The Relation Between Resting Respiratory Sinus Arrhythmia and Mental Health Challenges in Early Adolescents: The Role of Emotion Regulation Strategies

by

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DISSERTATION ABSTRACT

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Title: The Relation Between Resting Respiratory Sinus Arrhythmia and Mental Health Challenges in Early Adolescents: The Role of Emotion Regulation Strategies

Mental health challenges among early adolescents, even when subclinical, are associated with adverse outcomes. Preliminary research suggests that resting respiratory sinus arrhythmia (RSA)—a biological indicator of emotion regulation (ER) capacities—may help to identify youth at risk for mental health problems. To date, research on the link between resting RSA and mental health challenges during the critical period of early adolescence is limited. The literature will benefit from a greater understanding of this relationship as well as mechanisms through which resting RSA influences mental health in this population. One potential mechanism is that RSA affects mental health via use of ER strategies, which may be adaptive (e.g., cognitive reappraisal) or maladaptive (e.g., rumination). The current study thus aimed to replicate the association between resting RSA and mental health challenges in a community sample of early adolescents and investigate adaptive and maladaptive ER strategies as mediators in this pathway. Baseline data from 24 early adolescents (M_{age} =12.23 years; 54% female; 87% racial/ethnic minority) and their caregivers (79% biological mothers) from a substance use trial were used. RSA was collected, adolescents completed measures assessing ER strategy use and demographics, and dyads completed measures assessing adolescent mental health and pubertal development. Adjusted linear regression results demonstrated a large effect size

for the association between low resting RSA and adolescent mental health challenges based on caregiver-report (β = -.532, p = .012) but not self-report (β = .018; p = .925). Structural equation modeling was applied to test the joint indirect effects of adaptive and maladaptive ER strategies in these relationships, and post-hoc analyses explored whether the measures underlying latent variables functioned as individual mediators. Mediation was not found. Collectively, these findings underscore the importance of multiple informants when assessing adolescent mental health and illuminate limitations in the current study (e.g., dichotomization of ER strategies). Nonetheless, caregiver regression results reflect research that shows that lower resting RSA is linked with greater mental health challenges in adolescents. These findings have implications for interventions aimed at assessing and enhancing ER capacities in early adolescents and reducing vulnerability for mental health problems.

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CHAPTER 1

INTRODUCTION

The number of adolescents affected by mental disorders is an area of significant interest among clinicians, educators, and researchers (Achenbach et al., 2012; Insel, 2014; Paus et al., 2008; Polanczyk et al., 2015; Vander Stoep et al., 2005). Rates of diagnoses have increased exponentially (Costello et al., 2005), and a growing number of youth now require psychotherapeutic and pharmacological treatments, educational interventions, and a range of special services and accommodations (Fazel et al., 2014; Olfson et al., 2014; Sahakian & Morein-Zamir, 2007). Findings from The National Comorbidity Survey Replication-Adolescent Supplement (NCS-A) with a sample of over 10,000 adolescents indicate that anxiety disorders are the most common (32%), followed by behavioral disorders (19%), mood disorders (14%), and substance use disorders (11%; Kessler et al., 2005). Internalizing problems (e.g., anxiety) and externalizing problems (e.g., aggressive behaviors) are often not mutually exclusive, with a high percentage of adolescents experiencing both (Angold et al., 1999; Cosgrove et al., 2011; Nivard et al., 2017). Further, mental health difficulties in adolescence may increase the risk for later challenges, with some studies finding that adolescent depression predicts major depressive disorder and suicidal ideation and attempts in adulthood (Mueller et al., 1999; Solomon et al., 2004). Mental health challenges in adolescence appear to be pervasive and have the potential to lead to difficulties in adulthood.

While considerable attention is placed on diagnosable mental health disorders (e.g., Polanczyk et al., 2015), adolescents with subclinical mental health difficulties—who comprise a significant proportion of youth seeking mental health treatment (Angold

et al., 2002; Costello & Shugart, 1992)—also experience ramifications. In a sample of over 1,400 participants, Copeland et al. (2015) found that mental health symptoms in children and adolescents were predictive of adverse outcomes in adulthood (e.g., incarceration, residential instability) even when symptoms were subclinical and did not persist into adulthood. These findings remained even after accounting for adult psychological functioning and childhood adversities. Additionally, in a sample of 179 early adolescents, subclinical depressive symptoms predicted adulthood social challenges (Allen et al., 2014). It is plausible that mental health challenges in adolescence, regardless of whether they meet the diagnostic threshold, interfere with social and emotional development at a critical point, thus paving the way for long-term difficulties.

From a prevention and intervention standpoint, early adolescence—which spans from 10 to 14 years—is an important developmental period in which to identify mental health challenges. Early adolescence coincides with numerous psychological, social, and biological changes that increase vulnerability to mental health difficulties (Hayward, 2003; Susman et al., 2007). This developmental period encompasses social transitions from childhood to adolescence and from primary to secondary school. As youth are introduced to new settings, rules, teachers, and academic demands, the mismatch between their new context and individual development may create distress (Moilanen et al., 2010). This is further compounded by their exposure to increasingly complex social situations (Sebastian et al., 2010; Vartanian, 2000) and more conflict at home as they begin to seek out more autonomy and individuation from caregivers (Allison & Schultz, 2004). The strain placed on an individual's mental health during early adolescence is supported by results from one longitudinal study ($N = 220$), which found that a child's average

emotional state over a week was more negative in early adolescence compared to middle and late adolescence (Larson et al., 2002).

Increased mental health difficulties during early adolescence partly stem from biological changes that occur at this developmental juncture. Early adolescents experience rapid brain changes that lead to a "developmental mismatch" between the prefrontal cortex and limbic system (Mills et al., 2014), leading to a lack of top-down control and increased reactivity to emotion-laden stimuli and sensitivity to reward (Steinberg, 2005). This imbalance may be more severe for female early adolescents than their male counterparts. A study with a sample of 335 adolescents found that female adolescents experienced faster maturation of limbic structures during adolescence relative to male adolescents (Frere et al., 2020). Brain changes during early adolescence may therefore lead youth—particularly female early adolescents—to be more impacted by emotional context when making decisions and less effective at managing emotions (Ochsner & Gross, 2008).

For most early adolescents, brain chains occur in tandem with the onset of puberty (Dahl & Gunnar, 2009; Patton & Viner, 2007; Susman et al., 2007). Puberty is triggered by the activation of the hypothalamic-pituitary-gonadal axis, resulting in gonadarche (e.g., increased secretion of sex steroids), adrenarche (e.g., onset of pubic hair), and rapid physical growth (e.g., breast development in females, penis growth in males; Buck Louis et al., 2008; Dahl, 2004). The onset of puberty is associated with increased emotional reactivity and intensity and stress responsiveness due to factors such as fluctuating hormones and increased self-consciousness (Dahl & Gunnar, 2009). Females, who begin puberty on average 1.5 years earlier than males, are shown to

experience more significant emotional changes (Casey et al., 2008; Dahl & Gunnar, 2009; Negriff & Susman, 2011). While the developmental changes that occur in early adolescence may produce normative levels of distress for some, they may exacerbate or jumpstart the development of more serious problems for others, particularly females.

Emotion Regulation in Early Adolescents

In recent decades, emotion regulation (ER) has emerged as a key construct for understanding diverse mental health problems in children, adolescents, and adults (Beauchaine, 2015). ER is defined as an individual's automatic (implicit) and/or effortful (explicit) attempt to reduce or enhance a specific emotional state. Gross (1998) defines this as "the processes by which individuals influence which emotions they have, when they have them, and how they experience and express these emotions." Restated, ER refers to an individual's capacity to comprehend their emotional experiences and utilize specific strategies to manage an emotion or several emotions. Explicit ER processes require conscious effort and some level of insight and awareness, whereas implicit ER processes are thought to be evoked automatically by stimuli and run to completion without monitoring, often without insight or awareness (Gyurak et al., 2011). The current study will focus on explicit ER strategy use.

ER strategies are considered adaptive or maladaptive depending on their impact on affect, behaviors, and the development of psychopathology (Aldao et al., 2010). They may be adaptive when an individual meets their ER goal (e.g., avoiding conflict), successfully reduces negative emotions (e.g., calming down when feeling angry), or evokes positive emotions (e.g., watching a funny movie to elicit joy; Sheppes et al.,

2014). Among early adolescents, higher adaptive ER strategy use is associated with overall adjustment and long-term social and emotional health (Calkins & Hill, 2007; Morris et al., 2017; Shortt et al., 2010) and is protective against the development of mental health disorders (Aldao & Nolen-Hoeksema, 2012; Gross & John, 2003). Children who frequently use adaptive ER strategies are found to have higher peer status (Kim & Cicchetti, 2009), better quality relationships (Spinrad et al., 2006), and greater social competence at later developmental points (Rydell et al., 2003; Spinrad et al., 2006). The critical role of adaptive ER strategies is demonstrated by research that shows that decreased use of adaptive strategies predicts higher levels of depression in adolescents (Cracco et al., 2015; Garber et al., 1995; Mezulis et al., 2011; Silk et al., 2003; Yap et al., 2011). Adaptive ER strategies during childhood and adolescence thus play a critical role in healthy development.

Across age groups, maladaptive ER strategy use (e.g., repetitive thinking about negative situations) is less effective in regulating emotions and instead increases the risk for emotion dysregulation, a strong transdiagnostic correlate of mental health symptoms (Aldao et al., 2010). Emotion dysregulation is conceptualized as problematic patterns of emotional intensity, frequency, and duration, and difficulty managing emotions (Gross & Jazaieri, 2014). Higher use of maladaptive ER strategies is a mediating predictor of a range of mental health problems in adolescents (Boyes et al., 2016; Herts et al., 2012; John et al., 2017; Kullik & Petermann, 2013; Seymour et al., 2014; Sim & Zeman, 2005; Stikkelbroek et al., 2016; Vahidi et al., 2021; Wante et al., 2017; Yap et al., 2010). Wante et al. (2017) found that increased use of maladaptive ER strategies and decreased use of adaptive ER strategies jointly mediated the relationship

between impaired executive functioning and higher depressive symptoms in a sample of early adolescents (n = 579). Moreover, higher use of maladaptive ER strategies was found to be a significant mediator between body dissatisfaction and bulimic symptoms in a sample of female early adolescents (Sim & Zeman, 2005). Similarly, Herts et al. (2012) revealed that difficulties with ER—including more maladaptive strategy use—mediated the relationship between both peer victimization and stressful life events and aggressive behavior in a sample of early adolescents (N = 1,065). In short, ER strategies appear to represent a key mechanism underlying the mental health of early adolescents.

Fortunately, ER strategies can be improved upon via teaching and modeling and are thus an ideal target for intervention and risk prevention (Murray et al., 2022). Intervention studies have demonstrated success in improving adolescent ER abilities in both community and clinical samples (Brown et al., 2011; Eadeh et al., 2021; Houck et al., 2016; Moltrecht et al., 2021). Further, youth may be particularly responsive to ER interventions during early adolescence because of their transition from relying on basic external ER strategies, such as seeking emotional support from caregivers, to more complex internal ER strategies, including reinterpreting a situation to change its emotional impact (Ahmed et al., 2015; Eisenberg & Morris, 2003; Willner et al., 2022). Improvements to one's ER strategy repertoire during the critical period of early adolescence may serve to prevent or disrupt the development of mental health problems.

Theoretical Background

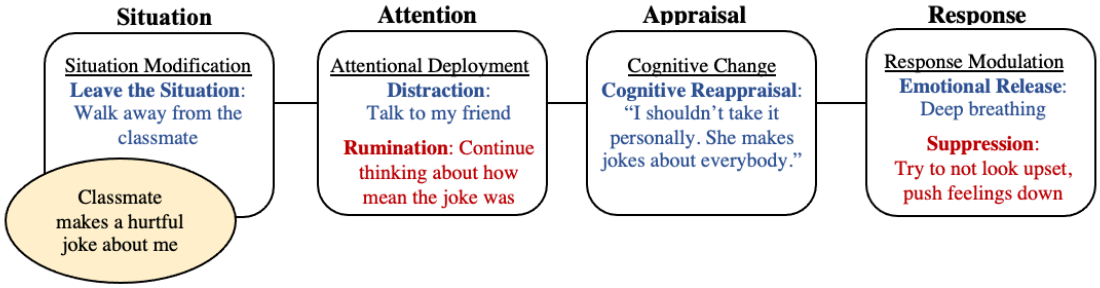
Gross' (2014) widely used process model categorizes ER strategies into five distinct domains: (a) cognitive change (reappraising the emotional trigger to change its

emotional impact); (b) attentional deployment (altering the allocation of attention to modify an emotional response); (c) response modulation (engaging in a behavior to change some aspect of an emotional response), (d) situation modification (modifying the situation that is leading to emotional difficulties); and (e) situation selection (avoiding or approaching a situation to alter the emotional valence). Each domain may be adaptive or maladaptive depending on the context. The current study will examine the following four adaptive ER strategies: cognitive reappraisal (cognitive change); distraction (attentional deployment); emotional release (response modulation); leave the situation (situation modification); as well as the following two maladaptive ER strategies: rumination (attentional deployment) and suppression (response modulation); see Figure 1. These adaptive and maladaptive strategies will be reviewed in more detail below and were chosen due to their well-established associations with positive and negative outcomes, respectively (Aldao et al., 2010; Gross, 2014; Hilt et al., 2010; Houck et al., 2016; McRae, 2016; Quoidbach et al., 2015; Willner et al., 2022).

Situation selection will not be examined in the present study, as early adolescents often lack autonomy over their "situations," which are typically managed by caregivers and other adults. Exclusion of this ER domain will maintain the focus on ER strategies that are within early adolescents' purview and require momentary decision-making versus the advanced planning required in situation selection.

Figure 1

The Process Model of Emotion Regulation



Note. Adapted from "Emotion Regulation: Conceptual Foundations," by J. J. Gross (Ed.), Handbook of Emotion Regulation (p. 8), 2014, New York, NY: Guilford Press. Copyright 2014 by Guilford Press.

Adaptive ER Strategies

Cognitive Reappraisal. Cognitive reappraisal—reinterpreting a situation in a way that modifies its original meaning or relevance and thus emotional impact (Gross, 2015)—is widely considered to be an adaptive ER strategy among adolescents (McRae et al., 2012; Picó-Pérez et al., 2017; Rood et al., 2012; Shapero et al., 2019). Its use is associated with greater expression of positive emotion and enhanced well-being (Gross, 2002; John & Gross, 2007). A 2022 systematic review of the development of cognitive reappraisal from early childhood through adolescence concluded that the frequency of cognitive reappraisal use as well as its effectiveness increases from middle childhood through adolescence (Willner et al., 2022). Studies demonstrate that instructed use of cognitive reappraisal decreases negative affect in both community sampled youth and those with mental health disorders, including anxiety disorders, autism spectrum disorder, and depressive disorders (Carthy et al., 2010; Platt et al., 2015; Samson et al., 2015). Findings from De Witte et al. (2017) revealed that cognitive reappraisal improved ER and

anxiety symptoms in both clinically anxious and healthy youth. Moreover, in a study conducted by Tan et al. (2012), youth aged 9-13 years who were either anxious or typically-developing completed phone interviews regarding their emotions and ER strategies they utilized. Across groups, cognitive reappraisal was one of the most frequently used strategies and the most effective in down-regulating sadness, anger, or "upset." Sex differences have been observed in the use of cognitive reappraisal, with female early adolescents reporting greater use than their male counterparts (Chervonsky & Hunt, 2019; Gullone et al., 2010). In short, cognitive reappraisal may promote positive affect, cognitive flexibility, and overall psychological resilience, and may be more frequently used by female early adolescents.

Distraction. Distraction is defined as intentionally diverting attention away from emotionally arousing stimuli (e.g., unpleasant thoughts) and toward an external stimulus (e.g., a comforting movie; Gross, 1998). Distraction may be particularly useful during early adolescence, a developmental period where too much focus on one's own distress may increase vulnerability for emotion dysregulation (Brand & Klimes-Dougan, 2010). Wante et al. (2018) found in a sample of early adolescents ($N = 184$) that use of distraction significantly increased happy affect and decreased sad affect, and that its impact was stronger than cognitive reappraisal. This is consistent with research that shows that when emotions are intense and there is minimal time for ER, distraction may be more accessible and adaptive than cognitive reappraisal (McRae, 2016; Sheppes & Gross, 2011). Furthermore, results from a study with a sample of children and adolescents from the Netherlands revealed that those who endorsed lower levels of distraction compared to rumination experienced more depression and anxiety over time,

whereas those who utilized more distraction had reductions in depression and anxiety (Roelofs et al., 2009). These findings align with those of Hilt et al. (2010) who examined a sample of racially and ethnically diverse middle schoolers ($N = 722$) and found that lower levels of distraction predicted increased depressive symptoms over time. Lastly, Park et al. (2004) compared the effects of instructed use of distraction compared to rumination and found that rumination worsened depressive symptoms in both depressed adolescents and healthy controls when compared to distraction. Overall, distraction appears to be highly effective in reducing negative affect in early adolescents.

Emotional Release. Another adaptive form of ER is releasing emotional energy through healthy means, such as talking to a supportive friend about one's feelings, deep breathing, exercising, or expressing one's feelings through artistic means (e.g., writing, painting, poetry). Though research is limited on the effects of emotional release on adolescent mental health outcomes, findings from adult studies highlight the effectiveness of these strategies. A systematic review on psycho-physiological correlates of slow breathing techniques in adults found associations between parasympathetic activity and emotional control and psychological well-being (Zaccaro et al., 2018). Findings revealed that slow breathing interacted with the cardio-respiratory system by increasing heart rate variability and respiratory sinus arrhythmia, suggesting activation of the parasympathetic nervous system. Across studies, slow breathing was associated with decreased anxiety, increased ease and comfort, relaxation, positive energy and pleasantness, and somatic-based emotional control strategies.

In a separate review of over 130 studies by Quoidbach et al. (2015; 23 included adolescents and young adults), Gross' process model was employed to review the

literature on adaptive ER strategies. Results indicated that response modulation strategies (including emotional release) were among the strongest in their ability to produce short-term increases in positive emotions. Several longitudinal studies in this review demonstrated that participants who shared daily positive events and their emotional experiences with others experienced increased duration and intensity of daily positive emotions (Gable et al., 2004; Gable & Reis, 2010; Langston, 1994). This suggests that emotional release may be an avenue both for preventing and managing emotion dysregulation.

Leave the Situation. The final adaptive ER strategy examined in the current study is choosing to leave a situation that is contributing to emotion dysregulation (Gross, 2014). While there is limited research on this ER strategy with adolescent samples, it may function similarly to distraction, in that when emotions are intense and youth are struggling to access higher-level ER strategies (e.g., cognitive reappraisal), removing themselves from the situation may be advantageous. Houck et al. (2016) examined this strategy with early adolescents with behavioral and emotional difficulties in a sexual risk intervention study. Participants were assigned to a control group or an experimental ER group whereby they learned ER strategies informed by Gross' process model, including leaving the situation. Though the impact of individual ER strategies on sexual risk behaviors was not assessed, participants in the ER group endorsed greater use of ER strategies and more favorable attitudes toward abstinence than the control group, suggesting that leaving the situation may have been an effective form of ER. Furthermore, Rueth & Lohaus (2022) found associations between situation modification (the ER domain that includes 'leave the situation') and prosocial behavior among a

German sample of older children and adolescents (M = 13.03, SD = 1.75). Although additional research is warranted, these initial findings suggest that leaving an emotionally charged situation may be an effective ER strategy for early adolescents.

Maladaptive ER Strategies

Rumination. Rumination (i.e., repetitive inward focus on one's unpleasant feelings, symptoms, and thoughts) is the most widely studied maladaptive ER strategy across developmental groups due to its association with psychopathology (e.g., Coleman et al., 2022; Olatunji et al., 2013; Palmieri et al., 2021). Though this strategy may be used to gain insight into one's feelings, rumination has been shown to have the unintended effect of prolonging distress and hindering the use of adaptive ER strategies (Nolen-Hoeksema et al., 2008; Park et al., 2004). Indeed, it is well established that adolescents who ruminate are at increased risk for developing depressive symptoms, and that rumination increases the severity of symptoms in depressed adolescents (Aldao et al., 2010; Cracco et al., 2015; Hilt et al., 2010; Mezulis et al., 2011). Moreover, there are gender differences among early adolescents in their use of rumination and co-rumination (i.e., friends discussing negative events and dwelling on negative emotions), with females reporting higher rates than males (Hilt et al., 2010; Rood et al., 2009). For example, Rose (2002) found among a sample of third, fifth, seventh, and ninth graders that female friend dyads were more likely to engage in co-rumination than males (Rose, 2002; Rose et al., 2007). These findings indicate that rumination is an ineffective approach to ER and may disproportionately impact early adolescent females.

Suppression. Lastly, suppression is defined as the conscious attempt to inhibit, hide, or reduce outward emotional expression (Gross & Levenson, 1993; Gross & John,

2003). While suppression reduces outward signs of emotion, it has little effect on modifying the emotional experience itself and is actually shown to increase activation of the sympathetic nervous system (Gross, 1998). Suppression may therefore give the illusion of calmness, but internally, an individual may be experiencing just as much emotion and even more physiological activation than if they were to express their emotions freely (Richards & Gross, 1999). The ineffectiveness of suppression in regulating affect is demonstrated by its link to adolescent psychopathology (Aldao et al., 2010; Chervonsky & Hunt, 2017). In a meta-analysis of 43 studies that examined the link between suppression and health outcomes in adults, children, and adolescents (13 studies included adolescents), greater emotional suppression was associated with worse mental health and social well-being (Chervonsky & Hunt, 2017). In general, male adolescents report higher rates of suppression (Silk et al., 2003; Vierhaus et al., 2007; Zimmermann & Iwanski, 2014). However, in a study with a sample of Australian early adolescents, no gender differences in the average level or change in suppression over time were found (Chervonsky & Hunt, 2019). The authors hypothesized that Western social norms that historically contribute to male emotional suppression may not have yet influenced their early adolescent sample (Chaplin, 2015). Relatedly, it is important to note that emotional suppression is common and normative in collectivist cultures and tends to serve prosocial goals (e.g., group harmony), which may buffer the strategy's adverse impact on mental health in these populations (Cheung & Park, 2010; Su et al., 2015; Young et al., 2022).

Limitations in the Measurement of Emotion Dysregulation

Although interventions may successfully promote the use of adaptive ER strategies and reduce the use of maladaptive strategies, there are challenges in both the identification of adolescents who may benefit from interventions and the detection of changes in strategy use in response to interventions. ER problems are most often identified using self-report, collateral-report, and less frequently, observational assessments (Zeman et al., 2007). However, self-report may be unreliable due to a range of issues, including the social desirability bias and adolescents' evolving emotional awareness (Zeman et al., 2007). There may also be paradoxical effects in ER interventions, whereby increasing emotional awareness may simultaneously draw adolescents' attention to their ER deficits and contribute to underreporting of ER deficiencies (Zeman et al., 2007). With respect to collateral report, studies indicate that a rater's negative perceptions of their environment as well as their own mental health challenges may lead to overreporting of adolescents' ER difficulties (Fergusson et al., 1993; Pas & Bradshaw, 2014). Lastly, observational assessment of ER abilities is limited by the laborious nature of coder training and adolescent attempts to modify their behaviors to appear better managed (Kerig & Lindahl, 2008). Thus, current ER measures may be insufficient at identifying youth at risk for emotion dysregulation, highlighting the need for other approaches that reduce biases and require less time and resources.

Respiratory Sinus Arrhythmia in Early Adolescents

Respiratory sinus arrhythmia (RSA), considered a biomarker of ER (Beauchaine, 2015), has the potential to circumvent limitations in current ER measurement. RSA—or high-frequency heart rate variability across the respiratory cycle—is an indicator of

parasympathetic nervous system (PNS) activity, which reflects an individual's physiological ability to respond to environmental demands and regulate emotions during times of stress (Beauchaine, 2015; Porges, 1995, 2007). Research suggests that RSA is an index of higher-order brain structures involved in emotional responding and decision making, including the prefrontal cortex's control over the amygdala (Churchwell et al., 2009; Shannon et al., 2009). The leading theory in RSA (Porges, 1995) distinguishes between three states of RSA: resting RSA (resting state), RSA reactivity (response to a stressor), and recovery RSA (once a stressor has been removed). Unlike traditional measures of ER, RSA does not depend on emotional awareness nor is it influenced by reporter biases or participant attempts to appear better managed. It is also non-invasive and considered to be a relatively stable biological measure of ER (Calkins, 1997; Propper & Moore, 2006). These advantages have led RSA to be of significant interest among ER scholars over recent decades.

Resting RSA may be particularly useful in measuring emotion dysregulation and its link to mental health challenges in early adolescents. For context, the PNS exerts control over the heart through the vagal nerve by regulating the heart rate, essentially serving as a vagal "brake" (Porges, 1995, 2007). While an individual is at rest, the vagal brake is activated, thereby lowering heart rate and blood pressure. Resting RSA is shown to increase in early childhood (Mezulis et al., 2010), plateau in late childhood (El-Sheikh, 2004), and decrease in early adolescence (Lisitsa et al., 2021; Salomon, 2005). Higher resting RSA represents an individual's ability to flexibly engage with their environment and is associated with higher use of adaptive ER strategies and fewer mental health problems in youth (Beauchaine, 2012; Cui et al., 2015).

In contrast, lower resting RSA is thought to be a transdiagnostic biomarker of emotion dysregulation (Beauchaine, 2015), as evidenced by its association with psychopathology in children and adolescents (Beauchaine, 2001, 2012; Hinnant & El-Sheikh, 2013; Vasilev et al., 2009) and numerous psychological syndromes, including anxiety (Hastings et al., 2008), non-suicidal self-injury (Crowell et al., 2005), attention problems (Rash & Aguirre-Camacho, 2012), depression (Rottenberg, 2007), conduct disorder (Beauchaine et al., 2007), trait hostility (Sloan et al., 1994), autism spectrum disorder (Guy et al., 2014), and panic disorder (Asmundson & Stein, 1994). This long list underscores that resting RSA may reflect one or more core self-regulatory functions that are disrupted across diverse mental health problems, which may help to explain the high co-occurrence of adolescent internalizing problems and externalizing problems (Angold et al., 1999; Cosgrove et al., 2011; Nivard et al., 2017). In other words, biological vulnerability to emotion dysregulation conferred by lower resting RSA may be a common thread across internalizing and externalizing problems in early adolescents.

Sex differences have been observed in resting RSA among children and adolescents. A 2017 meta-analysis with data from more than 5,000 children and adolescents revealed that healthy children and adolescents assigned female at birth displayed lower resting RSA and greater heart rate compared to their male counterparts (Koenig et al., 2017). Lower parasympathetic vagal activity among female adolescents may help to explain their higher prevalence of mood and anxiety disorders compared to males (Seedat et al., 2009). Though the mechanisms of reduced vagal activity underlying psychopathology is not well understood, Koenig et al. (2017) hypothesizes that emerging sex hormones during puberty may help to explain sex differences. It is important to note

that low resting RSA may be understood not solely as a marker of increased risk to psychopathology but as a marker of heightened neurobiological sensitivity to contextual factors, both positive and negative (Boyce & Ellis, 2005; Ellis et al., 2011). Early adolescents with low resting RSA may therefore be both vulnerable to adverse influences and highly receptive to interventions intended to strengthen ER strategies (Ellis et al., 2011).

Mediators in the Relation between RSA and Mental Health Challenges

Given their respective roles in combating or facilitating mental health problems (Aldao & Nolen-Hoeksema, 2012), adaptive and maladaptive ER strategies are important mediators to consider in the relationship between low resting RSA and mental health problems in early adolescents. Examination of this relationship is supported by extensive research that links ER strategy use with mental health (Aldao et al., 2010; Chaplin & Cole, 2005; Garnefski et al., 2001; John & Gross, 2004; McLaughlin et al., 2011), and resting RSA with both ER (Beauchaine, 2012) and adolescent mental health difficulties (Beauchaine, 2001, 2012; Hinnant & El-Sheikh, 2013; Vasilev et al., 2009). To date, no study has examined the mediating role of ER strategy use in the association between resting RSA and general mental health challenges in early adolescents or any other developmental group, though some studies have explored similar questions. Gyurak & Ayduk (2008) conducted a mediated moderation analysis to examine whether emotion control explained the buffering effect of high resting RSA on aggressive behavior among rejection-sensitive adults. Results demonstrated that emotion control mediated the effect of high resting RSA against aggressive behaviors. While this study's focus was on *high* resting RSA, these results may provide some support for the role of adaptive ER

strategies (e.g., emotional control) in reducing aggressive behaviors. Extending these findings to the current study, vulnerability to emotion dysregulation conferred by *low* resting RSA may contribute to higher use of maladaptive ER strategies and interfere with the use of adaptive ER strategies, thus creating a pathway for mental health problems (e.g., Aldao et al., 2010).

The Use of Latent Variables

Though most studies have examined ER strategies in isolation, it is unlikely that adolescents employ only a single ER strategy to manage their feelings. Rather, multiple ER strategies are often used concurrently, to different degrees, and in different contexts (Aldao & Nolen-Hoeksema, 2012; Brans et al., 2013; Gross & Thompson, 2007). It can also be expected that a wider range of adaptive ER strategies provide early adolescents more flexibility in utilizing different strategies when needed, whereas a broader range of maladaptive ER strategies may indicate a propensity toward emotion dysregulation. The multidimensionality of ER strategy use may best be captured using latent variables. For example, Wante et al. (2017) used latent variables to represent adaptive and maladaptive ER strategies and found that higher use of maladaptive ER strategies and lower use of adaptive ER strategies jointly mediated the relation between impaired executive functioning and higher depressive symptoms in early adolescents. Further, in a Chinese sample of older children and early adolescents ($N = 535$), the authors found that cognitive reappraisal, represented as a latent variable, mediated the relationship between negative affect and depressive symptoms and mood (Liu et al., 2022). Lastly, Malhi et al. (2017) indicated that the latent construct of emotion dysregulation fully mediated the association between irritability and internalizing symptoms in a sample of female adolescents. These

findings suggest that latent variables may help to capture the complexity of ER strategy use among adolescents and potentially provide more nuance to findings.

Current Study

The current study first sought to replicate the association between low resting RSA and general mental health challenges in a community sample of early adolescents. There are few studies that have examined resting RSA and mental health difficulties in adolescents (Beauchaine, 2001, 2012; Hinnant & El-Sheikh, 2013; Vasilev et al., 2009), and to my knowledge, none that have investigated this topic in an entirely early adolescent sample. These analyses adjusted for pubertal development and sex assigned at birth given the impact these factors have on mental health and ER strategy use (e.g., Casey et al., 2008; Chervonsky & Hunt, 2019; Dahl & Gunnar, 2009; Gullone et al., 2010). Analyses also adjusted for study condition (details below). The current study then aimed to build on this initial association by examining adaptive and maladaptive ER strategies as mediators in the relationship between resting RSA and mental health challenges. This analysis was driven by the hope of elucidating the development of mental health challenges among early adolescents to inform intervention and prevention efforts. The research aims and hypotheses for the current study were as follows:

Aim 1

Replicate the association between resting RSA and mental health challenges in an early adolescent sample.

Hypothesis 1. There will be a significant association between resting RSA and mental health challenges, whereby lower resting RSA will be associated with a higher

level of adolescent mental health challenges according to self-report and caregiver-report, respectively.

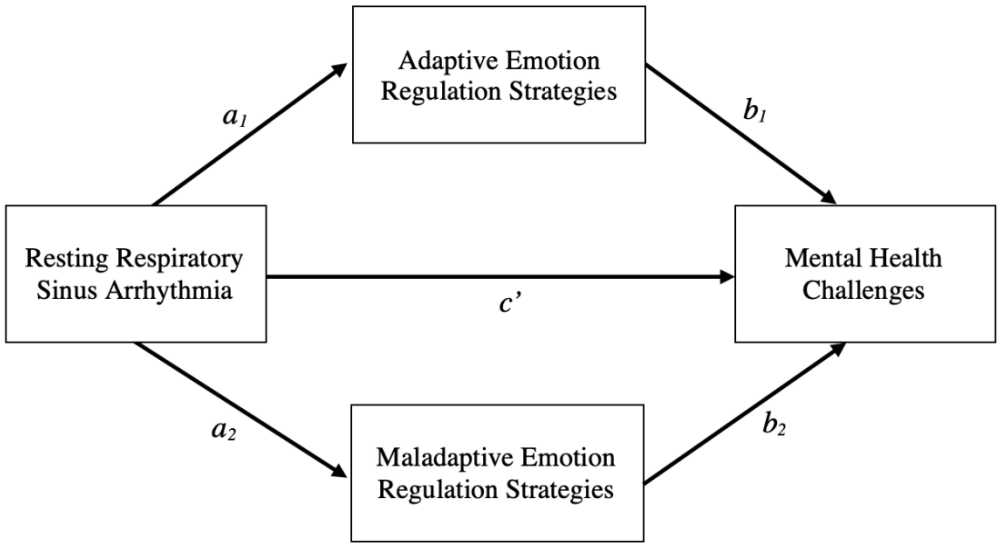
Aim 2

Investigate whether adaptive ER strategies and maladaptive ER strategies jointly mediate the relation between resting RSA and mental health challenges. See Figure 2.

Hypothesis 2. Lower use of adaptive ER strategies and higher use of maladaptive ER strategies will jointly mediate the relation between lower resting RSA and higher adolescent mental health challenges based on self-report and caregiver-report, respectively.

Figure 2

Adaptive and Maladaptive ER Strategies as Mediators Between Resting RSA and Mental Health Challenges



CHAPTER II

METHOD

Data for the current analyses were drawn from an active federally funded research study called Project LIVE (Longitudinal Investigation of Virtual Reality and Emotions; R01DA050603; Principal Investigators: Wendy Hadley and Christopher Houck). Project LIVE is a prospective longitudinal substance use measurement trial that is evaluating whether RSA detected in the context of a virtual reality risk-taking situation can predict the onset of substance use behavior among early adolescents. The current study included data from the baseline timepoint, which is ongoing.

Participants

The current study utilized data from a sample of 24 early adolescents (M_{age} =12.23 years; 54% female; 88% racial and/or ethnic minority) and their caregivers (79% biological mothers) who completed the LIVE baseline study visit. See Table 1 for sample characteristics. LIVE participants were recruited from primary care clinics from the Hasbro Children's Hospital in Providence, Rhode Island with the use of flyers, mailings, and in-person recruitment. Early adolescents were eligible for participation if they were between the ages of 12 years, 0 months and 12 years, 6 months to capture the onset of risk behaviors (i.e., substance use, sex) for the LIVE study. Additionally, participants were required to be able to speak and read in English, have an English or Spanish speaking caregiver, and read at a fourth-grade level. Early adolescents were excluded from participation if they had a known cardiac condition or developmental delay, were on the autism spectrum (youth with autism have been shown to have differences in RSA; Patriquin et al., 2014), were taking clozapine (which can modify RSA; Alvares et al.,

2016), were receiving hormone therapy in the context of gender affirming care (which can affect salivary hormones), or screened positive for motion sickness susceptibility (i.e., cybersickness), which could be triggered by immersive virtual reality (IVR) exposure. Additionally, adolescents with epilepsy, diagnosed migraines, or severe uncorrectable visual impairment were excluded as a precaution for IVR participation. Adolescents were eligible if they had not taken prednisone within 7 days of their study visit. Only one adolescent and caregiver dyad per household were eligible to participate to reduce impact of shared genetic and environmental influence on the biological outcomes.

Table 1

Sample Characteristics (n = 24)

	n (%) / M (SD)
Age	12.23 (.17)
Female	13 (54%)
Hispanic or Latiné	18 (75%)
White	5
Black/African American/Haitian	2
Multiracial	1
Other Race	9
Race Not Specified	1
Non-Hispanic or Non-Latiné	6 (25%)
White	3
Black/African American/Haitian	2
Multiracial	1
Pubertal Development	2.59 (.62)[a]
Caregiver Relationship to Adolescent	
Biological Mother	19 (79%)
Grandmother	2 (8%)
Stepmother	2 (8%)
Biological Father	1 (4%)
Household Income	
Less than $15,000	3 (13%)
$15,000 - $44,659	13 (54%)
$45,000 - $54,999	2 (8%)
$64,660 - $84,659	2 (8%)
$84,660 and above	3 (13%)
Prefer not to answer	1 (4%)

Note. [a] Total score for Pubertal Development Scale ranges from 1 (no puberty development) to 4 (completed development). Percentages may not add up to 100% because of rounding.

Design and Procedures

Informed consent procedures and study visits occurred at the Bradley/Hasbro Children's Research Center. Project staff met with eligible families who provided

permission to contact them; during these meetings, staff obtained in-person consent and assent for participation. LIVE participants and their caregivers completed assessments at baseline and 3-, 6-, 9-, 12-, 15-, 18-, 21-, and 24-months. The current study focused on the baseline assessment only, which had a duration of 3-3.5 hours. At baseline, participants completed the following tasks: RSA collection, urine and saliva collection, and computerized REDCap surveys on tablets that assessed adolescent demographics, mental health, use of emotion regulation strategies, substance use, and sexual behavior. Caregivers completed REDCap questionnaires that assessed caregiver and adolescent demographics and adolescent mental health and pubertal development. All procedures were approved by the study site's institutional review board. See Appendix A for the LIVE baseline study visit details.

RSA was collected in the context of a computerized risk-taking task (the Balloon Analogue Risk Task [BART]; Lejuez et al., 2002) and a IVR party that involves sexual behavior and substance use. Adolescents were randomized to order of administration of the IVR party and the BART (Condition A = BART first, Condition B = IVR party first). Resting RSA was collected during a 9-minute "neutral" condition (i.e., a task without significant cognitive or emotional demands) prior to both the BART and IVR. Before the BART, participants were asked to sit down, knees at a 90-degree angle, with both feet flat on the floor. They watched a 2D aquarium scene on a tablet for nine minutes, which included time to adjust to the position for one minute prior to the 8-minute resting RSA sample. Though resting RSA was collected prior to both conditions, only the BART resting RSA data were used for analyses given that past studies have utilized similar neutral conditions whereby adolescents viewed a neutral scene on a television or laptop

(Cui et al., 2015; Wielgus et al., 2016). Fewer studies have utilized neutral conditions that involved IVR (Hadley et al., 2014, 2023), therefore it is less clear how a IVR neutral condition would impact resting RSA. For participants who were randomized to IVR party first, there was the potential for this stress-inducing task to affect resting RSA levels measured prior to the BART. For this reason, the current study controlled for study condition; the IVR party is described below to provide further context.

For the IVR party, participants put on a head-mounted display (HMD), which replicated their head movements in the simulated scenario and allowed stereo, directional audio to be provided through sound-reducing headphones. At the start of the study session, they viewed 4 avatars (2 male, 2 female) and selected the one to whom they were most attracted; the IVR party then included this avatar as a potential sexual partner. Adolescents then navigated the 8-minute IVR party on a predetermined path. The party was comprised of three segments: orientation to the party (alcohol and marijuana use, partygoers can be seen talking and flirting), interactive substance use cues (e.g., participant is offered marijuana), and interactive sexual cues (e.g., the avatar that the participant identified as most attractive flirts with the participant and asks if they want to go into a private room). See Appendix B for a screenshot of the IVR party.

For the collection of RSA, adolescents were asked to follow a typical sleep routine the night before study participation and refrain from using caffeine before the appointment, consistent with recommendations for research involving RSA (Laborde et al., 2017). RSA collection occurred in a quiet room. Participants were asked to take a seat and place two disposable electrodes on their body to record heart rate, one on the chest and one on the upper abdomen. To determine the fit of the respiration belt, a research

assistant measured the adolescent's waist. Waist circumference was obtained to the nearest 0.1 cm with measuring tape placed around the abdomen, laterally at the level of the iliac crests and anteriorly at the umbilicus. The adolescent then put the belt on. To prevent distracting noises from affecting heart rate data, adolescents' phones were not allowed in the room.

Measures

At baseline, caregivers and adolescents both completed measures assessing adolescent mental health and pubertal development. Adolescents completed self-report measures that assessed ER strategy use and demographics (e.g., age, race, ethnicity, sex assigned at birth). Caregivers provided information on household income. RSA was collected from adolescents.

Resting RSA

RSA was obtained using the BIOPAC MP160 Data Acquisition system. ECG data were collected via electrodes placed on the participant's abdomen and chest using a Lead II placement. Respiration was obtained via a belt transponder placed around the waist. Respiration data were not used for the current analyses. ECG data were amplified and sent to the BIOPAC MP160 data collection and analysis system using the BioNomadix amplifier. Interrater reliability between the dissertation author and study principal investigator, Dr. Wendy Hadley, was confirmed before the dissertation author cleaned the ECG data. Artifact caused by body movement, etc., was manually identified and cleaned from Q-wave to Q-wave. RSA was then derived using spectral analysis in the BIOPAC system AcqKnowledge software. Spectral analysis is based on the fast Fourier transform, which calculates the power density (ms^2) of the high frequency band associated with

respiration in the ECG signal (Grossman et al., 1990). The age-appropriate frequency band of 0.15 and 0.4 Hz was used (Berntson et al., 2007). RSA was extracted in 30 second epochs and averaged across the 9-minute resting baseline interval to produce the total averaged RSA used in the current analyses.

Mental Health Challenges

Mental health challenges were assessed using the adolescent-reported Youth Self-Report (YSR) and the caregiver-reported Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2001). These instruments can be used with children ages 11 years and older to assess internalizing and externalizing behaviors based on eight empirically derived syndrome scales, including: anxious/depressed, withdrawn/depressed somatic complaints, social problems, thought problems, attention problems, rule-breaking behavior, and aggressive behavior. These syndromes can be categorized into internalizing and externalizing domains. A Total Problems summary score can also be calculated. Caregivers and adolescents rated 112 statements regarding the adolescent's mood and behavior over a six-month time period (e.g., "I/my child blurt(s) out the answers to questions before I/they hear the entire question") based on a three-point Likert scale (0 = *Absent*, 1 = *Occurs Sometimes*, 2 = *Occurs Often)*. Data were entered into the ASEBA scoring software and scored automatically. The YSR is among the most commonly used measures of child problem behaviors and demonstrates good reliability and an internal consistency as high as 0.89 (Achenbach & Rescorla, 2001; Ebesutani et al., 2011). Syndrome scale T-scores are interpreted as $\leq$64 = normal, 65-69 = borderline, $\geq$70 = clinical. Internalizing, Externalizing, and Total Problems scores are interpreted as $\leq$59 = normal, 60-64 = borderline, $\geq$65 = clinical (Achenbach & Rescorla, 2001).

To reduce the risk of type II errors in the small, community sample used in the present analyses, the Total Problems T-score was used. Multigroup analyses have found that the Total Problems T-score is reasonably invariant across genders, age groups, and countries, suggesting that it is a reliable measure of the general factor of psychopathology (Petot et al., 2023). Additionally, examining mental health challenges generally via the Total Problems T-score is aligned with the current study's emphasis on prevention and identification of early mental health problems. Lastly, the decision to use the Total Problems T-score is supported by research that shows that adolescent internalizing and externalizing problems often co-occur (Angold et al., 1999; Cosgrove et al., 2011; Nivard et al., 2017). Due to low adolescent-caregiver reliability in the current study (r = .294, p = .064), the Total Problem T-scores for the YSR and CBCL were examined separately.

Adaptive ER Strategies

Adaptive ER strategy use was measured with the Emotion Regulation Behaviors Scale (ERBS; Houck et al., 2016), and the Cognitive Reappraisal subscale of the Emotion Regulation Questionnaire for Children and Adolescents (ERQ-CA; Gullone & Taffe, 2012). The ERBS is a five-point scale ranging from 0 (*never*) to 4 (*all of the time*) and consists of nine self-report items that measure how often adolescents try to calm their feelings through: use of Distraction (1 item: "Doing something to get your mind off the person or thing causing your feelings"), Leaving the Situation (1 item: "Moving away from the person or thing causing your feelings"), Emotional Release (4 items; e.g., "Doing something to express yourself, like drawing or writing"), and Cognitive Reappraisal (3 items; e.g., "Thinking differently about the person or thing causing your feelings"). Higher scores indicate a higher frequency of each strategy domain utilized.

The ERQ-CA consists of 6 Cognitive Reappraisal items (e.g., "When I want to feel happier, I think about something different") rated on a 7-point Likert-type response scale, ranging from 1 (*strongly disagree*) to 7 (*strongly agree*), with higher scores indicating greater use. Good internal reliability was observed for both the ERBS ($\alpha = .75$) and the ERQ-CA Cognitive Reappraisal subscale ($\alpha = .89$) in the current sample. The ERBS is included in Appendix C, and the ERQ-CA is included in Appendix D.

Maladaptive ER Strategies

Maladaptive ER strategy use was measured with the Emotional Suppression subscale of the ERQ-CA (Gullone & Taffe, 2012) and the Perseverative Thinking Questionnaire – Child Version (PTQ-C; Bijttebier et al., 2015). The ERQ-CA Emotional Suppression subscale contains 4 items (e.g., "I keep my feelings to myself") that are rated on a 7-point Likert-type response scale from 1 (*strongly disagree*) to 7 (*strongly agree*), with higher scores indicating greater use. The PTQ-C consists of 15 items that assess perseverative/ruminative thinking (e.g., "I can't stop thinking about it"). Items are rated on a 5-point scale ranging from 0 (*never*) to 4 (*almost always*). Good internal reliability was observed for both the ERQ-CA Emotional Suppression subscale ($\alpha = .87$) and the PTQ-C ($\alpha = .95$) in the current sample. The ERQ-CA is included in Appendix D, and the PTQ-C is included in Appendix E.

Demographics

Participants were asked to indicate their sex assigned at birth (1 = female, 0 = male), age, ethnicity (Hispanic or Latino = 1, non-Hispanic or Latino = 0), and race (1 = American Indian or Alaskan Native; 2 = Asian, 3 = Black, African American, or Haitian, 4 = Native Hawaiian or Pacific Islander, 5 = White, and 6 = Other). Race options were

not mutually exclusive. Caregivers provided information on household income. Response options for the income question were modified early in the data collection process. Fifteen caregivers in the current study answered the question with the outdated response options: 1 = less than $15,000; 2 = $15,000-$24,999; 3 = $25,000-$34,999; 4 = $35,000-$44,999; 5 = $45,000-$54,999; 6 = $55,000-$64,999; 7 = $65,000-$74,999; 8 = $75,000-$84,999; and 9 = $85,000 and above. Nine caregivers answered the question with the updated response options: 1 = less than $12,880; 2 = $12,880-$17,419; 3 = $17,420-$21,959; 4 = $21,960-$26,499; 5 = $26,500-$31,039; 6 = $31,040-$40,119; 7 = $40,120-$44,659; 8 = $44,659-$64,659; 9 = $64,660-$84,659; 10 = $84,660-$104,659; 11 = $104,660-$124,659; 12 = $124,660-$144,660; and 13 = $144,661 and above.

Pubertal Development

Pubertal development was assessed using the Self-Rating Scale for Pubertal Development (PDS) and the Parent PDS (Carskadon & Acebo, 1993), both of which were adapted from the Pubertal Development Scale (Petersen et al., 1988). These measures include items rating physical development to classify the adolescents' pubertal development. Three items related to physical development were asked of both male and female adolescents regarding height, growth of body hair, and skin changes. Adolescents rated items on a 4-point scale from 1 (has not begun/started) to 4 (seems/are completed). Male adolescents responded to two items unique to biological male development, including "Have you noticed a deepening of your voice?" and "Have you begun to notice hair grow on your face?" Female adolescents responded to three items unique to biological female development, including "Have you noticed that your breasts have begun to develop?" and "Have you begun to menstruate (started to have your period)." If

female participants answered yes to the latter, they were asked, "How old were you when you first started to menstruate?" The yes/no question about onset of menarche was weighted more heavily. For both males and females, ratings were averaged to produce an overall score for physical maturation, with higher scores indicating more advanced pubertal development. For analyses, self-report data were primarily used. When self-report data were missing, items were supplemented with caregiver reported PDS items, which mirror the self-report options (e.g., "Have you noticed any skin changes in your son/daughter, especially pimples?"). The PDS has established validity and reliability, and significant correlations have been established between self-report and caregiver-report (Carskadon & Acebo, 1993). See Data Analyses section for more details about management of missing PDS data. See Appendix F for the self-report PDS.

Study Condition

The present study adjusted for study condition (Condition A = BART first, Condition B = IVR party first) to account for any lingering effects that IVR may have had on resting RSA for participants randomized to Condition B.

Data Analyses

Power Analysis

With power set at 0.8, simulations have found that a sample size of 71 is sufficient to detect significant mediation when the α and β paths are moderately associated (Fritz & MacKinnon, 2007). Based on this information, the current study originally aimed to recruit a minimum of 71 participants. However, due to difficulties with recruitment, the final sample size for the current study is 24, resulting in

significantly underpowered analyses. For this reason, effect sizes instead were primarily used to interpret the meaningfulness of results.

Data Screening

Assumptions of multivariate normality were assessed with the Shapiro-Wilk test, which is argued to be the most appropriate method for testing normality of data in small sample sizes (n = < 50; Mishra et al., 2019). Results of the Shapiro-Wilk test indicated that variables were normally distributed (p >.05) except for the CBCL Total Problems Score (p = .048). A visual inspection of histograms, normal Q-Q plots, and box plots showed that dependent variables were approximately normally distributed. Data were found to have slight kurtosis and skew with z-values that fell within the range of -1.96 and +1.96, indicating that they did not differ significantly from normality. Outliers were retained, as no outliers demonstrated undue influence on the model (i.e., Cook's distance of < 1). Data were considered to be approximately normally distributed.

Missing Data

Of the 32 enrolled LIVE participants, 7 (21%) were excluded from analyses due to missing all data on one or more questionnaire. These data were missing due to REDCap malfunctions (e.g., errors in REDCap project skip logic; n = 5), insufficient time to complete questionnaires during the research appointment (n = 1), and selecting 'prefer not to answer' across questionnaire items (n = 1). These data were determined to be missing at random, as most were missing were due to study design.

Among the 24 participants included in analyses, 2 had unusable/missing RSA data due to excessive artifact, 4 had missing data on the PTQ-C, ERBS, and/or ERQ-CA, 13 had missing YSR data, and 1 caregiver was missing a single CBCL item. Across these

measures, the percentage of total and individual missingness was less than 10%. Additionally, 11 participants had missing items on the PDS, with missingness for individual items ranging from 17% (n = 4) to 33% (n = 8). Closer inspection of the PDS data revealed that missingness was based on adolescent sex. Total missingness for male adolescent PDS data was below 10%. Percentage of missingness for individual female PDS items was as follows: 62% (n = 8) for female-specific item 4 (growth in breast size); 46% (n = 6) for item 1 (growth in height); 31% (n = 4) for item 2 (growth of body hair); and 23% (n = 3) for item 3 (skin changes). See Appendix F for PDS items. Little's Missing Completely at Random (MCAR) test determined that data in the analytic sample were not missing in a systematic pattern, $\chi^2(409, n = 24) = 25.84, p = 1.00$.

Missing self-report PDS items were supplemented with the caregiver reported PDS items, which mirror those of the self-report version. For YSR and CBCL forms that are missing less than 8 items, these items are treated by the ASEBA software as if the informant answered them with a '0,' and scores are generated accordingly (individual missingness did not exceed 7 items in the current study; Achenbach & Rescorla, 2001). Other missing data for the analytic sample (i.e., RSA, ERQ-CA, ERBS, PCT-Q) were managed with multiple chained equations, using variables of interest from all participants. Multiple imputation assumes that data are missing at random and unrelated to outcome measures after accounting for variables included in the imputation model.

Descriptives and Bivariate Associations

Bivariate associations among continuous variables were examined with Pearson r as the correlation coefficient and interpreted based on Cohen's (1988) guidelines: small = between .10 and .30 or -.10 and -.30; moderate = .30 and .50 or -.30 and -.50; and large =

≥ .50 or ≤ -.50; alphas were set to $p = .05$, two-tailed. Chi-square tests were used to examine bivariate associations among dichotomous variables. Independent T-tests were conducted to examine sex differences in study variables and were interpreted based on Cohen's *d* (1988) conventions: small = 0.20; moderate = 0.50; and large = ≥ 0.80. Preliminary descriptive statistics (i.e., frequencies, averages, standard deviations, maximum values, minimum values) were conducted to describe the sample (i.e., % female, mean age, race, ethnicity).

Linear Regressions

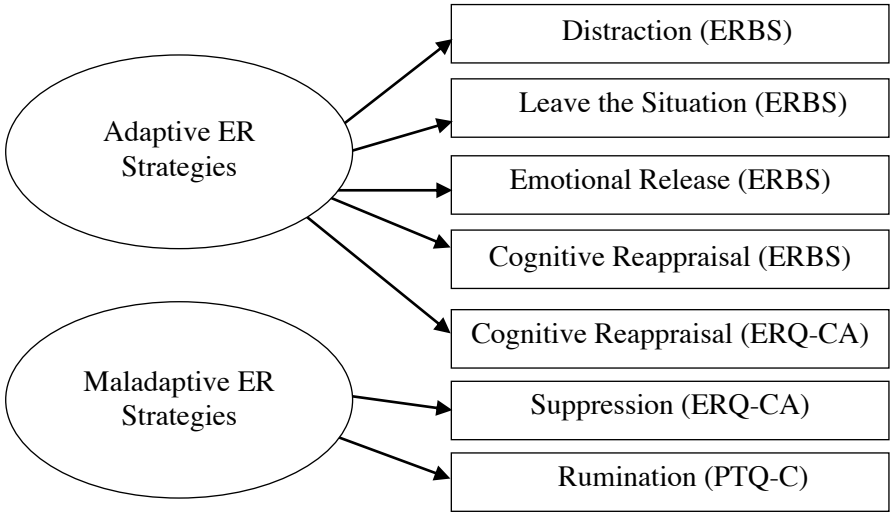
To examine the association between resting RSA and mental health challenges, linear regressions were performed. Adolescent mental health challenges were represented by caregiver report (i.e., CBCL Total Problems T-score) and adolescent report (i.e., YSR Total Problems T-score), respectively. Unadjusted regressions were first conducted to assess the bivariate associations between resting RSA and the Total Problems T-scores. Study condition and covariates (sex assigned at birth, pubertal development) were then added to the models. Effect sizes for individual variables were interpreted based on standardized regression coefficients (β): small = 0.10–0.29; moderate = 0.30–0.49; and large ≥ 0.50 (Cohen, 1988; Fey et al., 2023). Model effect sizes were interpreted based on Cohen's f^2 (1988) conventions: small = 0.02; moderate = 0.15; and large ≥ 0.35. SPSS version 29 (*IBM SPSS Statistics for Windows*, 2023) was used for multiple imputation, linear regressions, descriptive statistics, and missing completely at random (MCAR) testing.

Structural Equation Modeling

The indirect effects of adaptive ER strategies and maladaptive ER strategies in the relationship between resting RSA and mental health were jointly tested with structural equation modeling (SEM). Latent constructs were created to represent adaptive ER strategies (using the observed variables of cognitive reappraisal, distraction, leaving the situation, and emotional release) and maladaptive ER strategies (using the observed variables of rumination and suppression). See Figure 5. The factor loading of each variable was assessed, and items with factor loadings < 0.40 were omitted. Modification indices of values above 50 were assessed to determine how the SEM model could be improved when a specific restriction on a parameter was freed. Model fit was assessed using model approximate fit indices, including the comparative fit index (CFI), Tucker–Lewis index (TLI), root mean square error of approximation (RSMEA), and standardized root mean square residual (SRMR). Within SEM, cut-offs have been specified to indicate acceptable model fit, including a CFI and TLI ≥ 0.90, and a RMSEA and SRMR $\leq .08$ (Hu & Bentler, 1999; Schreiber et al., 2006). Given that the chi-square test tends to be stringent in testing for an exact fit of the data to the model, chi-square tests were utilized primarily to test improved fit. The correlation between the latent variables was analyzed and interpreted based on Cohen's (1988) Pearson's *r* guidelines as previously described.

Figure 5

Latent Variable Models for Adaptive and Maladaptive ER Strategies



Note. ER = emotion regulation; ERBS = Emotion Regulation Behaviors Scale; ERQ-CA = Emotion Regulation Questionnaire for Children and Adolescents; PTQ-C = Perseverative Thinking Questionnaire – Child Version.

Mediation was performed utilizing the latent variables depicted in Figure 5 as joint mediators. As recommended by Hayes and Rockwood (2017), mediation analyses were conducted with a focus on indirect effects. Bootstrapped confidence intervals are considered the superior procedure for testing mediated pathways because they allow for irregularities in the sampling distribution of the indirect effect and are shown to be more highly powered and less susceptible to type I and II errors (Hayes, 2017). Therefore, bias-corrected 95% confidence intervals and standard errors for all parameter estimates were produced using 5000 bootstrapped samples (MacKinnon, 2008; Preacher & Hayes, 2008). The advantage of a bootstrapping procedure is that it accounts for correlations

between the mediator and the influence of control variables and does not impose distributional assumptions. For this reason, mediation effects were reported independent of the influence of control variables (Preacher & Hayes, 2008). Indirect effects were interpreted based on standardized regression coefficients (β): small = 0.10–0.29, moderate = 0.30–0.49, large $\geq$ 0.50 (Cohen, 1988; Fey et al., 2023). Model effect sizes were interpreted based on Cohen's f^2 (1988) conventions: small = 0.02; moderate = 0.15; and large $\geq$ 0.35 Mediation was considered present when confidence intervals for indirect effects did not contain zero. M*plus* version 7.11 (Muthén & Muthén, 2013) was used to conduct SEM analyses.

CHAPTER III

RESULTS

Descriptives and Bivariate Comparisons

Table 2 shows descriptive statistics and bivariate correlations between study variables. Resting RSA was negatively associated with CBCL Total Problems (r = -.57, p = .003), and YSR Total Problems was positively associated with the ERQ-CA Suppression Subscale (r = .45, p = .026), the PTQ-C (r = .61, p = .001), and pubertal development (r = .61, p = .001). The ERBS was positively associated with the ERQ-CA cognitive reappraisal subscale (r = .69, p <.001) and suppression subscale (r = .57, p = .003). The ERQ-CA Cognitive Reappraisal subscale was positively associated with the ERQ-CA Suppression subscale (r = .42, p = .039). To unpack the latter finding, correlations between the two ERQ-CA subscales were calculated for each sex. The correlation estimate was not significant for males (r = -.17, p = .601) but was positive and significant for females (r =

.65, p = .015). Additionally, the ERQ-CA Suppression subscale was positively associated with the PTQ-C (r = .57, p = .004) and pubertal development (r = .42, p = .039). Lastly, the PTQ-C was positively associated with pubertal development (r = .66, p <.001).

Table 2

Descriptive Statistics and Bivariate Correlations Between Study Variables (n = 24)

Variables		1	2	3	4	5	6	7
1	Resting RSA							
2	YSR Total T-Score	-0.18						
3	CBCL Total T-Score	**-0.57****	0.38					
4	ERBS	0.23	0.08	-0.33				
5	ERQ-CA – CR	0.04	0.13	-0.24	**0.69****			
6	ERQ-CA - Suppression	0.20	**0.45***	-0.19	**0.57****	**0.42***		
7	PTQ-C	-0.23	**0.61****	0.21	0.02	0.01	**0.57****	
8	Pubertal Development	-0.37	**0.61****	0.35	0.06	0.25	**0.42***	**0.66****

Note. RSA = respiratory sinus arrythmia; YSR = Youth Self Report; CBCL = Child Behavior Checklist; ERBS = Emotion Regulation Behaviors Scale; ERQ-CA = Emotion Regulation Questionnaire for Children and Adolescents; CR = Cognitive Reappraisal; PTQ-C = Perseverative Thinking Questionnaire – Child Version. * p < .05, ** p < .01.

To further elucidate bivariate correlations, independent t-tests and chi-square tests were conducted to explore sex differences (females = 1, males = 0). Sex differences were found for most variables (see Table 3). Small effect sizes were indicated for adolescent age and YSR Total Problems, whereby males were slightly older than females (d = -.32, p = .444), and females had higher Total Problems YSR scores (d = .41, p = .326). There were moderate effect sizes for resting RSA and CBCL Total Problems, whereby males had higher resting RSA (d = -.59, p = .176), and caregivers of female adolescents reported more youth problems on the CBCL than caregivers of male adolescents (d = .62, p = .143). Males had higher scores on both adaptive ER measures (ERBS: d = -.84, p = .046; ERQ-CR: d = -.93, p = .028), and females had higher scores on the PTQ-C (d =

1.41, $p = .003$). Compared to males, females were further along in their pubertal development ($d = 1.05$, $p = .017$)

Table 3

Study Variable Comparisons by Sex Assigned at Birth

	Female (n = 13)			Male (n = 11)			Test Statistic[a]	95% CI	
Variable	*M (SD)*	Min	Max	*M (SD)*	Min	Max		Lower	Upper
Age	12.20 (0.15)	12.00	12.50	12.26 (.20)	12.00	12.50	d = -0.32	-1.13	0.48
Pubertal Development	2.86 (0.56)	2.0	3.8	2.27 (.54)	1.4	3.2	d = 1.05**	0.18	1.90
Resting RSA	6.65 (0.71)	5.43	7.63	7.17 (1.03)	5.47	8.52	d = -0.59	-1.41	0.23
YSR Total T-Score	62.92 (12.60)	41	81	57.45 (13.81)	35	75	d = 0.41	-0.40	1.22
CBCL Total T-Score	53.69 (8.09)	42	65	48.73 (7.86)	41	68	d = 0.62	-0.20	1.43
ERBS	19.15 (6.03)	9	28	23.83 (4.75)	16	32	d = -0.84*	-1.68	0.00
ERQ-CA-CR	17.38 (5.91)	6	24	21.73 (2.45)	15	24	d = -0.93*	-1.76	-0.07
ERQ-CA-Suppression	11.15 (3.73)	4	15	11.18 (2.85)	6	15	d = -0.01	-0.81	0.79
PTQ-C	33.54 (10.21)	15	50	18.45 (11.20)	0	35	d = 1.41**	0.49	2.30
Condition (VR First)	n = 7	–	–	n = 6	–	–	χ^2 = 0.97	0.19	4.87

Note. CI = confidence interval; RSA = respiratory sinus arrythmia; YSR = Youth Self Report; CBCL = Child Behavior Checklist; ERBS = Emotion Regulation Behaviors Scale; ERQ-CA = Emotion Regulation Questionnaire for Children and Adolescents; CR = Cognitive Reappraisal; PTQ-C = Perseverative Thinking Questionnaire – Child Version; VR = virtual reality.

[a]Female = 1; male = 0. * $p < .05$, ** $p \leq .01$.

Adolescent Mental Health

A summary of adolescent mental health descriptives and informant agreement can be found in Table 4. Syndrome scale T-scores were interpreted as ≤64 = normal, 65-69 = borderline, ≥70 = clinical. Internalizing, Externalizing, and Total Problems scores were interpreted as ≤59 = normal, 60-64 = borderline, ≥65 = clinical (Achenbach & Rescorla, 2001). On average and across scales, self-reported scores were higher than caregiver-report scores. T-scores fell within the *Normal* clinical range for all syndrome scales and composite scores except for the YSR Total Problems score, which was narrowly in the *Borderline* range (M_{Tscore} = 60.42). For the YSR, 54% of participants had Internalizing scores that placed them in the *Borderline* (*n* = 4) or *Clinical* range (*n* = 9), 38% had Externalizing scores that fell in the *Borderline* (*n* = 4) or *Clinical* range (*n* = 5), and 63% had Total Problems scores that placed them in the *Borderline* (*n* = 6) or *Clinical* range (*n* = 9). For the CBCL, 21% of participants had Internalizing scores that placed them in the *Borderline* range (*n* = 5), 13% had Externalizing scores that fell in the *Borderline* (*n* = 2) or *Clinical* range (*n* = 1), and 25% had Total Problems scores that placed them in the *Borderline* (*n* = 4) or *Clinical* range (*n* = 2). Sex differences were found, with females on average having higher scores than males across scales for both the YSR and CBCL. Scores for both sexes fell within the *Normal* clinical range except for the following female YSR scores, which were in the *Borderline* range: Social Problems (M_{Tscore} = 65.15, *SD* = 11.17), Thought Problems (M_{Tscore} = 66.00, *SD* = 9.66), Internalizing Problems (M_{Tscore} = 61.62, *SD* = 14.29), and Total Problems (M_{Tscore} = 62.92, *SD* = 12.60). Low adolescent-caregiver agreement was found for the Total Problems score (*r* = .29), and other correlations were weak to moderate (*r* = -.01 to .46).

Table 4

Adolescent Mental Health Descriptives and Informant Agreement

	YSR	Severity Level (*n*)			CBCL	Severity Level (*n*)			Informant
	M (SD)	N	B	C	*M (SD)*	N	B	C	Agreement[a]
Scale									
Anxious/Depressed	61.08 (10.17)	15	2	7	52.79 (4.22)	23	1	0	-.002
Withdrawn/Depressed	61.50 (10.56)	16	5	3	54.46 (6.70)	21	2	1	.465*
Somatic Complaints	58.50 (11.04)	18	4	2	56.08 (5.11)	22	2	0	.432*
Social Problems	62.79 (10.03)	13	5	6	55.33 (6.01)	21	3	0	.196
Thought Problems	64.00 (10.71)	12	4	8	54.13 (5.11)	23	1	0	.189
Attention Problems	62.37 (12.47)	15	4	5	55.88 (6.14)	21	2	1	.311
Rule-Breaking Behavior	55.75 (5.43)	22	2	0	53.79 (4.95)	23	1	0	.221
Aggressive Behavior	59.29 (7.82)	18	2	4	53.38 (4.61)	23	1	0	.139
Composite Score									
Internalizing	58.67 (14.24)	11	4	9	51.04 (7.79)	19	5	0	.443*
Externalizing	56.08 (9.94)	15	4	5	49.04 (9.28)	21	2	1	.371
Total Problems	60.42 (13.17)	9	6	9	51.42 (8.21)	18	4	2	.294

Note. T-scores were used. YSR = Youth Self Report; CBCL = Child Behavior Checklist;

N = Normal; B = Borderline; C = Clinical. [a] Pearson correlation coefficient, * $p < .05$.

Linear Regression Analyses

Results of the first unadjusted regression demonstrated a small effect size for the association between resting RSA and the YSR Total Problems (β = -.184, p = .390), which disappeared once study condition and covariates were added to the model (β = .018; p = .925). A large effect size was found for the association between pubertal development and the YSR Total Problems T-score (β = .665, p = .005), with more advanced pubertal development being associated with a higher T-score. See Appendices G and H for scatterplots of the association between resting RSA and the YSR, and the association between pubertal development and the YSR. In the unadjusted CBCL model, a large effect size was found for the association between resting RSA and the CBCL Total Problems T-score (β = -.578, p = .003), with lower resting RSA being associated with a higher CBCL Total Problems T-score. This effect remained in the presence of covariates and study condition (β = -.532, p = .012). See Table 5 for regression results and Appendix I for a scatterplot of the association between resting RSA and the CBCL.

Table 5

Association Between Resting RSA and Mental Health Challenges (n = 24)

Adolescent Report (YSR)	*B*	*B* 95% CI		*SE*	β	R^2	f^2
		LL	*UL*				
Unadjusted	-2.74	-9.23	3.74	3.12	-.184	.034	0.03
Step 1						.393	0.64
Female	-2.92	-13.36	7.51	5.02	-.113		
Pubertal Development	14.25*	5.72	22.79	4.10	.674		
Step 2						.414	0.70
Female	-2.72	-13.28	7.82	5.06	-.105		
Pubertal Development	13.96	5.31	22.61	4.14	.660		
VR Condition	3.75	-5.52	13.02	4.44	.145		
Step 3						.415	0.70
Female	-2.63	-13.69	8.42	5.28	-.102		
Pubertal Development	14.07*	4.85	23.29	4.40	.665		
VR Condition	3.71	-5.87	13.30	4.58	.143		
Resting RSA	.274	-5.76	6.31	2.88	.018		
Caregiver Report (CBCL)							
Unadjusted	-5.37*	-8.73	-2.01	1.61	-.578	.334	0.50
Step 1						.148	0.17
Female	2.91	-4.79	10.62	3.70	.181		
Pubertal Development	3.48	-2.82	9.78	3.03	.264		
Step 2						.196	0.24
Female	3.10	-4.60	10.81	3.69	.192		
Pubertal Development	3.20	-3.10	9.52	3.02	.243		
VR Condition	3.53	-3.23	10.31	3.24	.219		
Step 3						.429	0.75
Female	1.38	-5.42	8.19	3.25	.086		
Pubertal Development	1.24	-4.43	6.91	2.71	.094		
VR Condition	4.27	-1.62	10.17	2.81	.265		
Resting RSA	-4.95**	-8.67	-1.23	1.77	-.532		

Note. RSA = respiratory sinus arrhythmia; YSR = Youth Self Report; CI = confidence interval; *LL* = lower limit; *UL* = upper limit; CBCL = Child Behavior Checklist; VR = virtual reality

* $p \leq .005$, ** $p < .05$.

Structural Equation Modeling

An initial latent model was fit for adaptive ER strategies (ERBS and ERQ-CA Cognitive Reappraisal subscale) and maladaptive ER strategies (PTQ-C and ERQ-CA

Suppression subscale). Adaptive and maladaptive ER strategy factors were not correlated ($r = 0.08, p = 0.68$). Results indicated poor model fit, χ^2 (526) = 3124.09, $p < .001$; CFI = 0.12; TLI = 0.06; RMSEA = 0.45, 90% CI [0.43 - 0.46]; SRMR = 0.17. All standardized items loaded onto their respective latent factors at 0.40 or higher with p values of < .001, except for ERBS item 3 (i.e., "When you had strong feelings in the last month, how often did you try to calm your feelings by doing something to express yourself, like drawing or writing?"). A second latent model was created that excluded ERBS item 3 and correlated error terms for two similarly worded items from the ERQ-CA suppression subscale (items 6 and 9). Results indicated poor model fit, χ^2 (493) = 2893.62, $p < .001$; CFI = 0.13; TLI = 0.07; RMSEA = 0.45, 90% CI [0.43 - 0.46]; SRMR = 0.16. All standardized items loaded onto their respective latent factors in the final model. See Table 6 below for model fit. See Appendix J for standardized loadings.

Table 6

Fit Estimates for Latent Variable Models

	Model 1	Model 2	Model 3
Fit Indices	Initial Model	ERBS Item 3 Dropped	Correlated Uniqueness
χ^2	3,124.097*	2,912.014*	2893.625*
df	526	494	493
RMSEA [90% CI]	0.454 [0.438 -0.469]	0.452 [0.436-0.468]	0.450 [0.435-0.466]
CFI	0.120	0.128	0.134
TLI	0.061	0.068	0.073
SRMR	0.170	0.169	0.168

Note. ERBS = Emotion Regulation Behaviors Scale; RMSEA = root mean square error of approximation; CI = confidence interval; CFI = comparative fit index; TLI = Tucker–Lewis index; SRMR = standardized root mean square residual. * $p < .001$.

Though poor fit was indicated for the measurement model, previous studies suggest that the reliability of latent factors may sometimes be in contradiction with model fit, whereby models with strong measurement can fit poorly, and models with poor measurement can fit well (McNeish et al., 2018; Stanley & Edwards, 2016). Thus, mediation analyses were performed with the poorly fit models.

Indirect effects were tested using bootstrapping methods. Poor model fit was indicated for the YSR mediation analysis, χ^2 (664) = 4212.46, $p < .001$; CFI = 0.09; TLI = 0.04; RMSEA = 0.47, 90% CI [0.45 - 0.48]; SRMR = 0.20. Results showed that adaptive ER strategies and maladaptive ER strategies did not jointly mediate the relationship between resting RSA and YSR Total Problems (β = -0.11, 95% CI [-.40, .18], p = .533), nor did they emerge as individual mediators (adaptive: f^2 =.008, p = .904; maladaptive: f^2 =.041, p = .453).

For the CBCL mediation analyses, model fit was once again found to be poor, χ^2 (665) = 4209.73, $p < .001$; CFI = 0.09; TLI = 0.04; RMSEA = 0.47, 90% CI [0.45 - 0.48]; SRMR = 0.20. Adaptive and maladaptive ER strategies did not significantly mediate the relationship between resting RSA and the CBCL Total Problems T-score as joint mediators (β = -0.04, 95% CI [-.22, .14], p = .708) or as individual mediators (adaptive: f^2 =.012, p = .803; maladaptive: f^2 =.037, p = .784). Results indicated that there was a large effect size for the direct effect between RSA and the CBCL Total Problems T-score (β = -0.53, 95% CI [-.82, -.24], p = .002), which is consistent with regression results. A significant total effect was also found, β = -0.57, 95% CI [-.78, -.36], $p < .001$. In the

absence of significant indirect effects, the significant total effect is likely driven by the direct effect. Results and model fit are summarized in Table 8.

Table 8

Standardized Results and Model Fit for YSR and CBCL Mediation Analyses

			95% CI			
	Estimate	*SE*	*LL*	*UL*	R^2	f^2
Direct Effect						
RSA → YSR	-0.07	0.19	-0.39	0.24		
Specific Indirect Effects						
RSA → Adaptive ER Strategies → YSR	0.01	0.09	-0.14	0.16	0.008	.008
RSA → Maladaptive ER Strategies → YSR	-0.12	0.16	-0.38	0.14	0.040	.041
Total Indirect Effect						
RSA → Adaptive & Maladaptive ER → YSR	-0.11	0.17	-0.40	0.18		
Total Effect	-0.18	0.19	-0.50	0.12		
Direct Effect						
RSA → CBCL	-0.53*	0.17	-0.82	-0.24		
Specific Indirect Effects						
RSA → Adaptive ER Strategies → CBCL	-0.02	0.10	-0.20	0.14	0.012	.012
RSA → Maladaptive ER Strategies → CBCL	-0.01	0.05	-0.11	0.08	0.037	.038
Total Indirect Effect						
RSA → Adaptive & Maladaptive ER → CBCL	-0.04	0.11	-0.22	0.14		
Total Effect	-0.57**	0.12	-0.78	-0.36		
Model Fit Indices	YSR			CBCL		
χ^2	4212.46**			4209.73**		
RMSEA [90% CI]	0.472 [0.458-0.486]			0.471 [0.458-0.485]		
CFI	0.098			0.094		
TLI	0.045			0.042		
SRMR	0.202			0.204		

Note. Structural equation modeling was used for these analyses. YSR = Youth Self Report; CBCL = Child Behavior Checklist; ER = emotion regulation; CI = confidence interval; *LL* = lower limit; *UL* = upper limit; RSA = respiratory sinus arrhythmia; RMSEA = root mean square error of approximation; CFI = comparative fit index; TLI = Tucker–Lewis index; SRMR = standardized root mean square residual. $^{*}p < .005$, $^{**}p < .001$

Post-Hoc Analyses: Modified Mediation Models

Given the issues encountered with model fit and underpowered analyses, post-hoc mediation analyses were performed to explore other possible paths that may demonstrate a better fit and be more representative of the data. The measures and subscales that

comprised the latent variables were examined as individual mediators. More specifically, total scores from the ERBS, ERQ-CA Cognitive Reappraisal Subscale, ERQ-CA Suppression Subscale, and PTQ-C were examined as mediators in the direct pathways previously examined (i.e., RSA → CBCL; RSA → YSR). Bias-corrected 95% CIs and standard errors for all parameter estimates were produced using 5000 bootstrapped samples (MacKinnon, 2008; Preacher & Hayes, 2008). Effects were reported independent of the influence of covariates (Preacher & Hayes, 2008).

Unfortunately, model fit tests indicated that models were highly saturated. Results of the model fit tests were thus uninformative and not reported. Results should be interpreted with caution. For the association between resting RSA and YSR Total Problems T-score, evidence for mediation was not found for the ERBS ($\beta = 0.03$, 95% CI [-.09, .15], $p = .697$), the ERQ-CA Cognitive Reappraisal subscale ($\beta = 0.01$, 95% CI [-.07, .08], $p = .885$), the ERQ-CA Suppression subscale ($\beta = 0.10$, 95% CI [-.10, .30], $p = .406$), or the PTQ-C ($\beta = -0.14$, 95% CI [-.40, .11], $p = .354$). Mediation was also not indicated for the CBCL models (ERBS: $\beta = -0.05$, 95% CI [-.15, .05], $p = .437$; ERQ-CA Cognitive Reappraisal subscale: $\beta = -0.01$, 95% CI [-.11, .09], $p = .867$; ERQ-CA Suppression subscale: $\beta = -0.01$, 95% CI [-.11, .08], $p = .792$; PTQ-C: $\beta = -0.02$, 95% CI [-.12, .08], $p = .749$). Consistent with prior results, direct effects with large effect sizes were found for all CBCL analyses. Total direct effects were also significant, which in the absence of indirect effects, were likely driven by the significant direct effects. See Table 9 for a summary of the post-hoc mediation analyses.

Table 9

Standardized Estimates for Post-hoc Mediation Analyses

Predictor: RSA	Dependent Variable: YSR Total Problems					Dependent Variable: CBCL Total Problems				
	Direct	Indirect	95% CI		Total	Direct	Indirect	95% CI		Total
Mediators	Effect	Effect	*LL*	*UL*	Effect	Effect	Effect	*LL*	*UL*	Effect
ERBS	-0.21	0.03	-.09	.15	-0.18	-0.52*	-0.05	-.15	.05	-0.57*
ERQ-CA CR	-0.19	0.01	-.07	.08	-0.18	-0.56*	-0.01	-.11	.09	-0.57*
ERQ-CA Suppression	-0.28	0.10	-.10	.30	-0.18	-0.56*	-0.01	-.11	.08	-0.57*
PTQ-C	-0.04	-0.14	-.40	.11	-0.18	-0.55*	-0.02	-.12	.08	-0.57*

Note. Total scores were used for mediators. RSA = respiratory sinus arrythmia; YSR = Youth Self Report; CBCL = Child Behavior Checklist; CI = confidence interval; *LL* = lower limit; *UL* = upper limit; EBRS = Emotion Regulation Behaviors Scale; ERQ-CA = Emotion Regulation Questionnaire for Children and Adolescents; CR = Cognitive Reappraisal; PTQ-C = Perseverative Thinking Questionnaire – Child Version. * $p < .001$

CHAPTER IV

DISCUSSION

Summary of Results

The first aim of this study was to replicate the association between resting RSA and mental health challenges in a community sample of early adolescents. Resting RSA was found to be associated with caregiver-reported adolescent mental health challenges. It was not linked with adolescent-reported mental health challenges, though advanced pubertal development emerged as a significant covariate. These findings reflect inconsistencies in the literature regarding the relation between resting RSA and *self-reported* versus *caregiver-reported* youth mental health (e.g., Beauchaine et al., 2007, 2008; Gentzler et al., 2012; Shannon et al., 2007; Vaughn-Coaxum et al., 2020). Though speculative, it may be that self-reported mental health challenges in the current study reflect a temporary and context-dependent state that is influenced by developmental factors specific to early adolescence (e.g., increased social stress), for which pubertal

development may be a proxy. Caregiver-report, on the other hand, may represent enduring psychological characteristics that are relatively stable across the six-month CBCL assessment period, hence the CBCL's link to resting RSA, which shows reasonable temporal stability (El-Sheikh, 2004).

The current study sought to build on this initial association by examining the joint mediating role of adaptive and maladaptive ER strategies in the relation between resting RSA and adolescent mental health challenges. Evidence of mediation was not found for caregiver-report of mental health problems or adolescent-report. Given the issues encountered with model fit and low power secondary to a smaller-than-anticipated sample size, the measures and subscales that comprised the latent constructs were examined as individual mechanisms in the association between resting RSA and mental health challenges. Mediation was not found. Descriptive statistics demonstrated positive correlations between adaptive and maladaptive ER strategies, suggesting issues with the categorization of ER strategies and highlighting the importance of accounting for contextual factors related to strategy use (e.g., the role of culture, how effectively strategies were executed).

Resting RSA and Mental Health Challenges

Congruent with hypotheses and past research (Beauchaine, 2001, 2012; Hinnant & El-Sheikh, 2013; Vasilev et al., 2009), lower resting RSA was associated with greater adolescent mental health challenges. This relationship, however, was found based only on caregiver-report of adolescent mental health and not self-report. These findings are not unexpected given inconsistencies in the literature regarding the relation between resting RSA and *self-reported* versus *caregiver-reported* youth mental health (Beauchaine et al.,

2007, 2008; Bosch et al., 2009; Gentzler et al., 2012; Greaves-Lord et al., 2007; Shannon et al., 2007; Vaughn-Coaxum et al., 2020). However, findings similar to those of the current study have been observed. For example, Yan et al. (2021) did not find a link between low resting RSA and YSR-measured externalizing symptoms among a sample of older children and early adolescents, despite this association having been found—in the same sample—when the CBCL was used to measure externalizing behaviors (Beauchaine et al., 2007, 2008; Shannon et al., 2007). In a community sample of older children, Zhang et al. (2017) found that lower resting RSA was longitudinally associated with CBCL-measured externalizing and internalizing behaviors in males, with effects being stronger for externalizing behaviors. Though self-reported mental health challenges were not associated with lower resting RSA in the current study, this relationship has been found in other studies. Gentzler et al. (2012) and Shannon et al. (2007) indicated that older children and early adolescents with lower resting RSA self-reported more depressive symptoms. In contrast, in a study with a Dutch community sample of early adolescents (N = 1,653), depressive symptoms were measured with the YSR and CBCL in separate analyses, and neither report was related to resting RSA (Bosch et al., 2009). In short, while there is preliminary support for the current findings, the ability to draw conclusions is limited by mixed findings.

Another challenge in contextualizing the current findings within the broader literature is that the current study is the first to examine resting RSA and general mental health problems in a community sample of early adolescents. The current study's community sample and focus on general mental health is a strength given that early adolescents with subclinical mental health difficulties are at risk for adverse outcomes

(e.g., Copeland et al., 2015). At the same time, it is difficult to compare the current findings to those of other resting RSA studies, most of which have utilized clinical samples and/or examined specific mental health concerns (e.g., depression). These studies have primarily included adults, young children, or a range of child and adolescent ages (Campbell et al., 2019; Koenig et al., 2017), which limits the ability to draw parallels to the current study, as RSA is shown to increase in early childhood (Mezulis et al., 2010), plateau in late childhood (El-Sheikh, 2004), and decrease in early adolescence (Lisitsa et al., 2021). Further, early adolescents experience developmental changes (e.g., pubertal onset) that amplify their mental health concerns relative to youth in middle to late adolescence (Larson et al., 2002). Inclusion of multiple developmental groups in analyses may therefore lead to difficulties in understanding the unique mental health outcomes of early adolescents and contribute to mixed findings. While differences between the present study and others highlight the novelty in the current findings, they also pose challenges to interpretation.

In the absence of direct comparisons on sample and mental health outcome measurement, findings may be illuminated by closer inspection of the cultural and developmental context of the current sample that might lead to differing perceptions of youth mental health. Early adolescents reported a higher level of mental health challenges ($M_{\text{Tscore}} = 60.42$) than their caregivers reported about them ($M_{\text{Tscore}} = 51.42$), which is consistent with prior studies with community sampled youth (Breland-Noble & Weller, 2012; Grigorenko et al., 2010; Kushner & Tackett, 2017; Rescorla et al., 2013). Reporting discrepancies may have occurred for several reasons. First, as early adolescents begin to seek more independence and individuation from caregivers (Allison

& Schultz, 2004), they may withhold information from caregivers to gain autonomy or avoid disapproval (Finkenauer et al., 2005; Smetana et al., 2006), therefore limiting caregiver awareness of any mental health difficulties.

Second, discrepancies may have been related to cultural factors. Most adolescent-caregiver dyads in the current study were Hispanic or Latiné (75%; see Table 1). Past studies show that compared to their European American counterparts, racial/ethnic minority caregivers report fewer problems on the CBCL than their minority adolescent children report on the YSR (Lau et al., 2004; Vázquez & Villodas, 2019). This may be related to caregiver fear of stigma related to mental health difficulties, less familiarity with Western notions of mental health, and European American caregivers having greater access to mental health education (Lau et al., 2004). Moreover, studies suggest that Hispanic and Latiné individuals report more emotional suppression—the attempt to hide or conceal an emotional response—than European American individuals (Gross & John, 2003; Gross et al., 2006). For example, the Mexican cultural value of *simpatía* entails the expressive display of warmth, hospitality, and "positive" emotions as well as the avoidance of "negative" emotions and behaviors (Young et al., 2022). The tendency to inhibit culturally undesirable emotions and behaviors may have reduced caregivers' ability to identify mental health difficulties in their early adolescent children. While developmental and cultural factors may help to explain conflicting regression results, it is still unclear why lower resting RSA would be linked with mental health challenges according to caregiver-report but not self-report.

One clue that may elucidate findings is the association between lower resting RSA and advanced pubertal development in the YSR analyses. Although pubertal

development was only a covariate, it is a factor consistently shown to be related to emotional difficulties among early adolescents (Dahl & Gunnar, 2009). Thus, it may be that low resting RSA and pubertal development represent reliable but separate indicators of adolescent mental health difficulties in the current study. More specifically, the perspectives by which early adolescents and caregivers observe youth mental health (e.g., self versus other) and their contextualization of adolescent behaviors may lead to different albeit justifiable interpretations (e.g., De Los Reyes et al., 2023). The notion of "state" versus "trait" can be used to illustrate this idea. Self-reported mental health challenges in the current study may reflect a temporary and context-dependent psychological *state* that is influenced by developmental stressors (e.g., social pressure, physical changes that can create discomfort), for which pubertal development may be a proxy. This may have been particularly true for female early adolescents who identified as Hispanic or Latiné, for whom the literature reports earlier pubertal onset compared to peers (Biro et al., 2018).

Caregiver-report, in the current study, may represent *trait,* or enduring psychological predispositions or characteristics that are more stable across time and context. For example, on the CBCL/YSR item 'Doesn't get along with other kids,' a caregiver may consider their child's general ability to socialize with other children across the past six months (the timeframe in which responders were asked to base their ratings). If this were the case, it would make sense why resting RSA—which shows reasonable temporal stability (El-Sheikh, 2004)—would be associated with caregiver-report. On the other hand, early adolescents may have answered the same item from their current frame of reference, which is influenced by factors such as heightened amygdala activity and sensitivity to peer rejection (Silk et al., 2013). In other words, the CBCL may reflect

youth characteristics and tendencies that are relatively stable in comparison to the YSR, which may represent momentary distress that early adolescents experience in response to developmental stressors. Though conjectural, this theory may help to explain study findings.

Mediating Role of ER Strategies

Adaptive and maladaptive ER strategies—represented as latent constructs (Wante et al., 2017; Yap et al., 2011)—were examined as mechanisms through which resting RSA influences mental health challenges in early adolescents. Adaptive ER strategies included distraction, emotional release, "leave the situation," and cognitive reappraisal. Maladaptive ER strategies included suppression and rumination. It was predicted that lower use of adaptive ER strategies and higher use of maladaptive ER strategies would jointly mediate the relation between resting RSA and adolescent mental health challenges according to adolescent and caregiver-report. Results indicated that neither the adaptive ER strategies nor the maladaptive ER strategies jointly or individually mediated this association for either self- or caregiver-report. In an attempt to unravel these findings, the ER strategies that comprised latent constructs were examined as individual mediators. However, none of these strategies were found to mediate the association between resting RSA and mental health challenges based on either report.

Several explanations for these findings are proposed. First, explicit ER strategy use—the focus of the current study—requires conscious effort and some level of emotional insight and awareness (Gyurak et al., 2011). Early adolescents may struggle to identify their use of ER strategies due to their developing emotional awareness (Zeman et al., 2007). It is also likely that these findings are related to conceptual and

methodological weaknesses in the current study, including problems with model fit, low factor loadings, and correlations between adaptive and maladaptive ER strategies. For example, the ERBS, which measured adaptive strategies (e.g., distraction, "leave the situation," emotional release) was positively associated with the ERQ-CA suppression subscale from the maladaptive latent variable. It may be that items from the ERBS and ERQ-CA suppression subscale reflect similar constructs. Inherent in suppression and most of the ERBS items (e.g., doing something to get one's mind off an emotional stressor) is the act of redirecting one's attention away from an unpleasant emotional experience. Because these strategies reflect similar constructs, they may have been used in an adaptive *or* maladaptive manner in the current study. For example, inflexible use of emotional suppression is often characterized as deleterious (Chervonsky & Hunt, 2017; Webb et al., 2012) but is shown to be adaptive in short-term contexts when immediate regulation is needed (McRae, 2016; Sheppes & Gross, 2011). Further, suppression may have been used in a manner that is consistent with the cultural value of *simpatía* (i.e., expressive display of positive emotions, inhibition of negative emotions), suggesting that its use may have not been maladaptive. Indeed, suppression of positive emotions has been found to be associated with poorer well-being in Latiné cultures, whereas suppression of negative emotions is thought to have a neutral or even negative effect on mental health problems given its role in promoting interdependent social goals (Su et al., 2015; Young et al., 2022). Unfortunately, the absence of a psychometric evaluation of the ERBS and more detailed data on strategy use (e.g., duration of use, level of alignment with cultural values) limit the ability to explain the correlation. These findings highlight

challenges in the conceptualization and measurement of ER strategy use, which may have contributed to null results in the present study.

Similar to the ERBS and suppression, cognitive reappraisal and suppression were positively correlated among female participants. This finding conflicts with past studies that have found that the effects of cognitive reappraisal are independent from the effects of suppression (Gullone & Taffe, 2012). Notably, female early adolescents in the current study were further along in pubertal development. Greater pubertal maturation is associated with increased emotional reactivity and intensity and stress responsiveness (Dahl & Gunnar, 2009), especially for females (Casey et al., 2008; Dahl & Gunnar, 2009; Negriff & Susman, 2011). Occurring alongside pubertal onset is a range of developmental stressors and brain changes that lead to gradual refinement of cognitive systems (Willner et al., 2022). As a result, female early adolescents may be fully capable of cognitive reappraisal but be limited in how well they can execute it (McRae et al., 2012), which may result in compensatory use of suppression (Cracco et al., 2017; Zeman et al., 2006). As previously noted, the use of suppression over cognitive reappraisal may not always be maladaptive due to cultural factors (Young et al., 2022) and because cognitive reappraisal is shown to be costly and ineffective in high-intensity emotional situations (Sheppes et al., 2014; Sheppes & Gross, 2011). Although there is evidence that supports the notion of "adaptive" and "maladaptive" ER strategies (Wante et al., 2017; Yap et al., 2011), the present findings suggest that it may be inappropriate to dichotomize ER strategies unless steps are taken to account for the contextual factors that dictate their level of adaptiveness (e.g., cultural factors, duration of strategy use, how effectively the strategy was executed).

Limitations

Despite study strengths, study limitations exist. First, the study utilized a cross-sectional design, which hindered the ability to draw temporal conclusions. Longitudinal data would have allowed for a better understanding of how RSA and mental health challenges change over time as a function of ER strategy use. Analyses were significantly underpowered (n = 24), which increased the likelihood of spurious results, particularly for mediation analyses, which had a power analysis of 71 participants. Additionally, ER strategies and adolescent report of mental health challenges were based on self- and caregiver-report and are subject to informant biases (Fergusson et al., 1993; Pas & Bradshaw, 2014). Research suggests that a comprehensive assessment of adolescent mental health involves the use of reports from multiple informants (e.g., self-report, teachers, parents, peers, clinicians, official records) across a range of contexts and settings (De Los Reyes, 2011; Mash & Hunsley, 2005). This is because informants vary in terms of where they observe early adolescent behaviors (e.g., school versus home), and early adolescents vary in terms of where they demonstrate behaviors that reflect mental health difficulties (Achenbach et al., 1987; De Los Reyes et al., 2015). The absence of a third-party clinical assessment of adolescent mental health restricted the current study's ability to further explore the nature of the discrepancies between reports. Future studies should supplement their use of the YSR and CBCL with additional sources of data (e.g., teacher report, clinical interview). To further improve measurement validity and conceptualization of multi-informant data in future research, De Los Reyes & Epkins (2023) recommend the use of the Operations Triad Model to assist with understanding the specific patterns of data observed within multi-informant assessments.

In addition to methodological limitations, the sample used in the current study—a small, community sample of 12-year-olds from Rhode Island—may limit the generalizability of results. The sample was further restricted by LIVE exclusion criteria, which included a range of medical conditions (e.g., epilepsy), developmental disorders (e.g., autism), etc. To improve generalizability, studies with a larger sample of early adolescents should aim to control for some of these potentially confounding factors.

Another limitation was the inability to account for factors that are shown to have a strong influence on the primary study variables. For example, executive functioning abilities are associated with RSA (Staton et al., 2009), ER (Lantrip et al., 2016), and adolescent mental health (e.g., Dickson et al., 2017). Further, posttraumatic stress is shown to adversely affect adolescent ER and mental health, and has also recently been linked to low resting RSA (Gray et al., 2017; Miu et al., 2022; Villalta et al., 2018). Inclusion of these factors as covariates or moderators in future research may help to paint a clearer picture of the connection between resting RSA and mental health challenges in early adolescents.

Lastly, the current study used heart rate variability (HRV) that was not paired with respiratory analysis in the calculation of RSA. While measurement of RSA both with and without respiration data captures vagally-mediated HRV—which is in the frequency range of respiratory activity—the joint analysis of respiratory and HRV data provides a more reliable characterization of autonomic nervous system activity (Hernando et al., 2016). Grossman et al. (1990), however, suggests that these two approaches yield "very close comparability" (p. 711).

Clinical Implications and Future Research

The significant association being resting RSA and mental health challenges among early adolescents provides support for low resting RSA being an easily identified risk factor for mental health difficulties. Assessing ER abilities with the use of resting RSA may help to inform treatment planning and academic accommodations for adolescents with emotional and behavioral challenges. Additionally, pediatricians and other providers who specialize in the care of infants, children, and adolescents can engage in prevention efforts by integrating RSA assessments into patient exams. The relative biological stability of RSA, once again, is a primary advantage over other measures of ER, as it allows for early detection of ER difficulties.

Though ER strategy use was not found to be a significant mediator in the association between resting RSA and mental health challenges, these null findings have implications for ER interventions. Namely, ER strategy use is complex and context dependent. Rather than teaching ER strategies in a way that paints strategies as "adaptive" or "maladaptive," emphasis should be placed on the context in which strategies are used. For example, suppression may be adaptive as a short-term ER strategy and/or within certain cultural contexts but may contribute to worsened ER capacities if used in a long-term and inflexible manner. Further, clinicians should integrate the cultural values of early adolescents into their teaching of ER strategies and tailor ER interventions to the strengths and the weaknesses of early adolescents. The use of vignettes, roleplays, and daily diaries may promote a more nuanced understanding of adaptive ER strategy use that allows for greater flexibility and generalizability.

Considering that a primary limitation of the current study was the measurement of ER strategies, future studies should aim for a more comprehensive assessment of ER strategies that better accounts for factors that influence the relative adaptiveness of a strategy. Recent studies have used daily electronic diaries to measure ER strategy use (Gadassi Polack et al., 2021; Grommisch et al., 2020; McMahon & Naragon-Gainey, 2018). Daily diaries offer a contemporaneous approach to ER strategy measurement that may help to improve ecological validity, recall, and accuracy, which may be particularly important for early adolescent populations, for whom emotional awareness is still developing (Zeman et al., 2007). Moreover, though the use of latent variable models was a strength of the current study, future studies should consider exploratory factor analyses to help inform the creation of latent variables that better represent the underlying structures of ER strategies. Lastly, the use of cross-sectional data hindered the ability to understand the dynamic nature of within-person ER strategy use (Zeman et al., 2007). It may be beneficial to explore these relationships longitudinally and by sex given differences in mental health, ER strategy use, and RSA among early adolescents (e.g., Chervonsky & Hunt, 2019; Koenig et al., 2017; Seedat et al., 2009). Future research should also examine these associations by race and ethnicity due to earlier pubertal onset experienced by Hispanic, Latiné, and/or Black female youth (Biro et al., 2018; Keenan et al., 2014) as well as cultural differences in the use of ER strategies that may influence their adaptiveness (e.g., Young et al., 2022).

Conclusion

The current study sought to replicate the association between resting RSA and mental health symptoms in a sample of early adolescents. This association was found

when caregiver-reported adolescent mental health challenges was examined as the outcome but not present when adolescent self-report was examined. This study also aimed to explore the mediating role of ER strategy use in this relationship. However, underpowered analyses made it difficult to discern whether mediation was present, and correlations between adaptive and maladaptive ER strategies highlighted challenges in the categorization of ER strategy use. Despite study limitations, the use of resting RSA in the current study is a significant strength worth highlighting due to it being a more rigorous and reliable measure of ER than traditional methods. While its advantages have clear benefits across developmental groups, resting RSA may be particularly important in the study of ER in early adolescents, who are at increased risk for mental health challenges and may struggle to identify ER deficits due to their evolving emotional awareness. Study results have clear implications for future research and clinical interventions aimed at promoting ER strategy use in early adolescents and reducing the risk for mental health problems.

APPENDICES

APPENDIX A

Figure 3

LIVE Baseline Study Visit

CONDITION A: BART FIRST		**CONDITION B: IVR FIRST**	
0:00	Arrive	0:00	Arrive
0:05	Consent	0:05	Consent
0:25	Assent	0:25	Assent
0:30	Teach participant saliva procedure	0:30	Teach participant saliva procedure
0:35	Place electrodes for RSA collection	0:35	Place electrodes for RSA collection
0:40	Questionnaires (15 minutes)	0:40	Questionnaires (5 minutes)
		0:45	Saliva sample (baseline)
		0:50	Fit head-mounted display (HMD) for VR
0:55	*BART- 2D Aquarium (9 minutes)- 10 minutes after electrodes (now 20 minutes)	0:55	*IVR Aquarium (9 minutes)- 10 minutes after electrodes (now 20 minutes)
1:04	*BART (8 minutes)	1:04	*IVR Party (8 minutes)
1:12	*BART-2D Aquarium (8 minutes)	1:12	*IVR Aquarium (8 minutes)
1:20	Disconnect leads	1:20	Remove HMD
1:20	Questionnaires (40 minutes)	1:20	Saliva sample (reactivity/challenge) (30 minutes from start of baseline saliva collection)
		1:25	Disconnect leads
		1:25	Cybersickness assessment
		1:30	Questionnaires
		1:40	Saliva (15 minutes after end of last saliva- recovery)
		1:45	Questionnaires (30 minutes)
2:00	Reconnect leads		
2:00	Saliva sample (baseline)		
2:05	Fit head-mounted display (HMD) for VR	2:10	Reconnect leads
2:10	*IVR Aquarium (9 minutes) (58 minutes from end of last task)	2:10	*BART- 2D Aquarium (9 minutes) - (58 minutes after end of last task)
2:19	*IVR Party (8 minutes)	2:19	*BART (8 minutes)
2:27	*IVR Aquarium (8 minutes)	2:27	*BART-2D Aquarium (8 minutes)
2:35	Remove HMD	2:35	Disconnect leads
2:35	Saliva sample (reactivity/challenge) (30 minutes from baseline saliva collection)	2:35	Urine sample collection
2:40	Disconnect leads	2:40	Remaining questionnaires (at least 30 minutes)
2:40	Cybersickness assessment		
2:45	Questionnaires (10 minutes)		
2:55	Saliva (15 minutes after end of last saliva- recovery)		
3:00	Urine sample collection		
3:05	Remaining questionnaires/substance use interview		*Denotes RSA collection periods

APPENDIX B

Figure 4

Screenshot of Virtual Reality Party

APPENDIX C

Emotion Regulation Behaviors Scale (ERBS)

When you had strong feelings (like excited or angry) in the last MONTH, how often did you try to calm your feelings by...

Question	Never	Once in awhile	Sometimes	Often
Moving away from the person or thing causing your feelings?	1	2	3	4
Doing something to get your mind off the person or thing causing your feelings?	1	2	3	4
Doing something to express yourself, like drawing or writing?	1	2	3	4
Doing something to change how your body felt, like taking deep breaths or splashing water on your face?	1	2	3	4
Doing something physical to safely let out your feelings, like play a sport or punch a pillow?	1	2	3	4
Talking to someone about the person or thing causing your feelings?	1	2	3	4
Thinking differently about the person or thing causing your feelings?	1	2	3	4
Thinking about what someone who cares about you would say?	1	2	3	4
Thinking about what could happen if you act on your feelings?	1	2	3	4

APPENDIX D

The Emotion Regulation Questionnaire for Children and Adolescents (ERQ-CA)

Question	Strongly disagree	Disagree	Half and half	Agree	Strongly agree
When I want to feel happier, I think about something different	1	2	3	4	5
I keep my feelings to myself	1	2	3	4	5
When I want to feel less bad (e.g., sad, angry, or worried), I think about something different	1	2	3	4	5
When I am feeling happy, I am careful not to show it	1	2	3	4	5
When I'm worried about something, I make myself think about in a way that helps me feel better	1	2	3	4	5
I control my feelings by not showing them	1	2	3	4	5
When I want to feel happier about something, I change the way I'm thinking about it	1	2	3	4	5
I control my feelings about things by changing the way I think about them	1	2	3	4	5
When I'm feeling bad (e.g., sad, angry, or worried), I'm careful not to show it	1	2	3	4	5
When I want to feel less bad (e.g., sad, angry, or worried) about something, I change the way I'm thinking about it	1	2	3	4	5

APPENDIX E

Perseverative Thinking Questionnaire – Child (PCT-Q)

Instruction:
In this questionnaire, you will be asked to describe how you *typically* think about negative experiences or problems.

Please read the following statements and rate the extent to which they apply to you when you think about negative experiences or problems.

Question	Never	Rarely	Sometimes	Often	Almost always
The same thoughts keep going through my mind again and again.	0	1	2	3	4
My thoughts come on and I can't do anything against it.	0	1	2	3	4
I can't stop thinking about it.	0	1	2	3	4
I think about many problems without solving any one of them.	0	1	2	3	4
I can't do anything else while thinking about my problems.	0	1	2	3	4
The same thoughts return into my mind.	0	1	2	3	4
Thoughts come into my mind without me wanting them to.	0	1	2	3	4
When I am thinking about certain things, I get stuck and find it difficult to stop these thoughts.	0	1	2	3	4
I keep asking myself questions without finding an answer.	0	1	2	3	4
My thoughts prevent me from focusing my attention on other things.	0	1	2	3	4
I keep thinking about the same things all the time.	0	1	2	3	4
Thoughts just pop into my mind.	0	1	2	3	4
I feel as if I must keep thinking about the same things.	0	1	2	3	4
My thoughts are not much help to me.	0	1	2	3	4
My thoughts take up all my attention.	0	1	2	3	4

APPENDIX F

Pubertal Development Scale

Introduction: The next questions are about changes that may be happening to your body. These changes normally happen to different young people at different ages. Since they may have something to do with your sleep patterns, do your best to answer carefully. If you do not understand a question or do not know the answer, just mark "I don't know."

Question	Response Options	Point Value
1. Would you say that your growth in height:	has not yet begun to spurt[2]	1
	has barely started	2
	is definitely underway	3
	seems completed	4
	I don't know	
2. And how about the growth of your body hair? ("Body hair" means hair any place other than your head, such as under your arms.)		
Would you say that your body hair growth:	has not yet begun to grow	1
	has barely started to grow	2
	is definitely underway	3
	seems completed	4
	I don't know	
3. Have you noticed any skin changes, especially pimples?		
	skin has not yet started changing	1
	skin has barely started changing	2
	skin changes are definitely underway	3
	skin changes seem complete	4
	I don't know	
FORM FOR BOYS:		
4. Have you noticed a deepening of your voice?		
	voice has not yet started changing	1
	voice has barely started changing	2
	voice changes are definitely underway	3
	voice changes seem complete	4
	I don't know	
5. Have you begun to grow hair on your face?		
	facial hair has not yet started growing	1
	facial hair has barely started growing	2

facial hair growth has definitely started	3
facial hair growth seems complete	4
I don't know	

FORM FOR GIRLS:

4. Have you noticed that your breasts have begun to grow?

have not yet started growing	1
have barely started growing	2
breast growth is definitely underway	3
breast growth seems complete	4
I don't know	

5a. Have you begun to menstruate (started to have your period)?

yes	4
no	1

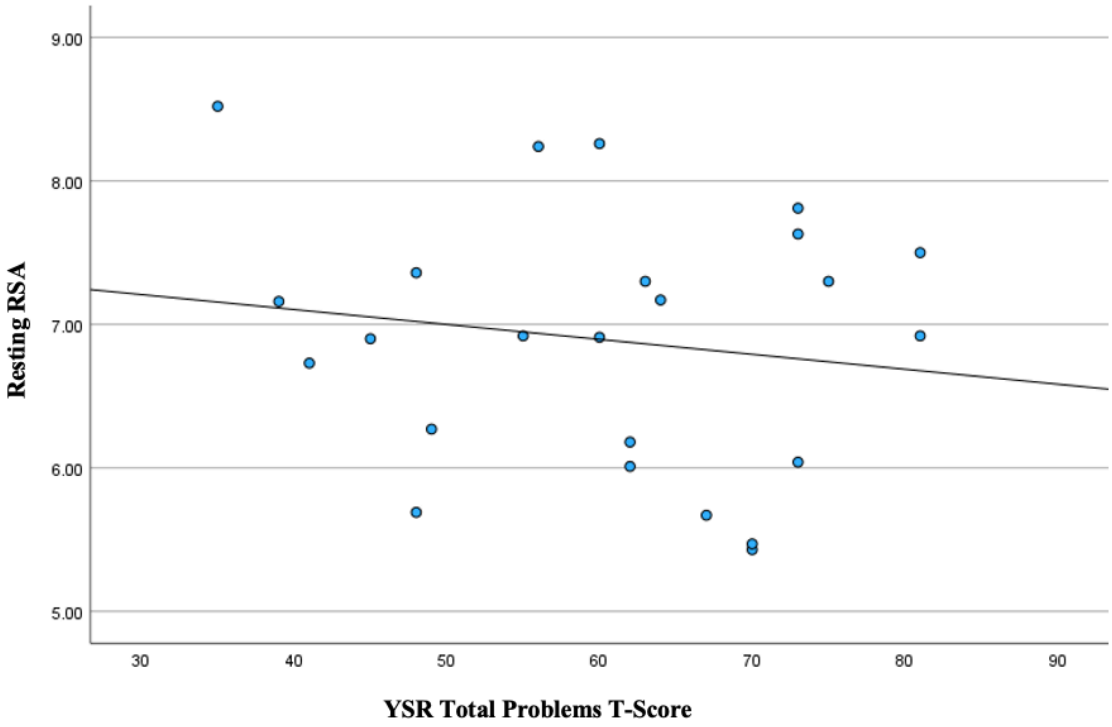
5b. If yes, how old were you when you started to menstruate?

age in years

APPENDIX G

Figure 6

Association Between Resting RSA and YSR Total Problems T-Score

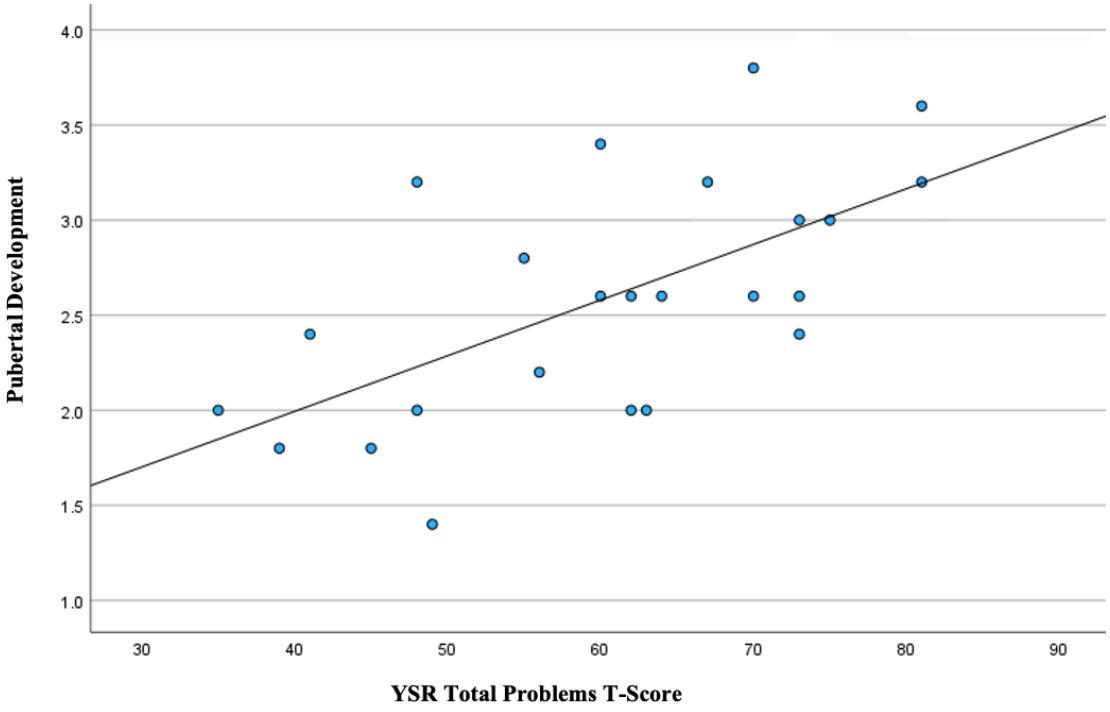


Note. Each dot represents an individual participant (n = 24). RSA = respiratory sinus arrhythmia; YSR = Youth Self Report

APPENDIX H

Figure 7

Association Between Pubertal Development and YSR Total Problems T-Score

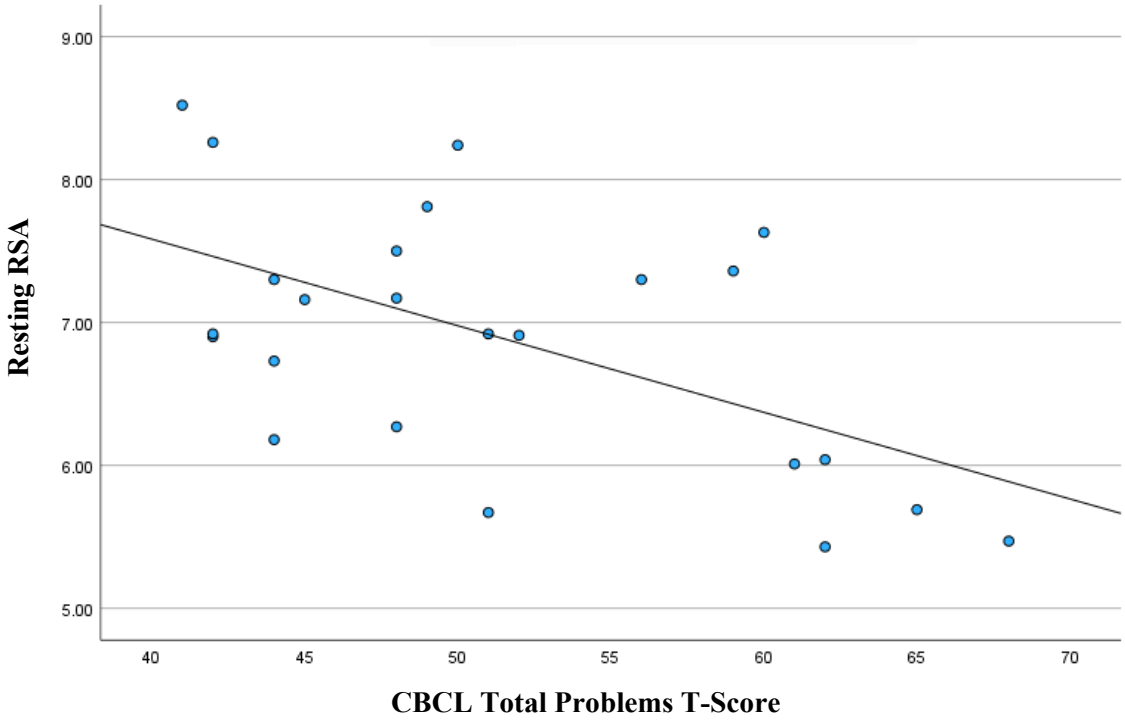


Note. Each dot represents an individual participant (n = 24). Total score for Pubertal Development Scale ranges from 1 (no puberty development) to 4 (completed development). YSR = Youth Self Report.

APPENDIX I

Figure 8

Association Between Resting RSA and CBCL Total Problems T-Score



Note. Each dot represents an individual participant (n = 24). RSA = respiratory sinus arrhythmia; CBCL = Child Behavior Checklist

APPENDIX J

Table 7

Standardized Factor Loadings for ER Strategy Latent Variable Models (n = 24)

	Model 1 Initial Model	Model 2 ERBS Item 3 Dropped	Model 3 Correlated Uniqueness
Adaptive ER Strategies			
ERBS 1	.43	.43	.43
ERBS 2	.48	.48	.48
ERBS 3	.01	–	–
ERBS 4	.45	.45	.45
ERBS 5	.45	.45	.45
ERBS 6	.44	.44	.44
ERBS 7	.50	.50	.51
ERBS 8	.47	.47	.47
ERBS 9	.63	.63	.63
ERQ-CA 1	.62	.62	.62
ERQ-CA 3	.75	.75	.75
ERQ-CA 5	.77	.77	.77
ERQ-CA 7	.81	.80	.80
ERQ-CA 8	.80	.80	.80
ERQ-CA 10	.79	.79	.79
Maladaptive ER Strategies			
ERQ-CA 2	.53	.53	.51
ERQ-CA 4	.74	.74	.73
ERQ-CA 6	.51	.51	.49
ERQ-CA 9	.46	.46	.40
PTQ-C 1	.70	.70	.70
PTQ-C 2	.86	.86	.86
PTQ-C 3	.61	.61	.61
PTQ-C 4	.86	.86	.86
PTQ-C 5	.79	.79	.80
PTQ-C 6	.74	.74	.74
PTQ-C 7	.79	.79	.79
PTQ-C 8	.74	.74	.74
PTQ-C 9	.80	.80	.80
PTQ-C 10	.73	.73	.73
PTQ-C 11	.77	.77	.78
PTQ-C 12	.56	.56	.57
PTQ-C 13	.77	.77	.78
PTQ-C 14	.79	.79	.79
PTQ-C 15	.50	.50	.49

Note. ERBS = Emotion Regulation Behaviors Scale; ERQ-CA = Emotion Regulation Questionnaire for Children and Adolescents; PTQ-C = Perseverative Thinking Questionnaire – Child Version. All parameter estimates were significant, $p < .001$ except for ERBS item 3.

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