Physiological Regulation in Children from Maltreating Homes

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Abstract

This project examined distinctions between the developmental physiology of maltreated children and non-maltreated children. Physiological regulation in childhood is a topic of increasing interest among researchers. Yet thus far there has been little exploration of physiological regulation outside the confines of ordinary childhood. This project moves beyond these confines to explore physiology regulation in maltreated children through an examination of cardiac vagal tone, an index of parasympathetic activation (Porges, 2007). Forty-six mothers and their 3-5 year old children participated in two home visits and a laboratory visit where children's cardiac vagal tone was assessed during a baseline and frustrating situation. Significant differences in RSA change scores were observed between maltreated and non-maltreated children during a moderately frustrating task indicating that maltreated children produce smaller changes in vagal tone activity during a challenging task.

Introduction

Research has shown that child abuse and neglect undermine central emotional and social tasks that are necessary for adaptive behavior (Belsky, 1993; Gunnar & Quevedo, 2007). Accordingly, maltreatment is defined as abuse and neglect that is detrimental to the child's psychosocial adaptation and lifelong productivity (Cicchetti & Toth, 1993). Maltreatment according to Cicchetti and Toth is abuse and neglect that is detrimental to the child's psychosocial adaptation and lifelong productivity. Definitions of child abuse and neglect are dynamic and dictated by current societal beliefs. The American cultural standard plays an invasive role in making the distinction between maltreatment and nonmaltreatment. The definition used in this project requires that actions by parents cause physical or emotional damage to the child, or introduces substantial risk that the child will suffer harm (Cicchetti & Toth, 1993). Part of that harm maltreatment produces lies in parent usage of unconstructive authoritarian practices such as negative control and severe discipline which then predict greater child behavior problems (Calkins, Smith, Gill, Johnson, 1998).

Children's emotion regulation skills influence social competence and aspects such as aggression and withdrawn behavior are characterized by a lack of emotion regulation skills. Furthermore children's emotion, behavior, and physiology are interdependent (Calkins et al.,

1998). Porges' Polyvagal Theory (2003) proposes that the autonomic nervous system provides the neurophysiological substrates for emotional experiences and affective processes that are major components of social behavior. An individual's neurobiological state operates to protect and maintain homeostasis, and is dictated by the context of an environment which includes the changes that occur in that environment (Porges, 2003) Homoeostasis is controlled by the autonomic nervous system which is separated into two sections: sympathetic and parasympathetic. The focus of this project is the parasympathetic system which houses the vagus nerve that generates the vagal tone.

Porges (2003) has theorized and research has supported the notion that cardiac vagal tone as an indicator of parasympathetic activation, and thus of physiological regulation. According to Porges (2003), vagal tone is the measure of heart rate variability which is determined through assessment of high frequency variability in heart rate tied to respiratory cycles of inhalation and exhalation, called respiratory sinus arrhythmia or RSA. Through the measurement of children's RSA during resting states and in response to challenge, the extent of physiological regulation can be evaluated, in calm, resting situation a well-adapted individual will have a high RSA. When an individual is faced with a moderate external challenge, typically, an individual with good adaptive skills will apply the "vagal brake" or in other words suppress or lower their RSA. The suppression of RSA is reported to allow the individual to shift focus from internal homeostatic demands to external demands that require coping strategies to control affective or behavioral arousal (Calkins et al., 1998). Thus, vagal suppression is thought to enable a child to adaptively engage or disengage from the environment. Research has documented that baseline RSA and RSA changes in response to challenge are associated with positive developmental outcomes in children (Calkins et al., 1998; Calkins & Keane, 2004).

Despite the fact that researchers have examined relations between children's physiological regulation in middle-class and otherwise low-risk environments, little is known about the effects of socioeconomic status or high-risk parenting such as maltreatment on children's capacities for physiological regulation. The examination of physiological regulation in maltreated children is innovative. Researchers have looked at physiological regulation in individuals who have experienced a normal childhood but have not yet explored the potential differences that may be seen in atypical childhoods. Through the focus on maltreated children this author hopes to bring greater insight into possible biophysiological distinctions between the two groups that extend beyond their differences in the way they were treated in childhood. Specifically, two aspects of children's vagal tone will be examined: baseline vagal tone and change in vagal tone during a challenging task. Baseline vagal tone is the body's physiological regulation during a resting state and is high when an individual is in this state. This project will examine individuals when they are resting and calm without any external challenge. Then an external challenge will be applied to examine variation in the extent to which children let up off the 'vagal brake" (Calkins et al., 1998) to attend and focus during the moderately frustrating task. In sum, this study was designed to investigate whether differences exist in children's capacities for physiological regulation depending on whether they come from maltreating vs. non-maltreating families. It is expected that children living in a maltreating family context will show greater difficulty with physiological regulation.

Hypotheses

Research has shown that maltreatment has extensive long-term, negative effects on children (e.g., Cicchetti & Toth, 1993). The first difference that I expect to see between the two groups is that maltreated children will show lower RSA baseline scores than non-maltreating

children, who in contrast will show higher baseline RSA scores. I made this presumption based on the fact that maltreating children have a higher exposure to violent behavior in which case they are less likely to display a resting state because their environment may constantly demand them to remain alert. So unlike their nonmaltreated counterparts, they do not experience a successive amount of physiological rest. Thus it is my belief that even when maltreated child is suppose to be in a rest state, physiologically they remain in an alert state.

Second, I predict that nonmaltreated children will demonstrate greater RSA change scores (i.e., reduction in RSA scores from baseline to engagement in a challenging task).

Methods

Participants

N = 46 mother-child dyads from five counties in rural, central Pennsylvania were recruited for this project. N = 20 families are nonmaltreated and the remaining 26 dyads are involved with Child and Youth Services Bureaus (CYS), for preventive or protective services. Twenty-six of the children were female and 22 were male with an average age of 3.64 years old. Ethnically the overwhelming majority of the children were white with 38, then 9 multiracial and 1 African-American. Mom's average age was around thirty years old and ethnically the majority matched that of the children's ethnic majority. N = 44 mothers where white, 1 was African-American, 1 was Hispanic/Latino, and 2 were multi-racial. The income of the dyads ranged from $10, 000 up to $50, 000 or greater. The majority of the families reported income levels between $10, 000 and $30, 000. In addition 29 mothers received their high school diploma, 13 received their Associates degree, 5 got their Masters and 1 went on to receive a degree post-Masters. As far as an occupation goes, 54.2% were unemployed, 14.6% were blue collar, 10.4% were clerical, and 20.8% were professional.

Instruments

Cardiac Vagal Tone. RSA will be used to index level of cardiac vagal tone, both at resting baseline, and during a moderately frustrating task. Electrodes are placed on the child on the distal end of the right clavicle, lower left rib cage chest, and the lower abdomen (Family Study Manual), and the signal is wirelessly monitored. Autonomic reactivity is recorded online using a MP100SW Cardiographs connected to an individual PDA computer equipped with data acquisition hardware and software (Mindware Technologies, Westerville, OH). Heart period is derived from the ECG waveform for analysis of cardiac vagal tone (RSA). To quantify heart rate data, ECG pulses are passed through an A/D converter programmed to trigger at each R spike of the ECG data.

The heart rate period data will be analyzed using Mindware software which outputs heart rate, heart period, and RSA values. The RSA values are derived from the interbeat interval series which is resampled at 25 msec to create a stationary wave form. The integral of the power in the RSA band (.24 to 1.04 for children) is extracted and the natural logarithm of this measure produces the RSA statistic. Periods of data that show movement artifact are edited manually. RSA baseline scores are averaged across 30" intervals during the 5' baseline assessment. The RSA data are edited in 30 second segments and averaged across segments (Family Study Manual). Baseline RSA is obtained on the child while s/he watches a neutral children's video for 5 minutes (Family Study Manual, 2008). RSA change scores are calculated by subtracting a child's mean RSA obtained during the Lockbox task from their baseline RSA value.

The Lockbox task was used as a moderately frustrating challenge during which vagal tone was assessed. The purpose of this task is to provoke frustration in these preschool children so to assess their emotion and emotion regulation capacities (Goldsmith, Lemery, Longley, Prescott, 1999). The child is presented with a clear plastic container inside which contains their favorite toy. This transparent box has a lock on it that can only be opened using a key. The interviewer demonstrates to the child how to open the open the lock with the key so that the toy can be retrieved. Before leaving the room the interviewer intentionally gives the child a set of incorrect keys and instructs the child to use the keys to open the box. While alone the child proceeds to attempt to open the box but typically frustration is induced after repeated failed attempts to get the lock open to retrieve the toy. This is where the more alert RSA levels are established and then used to detect the RSA change from RSA baseline to frustration task. After the 4 minutes the interviewer returns with the correct set of keys, apologizing to the child for giving them the incorrect set of keys. Following the task, children are given time to play with the toys.

Procedure

Dyads were invited to participate in an NIMH funded project called the FaMILY Study. The FaMILY study is an on-going project exploring how child maltreatment and the stresses families experience influence mother-child relationships, maternal emotion regulation, and children's self and emotion regulation development. In order to participate the children must meet the criteria of falling between the ages of three to five years old. Maltreating families must have been involved with CYS preventative or protective services during the previous three-year period. Mothers must still be the primary caregiver, at least 18 years old, and able to fluently speak English. There were three visits two of which are in the home of the family and one of which is held in the lab. The main focus of this project is the lab visit where the examination of physiological regulation takes place.

Following the closer examination into the status of the mother and child from either maltreating or nonmaltreating families during two home visits there is a final third visit at the lab. During this lab visit children's baseline vagal tone and vagal suppression was collected during a frustrating situation. Mother and child are observed behind a one way mirror in a room that is designed to appear to be a comfortable living room space.

Mother-child dyads excluded from this project included mothers were not the primary caregiver of their 3-5 year old. Also prohibited were mothers who were not cognitively competent which was determined from the Mini-Mental Status Exam given during the first home visit. Families that have any description of mother being the perpetrator of sexual abuse or the child experiencing sexual abuse are ruled out from this project. Additionally mothers or children diagnosed with a serious physical impairment were not included in this study.

Results

This study took a closer look at children's physiological regulation by way of cardiac vagal tone which is measured by Respiratory Sinus Arrhythmia (RSA). A comparison was then made between children from maltreating families vs. non-maltreating families in terms of their RSA levels during a baseline task and change in RSA from baseline to that during a frustrating task to test my hypotheses. My first hypothesis was that nonmaltreated children would have a higher RSA levels during baseline. My second hypothesis was that nonmaltreated children would post

higher RSA change scores from baseline to frustrating task, and thus would be better equipped physiologically regulate in response to challenge. Typically while making these group comparisons, a p-value = .05 is used to determine statistical significance. In this case statistical significance was assessed using a more liberal p-value = .10, because this project represents pioneering work and employs a small sample size.

A t-test was conducted comparing RSA baseline scores in nonmaltreating vs. maltreating children and the results were not statistically significant: t (44) = .17, p = .86. Thus there is no support to suggest a difference between the physiological regulations in children from maltreating versus nonmaltreated families. In other words, the results showed that nonmaltreating children and maltreating children have approximately the same level of vagal tone activity during RSA baseline.

Next a t-test was conducted on RSA change scores of children from nonmaltreating vs. maltreating families. Results of this t-test were significant: t (40) = 1.77, p = .08. So there was in fact a difference between the RSA change levels in nonmaltreated children versus maltreated children. My hypothesis was supported by the results proving that nonmaltreated children have a greater vagal suppression when experiencing a frustrating situation. Table 2

Below are two tables that show the results of the two t-tests and means and standard deviations for RSA baseline and change scores of children from maltreating vs. nonmaltreating families. Results indicate that children from nonmaltreating families show significantly higher RSA change scores than did children from maltreating families.

Table 1

Group Differences in Children's $RSA_{Baseline}$ and RSA_{Change} Scores by Family Maltreatment Status

Vagal tone	CM_Group	N	Mean	Std. Deviation
$RSA_{Baseline}$	non-CM	20	6.24	1.03
	CM	26	6.17	1.43
RSA_{Change}	non-CM	18	1.03*	.73
	CM	24	.61*	.79

*p-value < .10 Higher $RSA_{Baseline}$ scores indicate greater resting vagal tone. Higher RSA_{Change} scores reflect greater vagal suppression.

Discussion

This study was focused on discovering whether or not there was a difference in the physiological regulation of children from maltreating versus nonmaltreating families. Existing research has generally focused on lower-risk children and their ability to regulate themselves physiologically. So I wanted to explore whether or not high-risk maltreated children have more difficulties in physiologically regulating themselves. In order to check for each group's ability to regulate themselves when frustration is elicited I needed to make the comparision between their vagal tone at rest and then during a stressful situation. My first hypothesis was that at baseline vagal tone would be lower among children from maltreating families. Results suggest that group membership did not predict differences in children's baseline RSA.

However beyond baseline vagal tone, I also examined whether vagal change scores differed by maltreatment group, in order to learn whether children from maltreating families showed more maladaptive physiology in response to a frustrating situation. The data supported my second hypothesis in that children from maltreating families showed lower RSA change scores than did children from non-maltreating families. Since children from maltreating families showed lower vagal change in response to frustration that suggests they are less flexible in managing environmental challenges. Although these findings are exploratory and based on a small sample of at-risk children and thus should be carefully viewed, one plausible explanation for these findings is that children's difficulty with this critical skill signifies a maladaptive approach to dealing with new situations where there are external environmental demands.

Statistical power is important and influences whether significant findings are observed when they in fact exist in the population. The larger the sample size, the more statistical power an analysis has. Since my sample size was only N = 46 mothers, it is possible that the non-significant differences in baseline vagal tone scores of children from maltreating vs. nonmaltreating families would emerge as significant if a larger sample size had been employed. In other words, a larger sample would have provided more statistical power and perhaps support for my first hypothesis would have been observed. Beyond the fact that the sample size was already small, an even smaller amount of data was able to be analyzed. During each lab visit mother and child are fitted with electrodes but uncontrollable variables such as electrodes falling off or a bent wire disabling the heart rate variability reading of the data. Any disruption in the collection process further limits the sample size and curtails the statistical power of the conclusions to be made. Another implication that needs to be taken into consideration is the fact that this data was obtained using participants that had many demographic similarities. Besides the fact that the participants were all from rural central Pennsylvania they were for the most part generally white, of low socioeconomic status, minimal high school education, and unemployed. Thus it would be inappropriate for my findings to be used to generalize my results to any other population that do not match those listed traits.

Previous research exposed the fact that maltreatment can have a negative long-term affect on individuals (Cicchetti, 1993) and the results of my study exposed just how early some of those affects may begin. Maltreated children are regressing in the classroom and /or showing aggressive behavior, which are both early signs for an unsuccessful academic career (Calkins et al., 1998). The effect of an inability to physiologically regulate oneself illustrates itself not only in the classroom, but also in a lab when the feeling of frustration is elicited. In order to adaptively respond to an external challenge an individual needs to be able to the brakes on their RSA and engage the challenge. The context of a child's environment can either enhance or

dissolve this skill. While my findings are exploratory and should be carefully viewed, a plausible conclusion is that difficulty with this critical regulatory skill signifies a maladaptive approach to dealing with new situations where there are external environmental demands.

Future research could examine whether security of attachment plays an important role in children's physiological regulation abilities, above and beyond the effects of maltreatment severity or type (i.e., abuse vs. neglect). Attachment is developed very early on and although this project targeted young preschool-aged children, future research work is needed with even younger children in order to learn how early attachment may influence children's developing physiological regulation.

References

Belsky, J. (1993). Etiology of child maltreatment: a developmental - ecological analysis. *Psychological Bulletin*, *114*(3), 413-434.

Calkins, S. D., Smith, C. L., Gill, K. L., & Johnson, M. C. (1998). maternal interactive style across contexts: relations to emotional, behavioral and physiological regulation during toddlerhood. *Social Development*, 7, 351-367.

Calkins, S. D., & Keane, S. P. (2004). cardiac vagal regulation, across the preschool period: stability, continuity, and implications for childhood adjustment. *Developmental Psychobiology* 45: 101-112.

Cicchetti, D., & Toth, S. L. (1993).child abuse, child development, and social policy. *Advances in Applied Developmental Psychology*, *8*, 7-41.

Goldsmith, H. H., Reilly, J., Lemery, K. S., Longley, S., & Prescott, A. (1999). *The Laboratory Assessment Battery: Preschool Version (LAB-TAB).* University of Wisconsin, Madison.

Gunnar, M., & Quevedo, K. (2007). The neurobiology of stress and development. *Annual Review of Psychology*, *58*, 145-173.

Porges, S. W. (2003). The Polyvagal Theory: phylogenetic contributions to social behavior. *Physiology and Behavior*, *79*, 503-513.

Porges, S. W. (2007). The polyvagal perspective. *Biological Psychology*, *74*, 116-143.

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