



Respiratory sinus arrhythmia reactivity predicts emotion regulation and depressive symptoms in at-risk and control children

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ABSTRACT

We examined respiratory sinus arrhythmia (RSA), emotion regulation (ER), and prospective depressive symptoms in children at risk for depression and controls. Of the 65 children (35 boys; 5–13 years) in the sample, 39 had a parent with childhood-onset mood disorder and 26 had a parent with no history of major psychiatric disorder. RSA during pre- and post-film baselines and RSA reactivity to sad film clip were measured. Later, children's ER responses (focusing on sad/distressing affect) were assessed using a parent-reported questionnaire, and depressive symptoms were measured via clinical ratings. Results indicated that, compared to the initial baseline, a greater decrease in RSA (i.e., more vagal withdrawal) in response to the sad film clip predicted more adaptive ER responses and lower levels of clinician-rated depressive symptoms. However, tests for ER as a mediator of the association between RSA reactivity and depressive symptoms were precluded because maladaptive, but not adaptive, ER was associated with depressive symptoms. Overall, results suggest that cardiac vagal withdrawal (a greater decrease in RSA) in response to an emotional stimulus reflects more adaptive parasympathetic activity, which could facilitate children's ability to effectively manage their sadness and distress and predict lower risk of depressive symptoms over time.

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Gaining a better understanding of factors that contribute to depression in youth is critical given the disorder's debilitating nature and possible consequences (e.g., suicide attempts; Tamas et al., 2007). The primary symptoms of childhood depression involve protracted mood such as dysphoria and anhedonia, which implicates an inability to effectively regulate such negative emotions. Children's inability to regulate emotion, as well as their risk for depression, might stem in part from physiological vulnerabilities. In this paper, we examine one aspect of children's psychophysiology, respiratory sinus arrhythmia (RSA) or cardiac vagal tone, and test whether it is predictive of their emotion regulation (ER) responses and level of depressive symptoms. Our sample includes a group of children who are at elevated risk for developing depression, by virtue of having a parent with a childhood-onset mood disorder (COMD). These children were contrasted with a control group of children whose parents were free of major psychiatric disorders. We expected that children's resting RSA and RSA reactivity to an emotional task will predict their ER as well as level of depressive symptoms, and further, that

ER will mediate the presumed relationship between RSA and depression. As reviewed below, although RSA and ER links are prevalent in the literature, little work has examined how RSA is associated with depressive symptoms in youth, particularly at-risk children, and no studies have examined ER as an explanatory mechanism.

1. ER and depression

Researchers have theorized that depression results from problems with regulating one's emotions (e.g., Cole et al., 1994; Keenan and Hipwell, 2005), though limited data have addressed the association between emotion regulation and depression in childhood or adolescence. However, some findings indicate that offspring of a parent with depression, particularly girls, exhibit less adaptive ER than control offspring (Garber et al., 1991; Silk et al., 2006). Other work has found that children relying on certain strategies (e.g., less cognitive restructuring, more rumination) to cope with having a depressed parent are more likely to have higher anxiety/depression symptoms (Langrock et al., 2002). Similarly, studies with normative samples of youth have shown that maladaptive ER strategies, such as rumination, predict higher levels of depressive symptoms (e.g., Garber et al., 1995; Schwartz

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and Koenig, 1996; Silk et al., 2003). Overall, this literature suggests that certain ER strategies (e.g., those reflecting an inability to shift attention from sad feelings) could increase children's risk for depression, especially for certain subgroups (i.e., those with a depressed parent, girls).

1.1. RSA

One physiological measure of particular relevance to ER is RSA. RSA reflects the variation in interbeat intervals of the heart at the frequency of breathing, which is influenced by the parasympathetic branch of the autonomic nervous system, operating through one branch of the vagus nerve. The amplitude of RSA is one way to quantify vagal tone (Porges et al., 1994). Researchers typically study RSA while individuals are in a resting state or baseline. Also important however is reactivity in response to stressors or other emotional stimuli. A decrease in RSA from an initial baseline is indicative of vagal withdrawal in that the parasympathetic system is withdrawn once a stressor or other stimulus requires attention. RSA reactivity is often computed as task mean minus baseline RSA or residualized scores computed by regressing task mean onto baseline mean (e.g., Alkon et al., 2003). The term, recovery, is used to describe an individual's response after the stressor, and has been operationalized by measuring baseline RSA following the task to determine whether individuals return to their initial baseline levels (e.g., Santucci et al., 2008).

According to Porges' polyvagal theory (e.g., Porges, 1995; Porges et al., 1996), the vagal system plays a key role in preserving physiological homeostasis, where the organism can preserve resources at rest, but still respond to external demands when needed. At rest, parasympathetic activity results in a relatively high vagal tone or RSA, which is associated with slower heart rate (Porges et al., 1996). Higher RSA would be adaptive in that it reflects a greater capacity for self-regulation or social engagement. When individuals must respond to a challenge, parasympathetic activity or the "vagal brake" is withdrawn, thereby allowing heart rate to increase and the individual to meet environmental demands (Porges et al., p. 697). Once a stressor has subsided, individuals should show vagal recovery in that they return to baseline levels. Thus, greater withdrawal during stressors and subsequent recovery should be indicative of a more flexible physiological response system, which could facilitate individuals' ability to respond more adaptively to emotional challenges.

1.1.1. Links to ER

A growing body of research suggests that individual differences in children's vagal tone or RSA are associated with their regulatory behavior. Higher baseline RSA and a greater decrease in RSA have been found to relate to more positive and less negative affect, less emotion dysregulation, and more effective ER strategies (e.g., Bandon et al., 2008; Calkins, 1997; Calkins and Keane, 2004; Fabes et al., 1994; Gottman and Katz, 2002; Hessler and Katz, 2007). Our own research showed that during a waiting task (delay of gratification), children exhibiting less RSA recovery engaged in more maladaptive ER (i.e., negative focus on delay) during a different delay task (Santucci et al., 2008). Associations may be more complex as well, as recent research suggests that 4-year-old children with higher baseline RSA whose mother reported clinical levels of depressive symptoms did not show normative increases in emotion regulation by age 7 years that other children did (Bandon et al., 2008). Thus more work is needed to determine how RSA may predict how ER unfolds over time or may interact with maternal depression. But the overall pattern of findings support the premise that children's RSA, reactivity, and recovery may be key indicators of their physiological capacity to effectively regulate emotions.

1.1.2. Links to depression

With adults, evidence on how RSA relates to depression is mixed. In a recent meta analysis, Rottenberg (2007) found that depression had a small to medium effect on resting RSA and also identified several factors that are likely to lead to distorted estimates of depression effects (e.g., diminished physical activity, comorbid disorders, medication status, particular symptom presentations). The relation to RSA reactivity is equivocal as well (Rottenberg, 2007). In a study of adults with major depressive disorder (MDD), Rottenberg et al. (2005) found that the individuals who fully recovered from an episode exhibited a greater decrease in RSA to a sad film clip 6 months earlier than those whose depression did not remit. But other work has found that a higher level of depressive symptoms relates to increased or decreased RSA reactivity depending on the task (Hughes and Stoney, 2000). Also, depressed adults do not show recovery in RSA following a stressor that nondepressed adults exhibit (Rottenberg et al., 2003).

The only studies addressing links between RSA and depression in children are those examining symptoms using parent- or self-report measures, and the results are somewhat contradictory. With children from the current project, Forbes et al. (2006) found that lower baseline RSA was linked to internalizing symptoms for children at-risk for depression but not for controls. Similarly Shannon et al. (2007) found that children with resting RSA below the median reported high levels of depressive symptoms regardless of maternal melancholic depressive symptoms, but for those with resting RSA above the median, children had higher symptoms only when mothers had more melancholic symptoms. Studies also have shown that greater decreases in RSA in response to a stressor are a protective factor against children developing internalizing or externalizing symptoms (El-Sheikh et al., 2001; El-Sheikh and Whitson, 2006; Katz and Gottman, 1997). Yet others have found that higher levels of internalizing symptoms (Boyce et al., 2001) or a combination of both internalizing and externalizing symptoms (Calkins et al., 2006) are associated with greater vagal withdrawal to emotional tasks. Also, Ashman et al. (2008) found that offspring of chronically depressed mothers had greater decreases in RSA to a sad film clip than offspring of mothers who had either no depression, stable but mild, or decreasing levels of depression. Thus, as with adults, a better understanding of the associations between children's RSA, especially RSA reactivity, and depressive symptoms is needed. Our study can contribute to the extant literature by testing whether RSA or change in RSA predicts ER and clinician-rated depressive symptoms, and if these associations vary for at-risk and control children.

1.2. The present study

The goal of the present study is to investigate whether children's RSA predicts their subsequent ER and level of clinical depressive symptoms (see Fig. 1). We expect that higher baseline RSA, a larger decrease in RSA (greater vagal withdrawal) during a film clip, or greater recovery (i.e., higher baseline after the task) will predict a greater reliance on adaptive ER strategies and less on maladaptive ER strategies (path a), and prospectively, having fewer depressive symptoms (path b). Furthermore, if we also find that lower scores on adaptive ER or higher scores on maladaptive ER relate to more depressive symptoms (path c), we can test whether ER responses mediate the relationship between RSA and symptom level. We also examine concurrent associations between children's RSA and internalizing symptom level. This way, when testing RSA's association to later depressive symptoms (path b), we can control for concurrent symptoms so that we are predicting change in depressive symptoms across time.

In examining associations among RSA, ER and depressive symptoms, we included group status (at-risk vs. control) and child

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