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Respiratory sinus arrhythmia as a predictor of self-injurious thoughts and behaviors among adolescents☆

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ABSTRACT

Research suggests that self-injurious thoughts and behaviors (SITBs) may function as maladaptive emotion regulation strategies. One psychophysiological index of emotion regulatory capacity is respiratory sinus arrhythmia (RSA). The temporal course of RSA responsivity to a stressor may be characterized by basal RSA, RSA reactivity to stressor, and RSA recovery post-stressor. RSA has been linked to both internalizing and externalizing symptoms in adolescents, but little is known about the relation between RSA and SITBs. Initial research has shown a cross-sectional relation between lower basal RSA and greater RSA reactivity to a sad mood induction and self-injury. To date no prospective research on the relation between RSA and SITBs exists. The current study aims to investigate the prospective relation between RSA and SITBs in a community sample of 108 adolescents (M_{age} = 12.82, SD_{age} = 0.82, 53.70% female). At the initial laboratory visit (T1), participants completed an unsolvable anagram stressor task, during which RSA (basal, reactivity, and recovery) was measured. SITBs were assessed at T1 and at the 6-month follow-up (T2). Results indicated basal RSA and RSA reactivity did not significantly predict engagement in SITBs between T1 and T2. Poorer RSA recovery from the stressor task at T1 did significantly predict engagement in SITBs between T1 and T2, over and above depressive symptoms and lifetime history of SITBs. This suggests that adolescents with poor ability to regulate physiologically following a stressor may turn to maladaptive emotion regulation strategies like SITBs.

1. Introduction

1.1. Self-injurious thoughts and behaviors

Self-injurious thoughts and behaviors (SITBs) refer to thoughts and behaviors in which individuals think about or engage in "directly and deliberately" injuring themselves (Nock and Favazza, 2009, p. 10). SITBs include suicidal ideation, urges, and behaviors (including attempts), as well as nonsuicidal self-injurious thoughts, urges, and behaviors. SITBs among adolescents are a major public health concern. Nock et al. (2008) reported that the 12-month prevalence of SITBs among adolescents ranged from 11.7–26.0% for suicidal ideation, 5.0–15.0% for suicidal plans, and 1.8–8.4% for suicide attempts. While rates of SITBs increase over adolescence (Nock et al., 2008), there is a dearth of prospective research available for this age group. Further, SITBs are associated with several negative concurrent and prospective outcomes, including significant distress (Klonsky, 2007), mental health problems (Andover et al., 2005; Klonsky et al., 2003), and increased risk for suicide attempts (Jacobson and Gould, 2007; Klonsky et al., 2013). Of particular concern, SITBs are significant predictors of completed suicide (see Horwitz et al., 2015), which is the 2nd leading cause of death in this age group globally (World Health Organization, 2014).

SITBs often co-occur, are closely related, and display common vulnerabilities and associated outcomes (e.g. Nock and Kessler, 2006; Reinherz et al., 2006). However, the rate of engaging in any one SITB remains fairly low. Given the close relation between SITBs and the low occurrence rate of any one SITB (e.g. Nock and Kessler, 2006; Nock et al., 2008; Reinherz et al., 2006), it is appropriate to study SITBs together in order to understand their onset and developmental trajectory. Dominant theories explain that SITBs often occur in the context of emotional distress (Nock et al., 2009) and function as maladaptive emotion regulation strategies (Jacobson and Gould, 2007; Nock and Prinstein, 2004, 2005). Emotion regulation refers to modifying the intensity, duration, and valence of an emotion (Cole et al., 2004; Gross, 1998). Research has shown that both adolescents and adults who engage in SITBs have difficulty with emotion regulation (Gratz et al., 2010; Gratz and Chapman; 2007; Gratz and Roemer, 2008; Linehan, 1993). In fact, the most common self-reported reason for engaging in self-injury is to

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reduce emotional distress (Klonsky, 2007). Thus, SITB engaged individuals may be less able to regulate emotional reactions to stressors, and engage in SITBs as an attempt to regulate emotions (Heath et al., 2008).

Little is known about the predictive relation between physiological markers of emotion regulatory capacity and engagement in SITBs. Recent theory and research has identified biomarkers of emotion regulatory capacity, which may provide insight into potential physiological predictors of SITBs, given their function as emotion regulation strategies. Several psychophysiological researchers have proposed that respiratory sinus arrhythmia (RSA) is an index of emotion regulatory capacity (Beauchaine, 2001; Berntson et al., 2007; Porges, 1995). RSA indexes parasympathetic nervous system (PNS) activity and is a measure of physiological response to environmental demands. The PNS, a branch of the autonomic nervous system, plays a central role in regulating physiological responses to stress through acute withdrawal of its inhibitory effects on bodily organs during stress and facilitating restorative functions following stress (McLaughlin et al., 2013; Zisner and Beauchaine, 2016). Differences in PNS responsivity to stressors, including an excessive and prolonged stress response, may be associated with increased risk for SITBs among adolescents (Crowell et al., 2005). The purpose of the current study is to examine the prospective relationship between RSA (basal, reactivity, and recovery) and SITBs among adolescents.

1.2. RSA as an index of emotion regulatory capacity

Vagal tone, or activity of the PNS, is the tonic influence of the vagus nerve on the sino-atrial node of the heart (Porges, 1995). Vagal tone cannot be directly measured, so other psychophysiological measures are used to index vagal tone, one of which is RSA. RSA measures high frequency variability in heart rate across the breathing cycle and quantifies vagal efference to the heart (see Grossman, 1992; Lewis et al., 2012). Research has shown that under certain conditions, RSA correlates with vagal efference to the heart (see Allen et al., 2007; Grossman et al., 1990). Given that vagal tone, or PNS activity, is implicated in regulating physiological stress responding, RSA can serve as a marker of one's ability to adapt flexibly to environmental demands (Porges, 1995), and to regulate emotions (Berntson et al., 2007; Zisner and Beauchaine, 2016). In fact, RSA has been linked to emotion dysregulation and many forms of psychopathology, including nonsuicidal self-injury (see Beauchaine, 2012; Beauchaine and Thayer, 2015; Crowell et al., 2005).

RSA as an index of emotion regulatory capacity has many different components. Basal RSA indexes vagal tone at rest, while RSA reactivity and RSA recovery index vagal responsivity to stress. Basal RSA is measured during a resting state prior to a stressor. Research has shown that higher basal RSA is associated with the use of more adaptive emotion regulation strategies (see Gentzler et al., 2009), whereas lower basal RSA has consistently been linked to both internalizing and externalizing symptoms and emotion dysregulation (see Zisner and Beauchaine, 2016). Thus, we expected to find that SITB engaged adolescents had lower basal RSA.

RSA reactivity is a measure of the degree to which vagal tone changes during a challenging or stressful situation. During stressor tasks, RSA reactivity indicates how an individual adapts to environmental demands (Porges, 1995). Reduced vagal tone during stressor tasks means that the vagus nerve is withdrawing its inhibitory effect of cardiac function and allowing metabolic resources to be used to respond to environmental demands. Literature suggests that the relationship between RSA reactivity and emotion regulation is mixed (see Graziano and Derefinko, 2013). Some have found that the combination of both low basal RSA and excessive RSA reactivity to stressors is related to emotion dysregulation (Beauchaine, 2001). However, other studies have shown that low RSA reactivity to stress may also be an indicator of poor emotion regulation, as it may indicate relatively little responsivity to changes in environmental demands (Zisner and Beauchaine, 2016). One explanation of these mixed findings is that the child and adolescent literature has used both clinical and normative, community samples. Clinical populations may be more likely to present with low basal RSA and excessive RSA reactivity, whereas community samples may be more likely to exhibit low RSA reactivity to stress (for a review, see Zisner and Beauchaine, 2016). Second, differences in task conditions may account for these mixed findings. For example, both excessive and suppressed RSA reactivity have been found to be associated with externalizing symptoms, depending on the nature of the task; emotion evocation tasks show a pattern of excessive RSA predicting symptoms (Beauchaine et al., 2007; Beauchaine and Gatzke-Kopp, 2012), while cognitive, executive functioning, and problem solving tasks show a pattern of suppressed RSA predicting symptoms (Dietrich et al., 2007; Hinnant and El-Sheikh, 2009; Obradović et al., 2010). The current study employed a community sample, and participants completed a problem-solving stressor task, which may indicate that we should expect less RSA reactivity. However, given the extreme nature of SITBs, and their relation to emotional dysregulation, we anticipated finding a pattern of excessive RSA reactivity among the SITB engaged adolescents.

Following a physiological response to a stressor, it is expected that vagal tone will return to basal levels. The period during which RSA returns to the pre-stress, basal level is termed RSA recovery. Less research has been conducted on RSA recovery as it links to psychopathology and emotion dysregulation. However, theory indicates that adaptive stress responding includes re-engagement of the PNS, which functions as a restorative system to bodily organs (Zisner and Beauchaine, 2016). Poor RSA recovery may indicate an ongoing physiological stress response. Thus, poor recovery to stress may indicate the absence of or an inability to access other adaptive emotion regulation strategies (Santucci et al., 2008). Individuals who exhibit poor recovery to stress may be at increased risk for SITB engagement because they are unable to regulate negative or prolonged emotions in the moment and turn instead to maladaptive emotion regulation strategies. Thus, we expected to find that SITB engaged adolescents would exhibit a poorer recovery to stress. Using all three components of RSA (basal, reactivity, and recovery) measures the temporal course of emotional responsivity to a stressor and the ability to regulate emotion in physiological systems (Fox, 1998; Santucci et al., 2008).

1.3. RSA and SITBs

Literature has linked RSA to both internalizing and externalizing symptoms among adolescents (Beauchaine, 2012; Gentzler et al., 2009). However, scant research exists concerning the relationship between RSA and SITBs. Research shows that basal RSA is negatively correlated with suicidality among depressed adults (Rottenberg et al., 2002; Chang et al., 2012) and among adults with remitted depression (Chang et al., 2013). Crowell et al. (2005) found that compared to controls, self-injuring adolescents exhibited reduced basal RSA and greater RSA reactivity to a sad mood induction task, but found no differences between groups in RSA recovery. The finding that self-injury was associated with lower basal RSA is not surprising due to the substantial body of literature that has shown that reduced basal RSA is linked with emotion dysregulation (Zisner and Beauchaine, 2016), and SITBs are often used to regulate emotion (e.g. Nock and Prinstein, 2004, 2005). Further, the finding that excessive RSA reactivity was exhibited by the self-injuring adolescents may indicate that they experienced the task as emotionally overwhelming, in that they showed a greater change in RSA during the task than the control participants (Crowell et al., 2005). The finding that self-injuring participants did not exhibit a slower recovery to basal levels of RSA was inconsistent with Crowell et al.'s (2005) hypotheses. These initial findings indicate that there may be a cross-sectional association between RSA and SITBs, but more work is needed to fully understand the extent of the relationship. Of particular note, no studies have