher HP during baseline than either maze or post-baseline. In general the HWD group is evidencing overall lower means across all three times when compared to the LWD group. Both the HWD and LWD groups have the highest heart period at the time 1 measure of baseline as compared to the other two times. There is a different pattern of change across the groups between the maze task and the post-baseline which indicates that although both groups had the highest HP at the baseline measure, and showed decreased HP to the maze task, the LWD group decreased again to the post-baseline, whereas the HWD group showed increased HP to the post-baseline (See Figure 4; supplemental means and standard deviations for HWD and LWD groups can be found in Tables 2-5 in the Appendix).

Figure 4. **<u>Heart Period and Vagal Tone for LWD and HWD Groups at Three Times</u>**

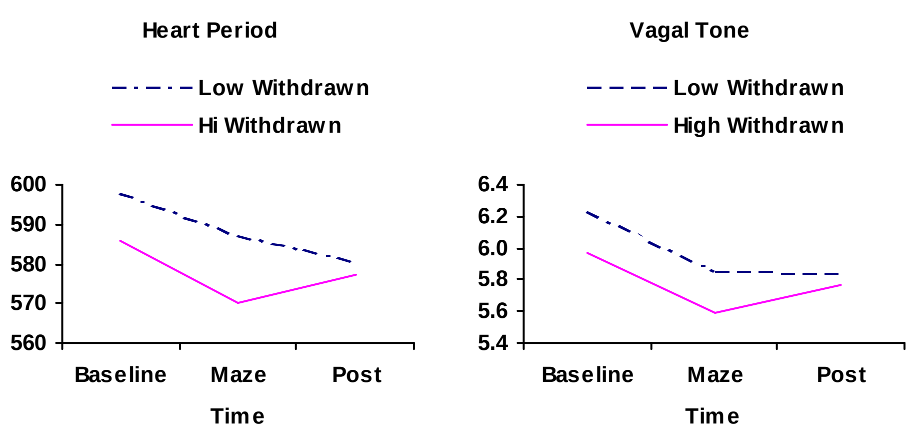
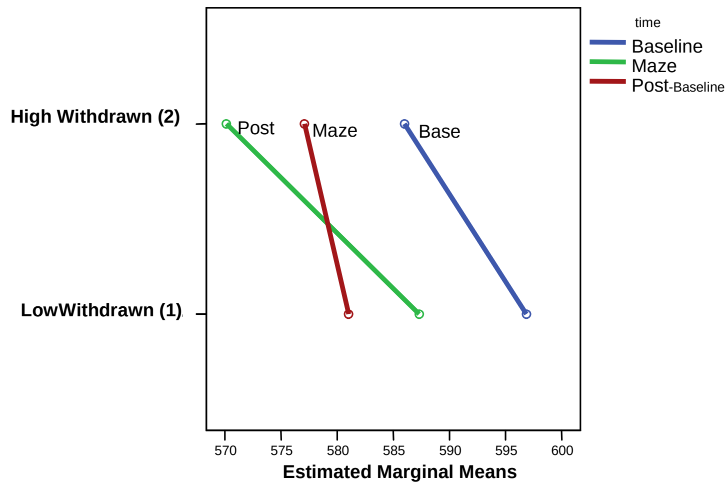


Figure 5

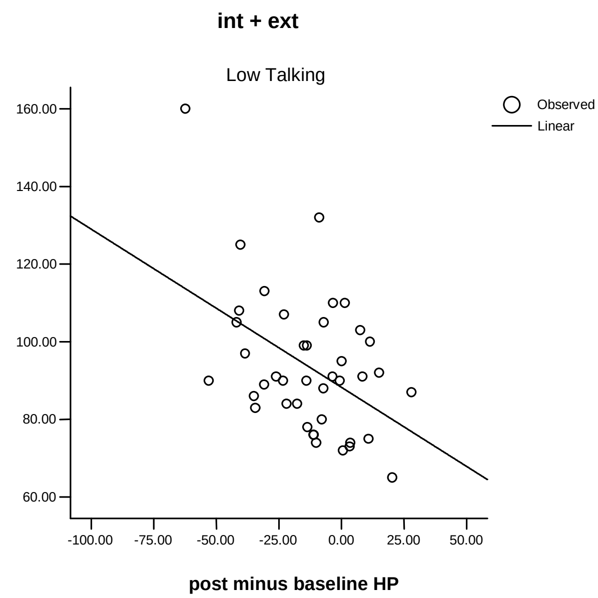
<u>Interaction Between Time and Level of Withdrawal for HP</u>



A 3 x 2 repeated measures ANOVA of vagal tone was also run with Time (post-baseline minus baseline; maze minus post-baseline; and maze minus baseline) as the within subjects factor and withdrawal level (Low/High) as the between subjects factor. A main effect of time was found [F (2, 176) = 24.2, p = .00, ε = .99]. There was no significant interaction between time and level of withdrawal [F (2, 176) = 2.17, p = .12, ε = .99], although it was in the same direction as the HP analyses. Post-hoc analysis again found that the effect was carried by values for baseline. Here vagal tone at baseline was significantly higher than for either the mazes or the post-baseline.

Following these analyses, the lunchtime variable of talking was further analyzed by doing a median split and forming 2 groups, one group included subjects low in talking (LT), and another group including those with high talking (HT). There were significant findings for the LT group in relation to HP. Specifically, the response score from baseline to maze was correlated with total problems (*r* (41) = -.314, *p* = .046), and the change score from baseline to post-baseline was significantly correlated with internalizing (*r* (41) = -.50, *p* = .001), externalizing (*r* (41) = -.351, *p* =.024), and total problems (*r* (41) =- .455, *p* = .003).

Figure 6. **HP from Baseline to Postbaseline and Total Problems for LT Group**



Indicating that the better the subject is returning to baseline measures (i.e. better recovery), the less problems.

Significant vagal tone findings included the change score from baseline to post-baseline and internalizing (*r* (41) = -.461, *p* = .002), externalizing (*r* (41) =- .356, *p* =.022), and total problems (*r* (41) = -.437, *p* = .004). Again indicating that the more the children in the LT group were recovering back to baseline measures, the less problems they exhibited.

Gender differences were examined by conducting t-tests. Significant differences were found for baseline measures of heart period (*t* (92) = 2.99, *p* = .004), and vagal tone (*t* (92) = 2.62, *p* = .01) as well as for video vagal tone and HP, post baseline HP and vagal tone, and maze minus baseline HP and vagal tone (see Table 1 for subsequent t values and significance, and Table 2 for mean differences). As all the subsequent measures were significant after baseline, and the baseline to post baseline measure was not significant, this indicates that one group (the males) were starting out with higher baseline and vagal tone and staying high throughout the session. Neither internalzing, externalizing nor total problems reached significance (t (81) <2.98, p's > .283), and none of the lunchtime variables reached significance either (t (95) < 1.5, p's > .127).

Table 1. **Significance of Differences of Physiological Measures for Males and Females**

Baseline HP	t (92) = 2.99, p = .004
Video HP	t (91) = 2.43, p = .017
Post baseline HP	t (91) = 2.73, p = .008
Maze - Baseline HP	t (91) = -2.35, p = .029
Baseline VT	t (92) = 2.62, p = .01
Video VT	t (91) = 2.04, p = .044
Post Baseline VT	t (91) = 2.25, p = .029
Maze - Baseline VT	t (91) = -2.1, p = .029

Table 2. **Mean Differences between Males and Females**

	sex	N	Mean	Difference
Baseline HP	male	41	608.8183	34.41
	female	53	576.4051	
Baseline VT	male	41	6.4502	.669
	female	53	5.7804	
Video HP	male	40	615.9885	29.9
	female	53	586.0828	
Video VT	male	40	6.4720	.548
	female	53	5.9236	
Post baseline HP	male	40	595.0775	29.74
	female	53	565.3345	
Post baseline VT	male	40	6.1092	.561
	female	53	5.5474	
Maze minus baseline HP	male	40	-18.4208	-10.36
	female	53	-8.0517	
Maze minus baseline VT	male	40	-.4990	-.236
	female	53	-.2626	

A group of children who showed heart period patterns of decreasing to the maze and increasing to the post baseline were compared with a group of children who showed patterns of heart period decreasing to the maze and then decreasing again to the postbaseline by conducting a one-way ANOVA. There were no significant differences for internalizing [F (57) = 3.614, p = .062], externalizing [F (57) = 1.24, p = .27], total problems [F (57) =2.59, p = .113], or withdrawn behavior [F (62) = .613, p = .437], so no further analyses were conducted.

Chapter 5: Discussion

Implications

Understanding the physiological mechanisms involved in an individual's regulatory capacities could lead to important knowledge about individuals who do have problems regulating various aspects of emotion and behavior. Looking at preschool aged children is important as the constructs of vagal tone, externalizing, and internalizing behaviors do show relative stability over time (Doussard-Roosevelt, Montgomery, & Porges, 2003; Rubin, Burgess, Dwyer, & Hastings, 2003; Loeber, 1982; Porges, Doussard-Roosevelt, Portales, & Suess, 1994). This indicates that early detection of children who do have self-regulatory problems could be of great benefit, as intervention could be started early so that the problems don't become more pervasive and lead to greater detrimental consequences as the child develops. In the current study, baseline measures of vagal tone and heart period under conditions of rest or minimal demand as well as change to a challenge and to post baseline were measured in a group of preschool children. Parent measures were collected using the CBCL, and observations of children's behavior were made during the lunchtime period.

It is apparent that certain withdrawn behaviors are being observed during the lunchtime. Recall that the withdrawn category was defined as not clearly engaged in a conversation (either talking or listening), not glancing around the room, and either looking down, absorbed in him/herself, or seemingly staring at nothing. When the whole sample was examined, recovery scores for heart period from the maze to the post-baseline indicated a relationship in which the lower the difference score was (i.e. the more negative), the more recovery there was, and hence, the more withdrawn behavior exhibited. Conversely, the higher the score was, the less recovery, and the lower the withdrawn behavior.

This may seem counterintuitive in that children exhibiting higher recovery (i.e. better regulation) should be exhibiting lower withdrawn behavior, however it could be suggested that children higher in withdrawal behavior during lunch appear to exhibit better regulation in the sense that they are more on task, witnessed by better recovery from a challenge task, and children who show decreased recovery from the challenge are showing less regulatory capabilities and hence less withdrawn behavior. Overall, when the sample was split into high and low withdrawal groups, it appears that children displaying high levels of withdrawn behavior as coded during lunchtime observations do behave significantly different than children displaying low withdrawn scores. Specifically, the children in the high withdrawn group characteristically exhibited significantly lower talking and lower watching as compared to the low withdrawn group.

The significant correlations that were apparent in the HWD group in relation to heart period were the change scores from baseline to post-baseline and internalizing, externalizing and total problem behavior, as well as the heart period recovery measure from the challenging task in relation to total problems. This indicates that in the HWD group, children who have better recovery scores of heart period from the maze to the post-baseline show a decrease in total problems. Children in the HWD group who show better heart period change scores as indicated by a lower difference score from baseline to post-baseline are exhibiting lower internalizing, externalizing and total problems.

This is somewhat in line with the previous hypotheses mentioned, although it would seem that children displaying withdrawn behavior would demonstrate more internalizing problems as compared to externalizing, it appears in this study that is not the case. This could be due to the fact that children who are withdrawn during lunchtime are not withdrawn to the point where it is indicative of further problems that are apparent in other situations, and in turn this behavior is not coming out in the parent report. In another sense, these withdrawn behaviors exhibited by children during lunch could be a result of simply being more focused on eating, and perhaps a consequence of learning and experience, due to a number of possible reasons, that the lunch time is not a social period.

Vagal tone change scores from baseline to post-baseline in the HWD group were significant for externalizing and total problems, indicating that the more the subject recovered to post-baseline, the less externalizing and internalizing problems that were exhibited. This result is consistent with the general hypothesis that the better the recovery, the more likely subjects will be to have low parent report of problem behavior. This finding was expected, as subjects who are better able to recover from a challenging task are better regulated and should exhibit lower problem behaviors as reported by parents. It would be expected that children who have higher withdrawn behavior exhibit lower externalizing problems. However, it is also possible that children high on withdrawn behavior have more internalizing problems, which perhaps aren't being seen because parents aren't picking up on them in the home environment. It could also be again that the withdrawn behavior exhibited during lunch is an isolated incident and not seen during other times of the day.

When examining the interaction effects of time (baseline, maze, and post-baseline), with level of withdrawal (high withdrawal: HWD, and low withdrawal: LWD), the pattern of change across the groups between the maze task and the post-baseline indicate that the LWD children are decreasing slightly to the post-baseline, whereas the HWD children are increasing to the post-baseline. Recall that a high heart period represents low heart rate, so in essence, the HWD children are showing an increase in heart rate to the challenge task, and then a decrease in heart rate during the post-baseline, which could be indicative of more engaged, attentive behavior to the task at hand. The LWD group is showing an increase in heart rate to the challenge task, and then another increase in heart rate during the post-baseline measure, which could represent an inability to focus on or engage in the task.

The gender differences seen in the baseline levels of HP and vagal tone, specifically the finding that males had higher baseline (HP and vagal tone) than females were interesting, however, these differences did not come out as significant in relation to any other variables (i.e. lunchtime observations, internalizing, externalizing, or total problems). Due to the fact that the change from baseline to postbaseline is not significant for males over females, it doesn't seem to be that they are showing different magnitudes of change, just that the males are starting out with higher baseline vagal tone and HP and continuing that pattern across all four conditions (baseline, video, maze, and postbaseline). Given that high vagal tone has been linked to uninhibited rather than inhibited behavior (Eisenberg et. al., 1996), it would follow that these males should indicate higher externalizing scores than females, however this higher baseline vagal tone and HP does not seem to affect parent ratings of externalizing behaviors in this sample.

Limitations

One limitation to the present study is that observations were collected only during the lunch period. This design would be improved by additional observations throughout the day, allowing for a more comprehensive view of children's behavior. It could also address several questions regarding these HWD children and whether they could possibly be withdrawn during the lunchtime and not during the rest of the day, or if they are withdrawn throughout the entire day. A second limitation is that more parental measures should have been included, more specifically ones that assess overall temperament, as it has been demonstrated that vagal tone is linked with its dimensions of reactivity, self-regulation and expressivity (Field, Healy, Goldstein, Perry, & Bendell, 1988; Porter, Porges, & Marshall, 1988; Fox, 1989).

Children that are not returning to baseline measures of heart period in the post-baseline are displaying poor recovery ability, seen in the lack of significant change from the maze to the post-baseline heart period measures. Although it appears this is in some part related their physiology, it could also be that there was not enough time between the stressor and the post-baseline to recover to normal levels. Another variable when examining heart period is that it is linked with movement in the subject. Even though the participants were instructed before beginning the baseline measures and reminded throughout to sit as still and as quiet as possible, there was of course some inevitable movement, which could have increased the heart rate (visible in a decrease in heart period), which, though doubtful, could have affected the findings. Overall, it appears that to some extent physiology does make a difference, especially when examining children who are rated high in withdrawal behavior.

Summary

In general, it would appear that skills that support social competence are acquired before the child enters school. Once toddlers have managed language and movement, they become able to perform many of the behaviors that define social interaction and social competence, such as cooperating with others, engaging in pretend play and establishing friendships. Peer relationships also appear to play a significant role in the adjustment of children, and peer rejection can have deleterious effects, including learning difficulties, conduct problems, and criminality. For these reasons, understanding some of the underlying correlates of social relations is clearly significant. Among these underlying constructs is temperamental behavioral inhibition, which is associated with physiological and behavioral signs of emotional dysregulation, frequently playing a role in a child's ability to regulate their emotions and behaviors, as well as their ability or lack of ability to have meaningful social interactions. Factors such as emotional expressivity, reactivity, emotional regulation, and attention all contribute to the nature and course of social behavior, including internalizing and externalizing constructs, and social interactions among children (Calkins, Gill, Johnson, & Smith, 1999).

As such, the present study has shown the important link of heart period and vagal tone measures in terms of the capacity or lack thereof of some children to return to baseline measures of homeostasis after a challenging task. It seems most important when examining children who display high withdrawn behavior during lunchtime, in that children in this high withdrawn group who display poor heart period recovery are also displaying higher levels of problem behavior. Similarly, when viewing vagal tone, the ability to return to homeostasis is related to problem behavior in that the less recovery a child exhibits, the more problem behavior they display.

Overall, it appears that autonomic regulation through the vagal system is related to behavioral and affective regulation, to attention, and in response to internal and external stimuli. Although cognition, learning, temperament, and attachment all play roles in emotion regulation, their roles are each influenced by the physiological pattern of reactivity and regulation within the individual. Understanding the physiological correlates to overt behaviors is also important because it could help teachers and parents understand that it is not necessarily improper discipline that leads to trouble behaviors in children, but actually the underlying physiological mechanisms which may influence the extent to which the individual is capable of self-regulation. This could lead to alternative interventions and help the parent and teacher understand the child better and help them deal with the frustration of raising and dealing with a child who displays an inability to self-regulate their emotions and emotional responses. As social engagement is a key component of development, the ability to regulate physiological processes such as vagal tone during emotional or cognitive challenges may have significant implications for the developmental course of the individual.

Appendices

Table 3: **<u>Descriptive Statistics for CBCL, HP, Vagal Tone, and Lunchtime Behaviors</u>**

Descriptive Statistics			
Variables	**Means**	**Standard Deviations**	**Sample Size**
CBCL Measures			
Internalizing	45.94	9.77	83
Externalizing	45.57	9.28	83
Total Behavior Problems	91.51	17.72	83
Heart Period Measures			
Baseline Heart Period	590.54	54.36	94
Video Heart Period	598.95	60.34	93
Maze Heart Period	577.5	52.73	93
Post-Baseline Heart Period	578.13	53.82	93
Maze Minus Baseline (Response) Heart Period	-12.51	21.5	93
Maze minus Post-Baseline (Recovery) Heart Period	-0.63	24.73	93
Post-Baseline minus Baseline (Change) Heart Period	-11.88	21.25	93
Vagal Tone Measures			
Baseline Vagal Tone	6.07	1.27	94
Video Vagal Tone	6.16	1.3	93
Maze Vagal Tone	5.7	1.25	93
Post-Baseline Vagal Tone	5.79	1.23	93
Maze Minus Baseline (Response) Vagal Tone	-0.36	0.5	93
Maze minus Post-Baseline (Recovery) Vagal Tone	-0.092	0.54	93
Post-Baseline minus Baseline (Change) Vagal Tone	-0.272	0.51	93
Lunchtime Behaviors			
Watching	121.35	19.21	97
Talking	23	13.24	97
Listening	9.13	13.54	97
Away from Table	16.16	16.43	97
Control Problems	1.42	13.5	97
Eating	9.13	13.54	97
Withdrawn	24.81	15.21	97

Table 4: **<u>Descriptive Statistics for Low Withdrawn Group</u>**

Descriptive Statistics for Low Withdrawn Group			
Variables	**Means**	**Standard Deviations**	**Sample Size**
CBCL Measures			
Internalizing	44.83	9.94	35
Externalizing	44.31	8.43	35
Total Behavior Problems	89.14	6.63	35
Heart Period Measures			
Baseline Heart Period	597.81	52.57	45
Video Heart Period	608.63	53.55	44
Maze Heart Period	587.31	52.52	44
Post-Baseline Heart Period	581.01	49.27	44
Maze Minus Baseline (Response) Heart Period	-9.55	21.81	44
Maze minus Post-Baseline (Recovery) Heart Period	6.29	24.01	44
Post-Baseline minus Baseline (Stability) Heart Period	-15.84	20.3	44
Vagal Tone Measures			
Baseline Vagal Tone	6.23	1.18	45
Video Vagal Tone	6.35	1.16	44
Maze Vagal Tone	5.86	1.18	44
Post-Baseline Vagal Tone	5.84	1.18	44
Maze Minus Baseline (Response) Vagal Tone	-0.345	0.559	44
Maze minus Post-Baseline (Recovery) Vagal Tone	0.021	0.598	44
Post-Baseline minus Baseline (Stability) Vagal Tone	-0.366	0.516	44
Lunchtime Behaviors			
Watching	129.24	19.7	47
Talking	26.08	13.44	47
Listening	10.54	17.76	47
Away from Table	16.97	15.26	47
Control Problems	2.94	19.39	47
Eating	10.54	17.76	47
Withdrawn	13.08	6.24	47

Table 5:**Descriptive Statistics for High Withdrawn Group**

Descriptive Statistics for High Withdrawn Group			
Variables	**Means**	**Standard Deviations**	**Sample Size**
CBCL Measures			
Internalizing	47	9.93	45
Externalizing	46.71	10.09	45
Total Behavior Problems	93.71	18.93	45
Heart Period Measures			
Baseline Heart Period	585.99	54.36	46
Video Heart Period	593.14	63.87	46
Maze Heart Period	570.13	50.7	46
Post-Baseline Heart Period	577.1	56.55	46
Maze Minus Baseline (Response) Heart Period	-15.86	21.6	46
Maze minus Post-Baseline (Recovery) Heart Period	-6.97	24.5	46
Post-Baseline minus Baseline (Stability) Heart Period	-8.89	22.06	46
Vagal Tone Measures			
Baseline Vagal Tone	5.97	1.31	46
Video Vagal Tone	6.06	1.39	46
Maze Vagal Tone	5.59	1.27	46
Post-Baseline Vagal Tone	5.78	1.27	46
Maze Minus Baseline (Response) Vagal Tone	-0.38	0.498	46
Maze minus Post-Baseline (Recovery) Vagal Tone	-0.19	0.447	46
Post-Baseline minus Baseline (Stability) Vagal Tone	-0.19	0.479	46
Lunchtime Behaviors			
Watching	113.94	15.6	50
Talking	20.11	12.49	50
Listening	7.8	7.7	50
Away from Table	15.4	17.59	50
Control Problems	0	0	50
Eating	7.8	7.7	50
Withdrawn	35.84	12.66	50

Table 6: **<u>Descriptive Statistics for Interaction between Level of Withdrawal and Time of Collection</u>**

Interaction Means and Standard Deviations				
		Baseline (M, sd)	**Maze Task (M, sd)**	**Post-Baseline (M, sd)**
Heart Period	Overall	590.01 (54.41)	577.49 (52.73)	578.12 (53.82)
	Low Withdrawal	597.81 (52.56)	587.31 (52.52)	581.01 (49.27)
	High Withdrawal	585.99 (54.36)	570.13 (50.70)	577.10 (56.55)
Vagal Tone	Overall	6.06 (1.27)	5.70 (1.25)	5.79 (1.23)
	Low Withdrawal	6.23 (1.17)	5.86 (1.18)	5.84 (1.18)
	High Withdrawal	5.97 (1.31)	5.59 (1.27)	5.77 (1.27)

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