CHILDHOOD DEPRESSIVE DISORDER SYMPTOMS: RELATIONS WITH TWO PHYSIOLOGICAL INDICES OF EMOTION REGULATION

by

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ABSTRACT

Theoretical models of depression postulate that one's ability to regulate emotions may be a core factor in the development of depressive disorder symptoms. The present study aimed to understand how physiological measures of emotion regulation are related to depressive disorder symptoms among a community sample of 7-10 year-old children. Specifically, we sought to investigate how resting heart rate variability and the change in heart rate variability from a resting baseline to a stressor are related to child- and-caregiver-reported depressive symptomology. The children's physiological measures (i.e., heartbeat patterns, respiration) used to calculate high-frequency heart rate variability for each task were collected as the child sat quietly (3 minutes), watched a relaxing Coral Reef video (3 minutes), traced a star pattern while looking in a mirror (3 minutes), and played Hungry, Hungry Hippos on an iPad (3 minutes). In addition, children and their primary caregivers completed a series of questionnaires about the child and family demographics and child's depressive disorder symptoms. We conducted bivariate correlations, paired samples *t*-tests, multiple regression analyses (controlling for age, gender, and mean respiration rate at baseline) to examine the relations between both resting heart rate variability and change in heart rate variability in response to a stressor or positive task and child- and caregiver-reported depressive disorder symptoms. We found a significant relation between the child-reported depressive disorders and the change in HRV from resting baseline (traditional and video) to the stress task. However, we did not find that gender moderated this relation, nor did we find any significant relations between the resting baseline (traditional and video) and child-or-caregiver-reported depressive symptoms. Finally, not associations were found between and the change in HRV from resting baseline (video) or the Mirror Star Tracer task Baseline to the Hungry Hungry Hippo task and child-or-caregiver-reported depressive symptoms. Future research should consider the nature of the task demands relative to arousal and also the diversity and size of the sample. Our findings demonstrated a unique pattern in HRV change from resting baseline (traditional and video) to a stress task that allow for new questions to be asked and a foundation for further research.

CHAPTER ONE

INTRODUCTION

> "Depression is such a cruel punishment. There are no fevers, no rashes, no blood tests to send people scurrying in concern. Just the slow erosion of the self, as insidious as any cancer. And, like cancer, it is essentially a solitary experience. A room in hell with only your name on the door."
>
> -Martha Manning

Depression is a highly prevalent and serious mental health problem among children and adolescents. Specifically, the National Survey of Children's Health found that the prevalence rates of depressive disorders have risen from 5.4% in 2003 to 8.4% in 2012 and that one in twenty youth had a current diagnosis of major depressive disorder (Bitsko et al., 2018). Although the median onset of major depressive disorder is between 11 and 14 years of age and prevalence rate estimates of children under 12 is less than those of adolescents (approximately 2% vs. 5-17.5%; Center for Disease Control and Prevention, 2018), Bitsko et al. (2018) suggests there is a gradual increase in depression amongst children. In addition, if the onset of depression is primarily observed in adolescence, it is imperative we understand how theoretical causal mechanisms of depression are related to depressive disorder symptoms in childhood. Thus, the present study aims to investigate whether physiological indices of emotion regulation (i.e. resting heart rate variability and change in heart rate variability in response to a stressor) are

associated with child- and caregiver-reported depressive disorder symptoms in a community sample of 7-10 year-old children.

Depression and Emotion Regulation

Depression in Youth

Depression may manifest itself a number of ways in youth (Stringaris, Maughan, Copeland, Costello, & Angold, 2013; American Psychiatric Association, 2000). For example, depressed youth often experience a lack of energy or motivation to engage in activities and sustain meaningful relationships with their family and peers. Moreover, they may experience feelings of worthlessness and frustration, low self-esteem, and physical changes (e.g., loss of appetite or sleep), which may contribute to a decline in educational engagement and decrement to their cultivated physical health. The compounding effects of depression can begin to accumulate as early as childhood and persist into adulthood. Children are garnering increased recognition in depression research due to the emergence of atypical emotional and behavioral patterns that is affecting their education and social development. One of the core mechanisms theorized to contribute to the development of depressive disorder symptoms seems to be atypical emotional responses and regulatory processes (Cicchetti & Toth, 1998; McLaughlin, Michl, & Herts, 2013).

Although research on depression and its relation to theoretical risk and protective factors in children is sparse, the importance of examining these relations in childhood is growing. Not only is the occurrence of depression during childhood developmentally atypical, but the negative impact of depression on children is not short-lived. Theory and

research suggests that depressive disorder symptoms in children can cause a significant decrease in life quality and interfere with typical psychological and physical development across the lifespan (Cicchetti & Toth, 1998; McLaughlin et al., 2013). For example, children experiencing depression are at greater risk for developing mood disorders in adolescence and adulthood, which may result in a number of negative sequelae later in life, such as obesity, substance abuse, and suicide (McCarthy, Curtin, Piper, & Baker, 2010).

Developmental psychopathology theories of depression have postulated that one of the causal or meditating factors of depression and Major Depressive Disorder (MDD) development in childhood and adolescence is emotional dysregulation (Cicchetti & Toth, 1998; McLaughlin et al., 2013). We define emotion regulation as the automatic or effortful modulation of both positive and negative emotional responses and experiences (Gross, 1998; Scott & Weems, 2014). In addition, we assert that emotion regulation may occur independently or interactively across multiple levels of the individual, including cognitive, behavioral, and physiological systems. Prior theory suggests that children and adolescents who experience depression or develop MDD use maladaptive emotion regulation mechanisms to cope with negative affect and moods, such as sadness or depressed states. Two of the major theories on the experience of depression and the development of MDD in youth and the role of emotion regulation is described in the next section.

Theoretical Models of Youth Depression: The Role of Emotion Regulation

McLaughlin et al. (2013) propose that the dysregulation of emotion may serve a mediating role in the association between exposure to atypical experiences across development and youth depressive disorder symptoms. Specifically, they postulate that deviations from healthy environments across childhood and adolescence (e.g., marital conflict; peer rejection) may 1) increase their emotional and physiological reactivity to stressful situations and 2) disrupt the development of adaptive emotion regulation mechanisms in cognitive, behavioral, and physiological domains to effectively modulate this increased reactivity. Thus, establishing a relation between emotion regulation mechanisms and depressive disorder symptoms in youth is an important and necessary step to identifying theoretical causal mechanisms associated with MDD development in childhood. Several studies have demonstrated the relation between the use of maladaptive cognitive and behavioral emotion regulation mechanisms and greater depressive disorder symptoms in youth (for in-depth review see Shäfer, Naumann, Holmes, Tuschen-Caffier, & Samson, 2017). They have shown that youth who experience greater depressive disorder symptoms report using more maladaptive cognitive and behavioral emotion regulation strategies, such as rumination, emotional suppression, and behavioral avoidance or withdrawal.

Cicchetti and Toth (1998) further postulate that the physiological dysregulation of emotional reactivity, which results in the increase of negative affect and decrease of positive affect, plays a central role in the development of MDD in youth. They suggest that disruption of physiological regulation may begin as early as infancy with several

individual and environmental factors, such as learned helplessness and inconsistent caregiver responsiveness, interfering with the broad development of affect regulation throughout childhood and adolescence. Past studies have investigated these associations between physiological regulation of emotion and depression using 1) resting heart rate variability (HRV), a widely-used measure of general emotion regulation, and 2) changes in HRV in response to a stressor, a less often used measure of physiological regulation of emotion during a stressful or challenging event. However, there is a paucity of research using these HRV measures to test relations between physiological regulation of emotion and depressive disorder symptoms in youth and the extant findings described in the next section are mixed (for in-depth review see Hamilton & Alloy, 2016 and Koenig, Kemp, Beauchaine, Thayer, & Kaess, 2016; El-Sheikh, Harger, & Whitson, 2001; Pang & Beauchaine, 2013).

Heart Rate Variability: Two Physiological Indices of Emotion Regulation

Resting Heart Rate Variability and Depression

Heart rate variability (HRV) is widely used as a reliable and non-invasive method for evaluating self-regulation, including emotion regulation (Appelhans & Luecken, 2006). Previous theory and research findings suggest at rest (or baseline), HRV is an indicator of an individual's general ability to regulate both positive and negative emotions (Mather & Thayer, 2018; Appelhans & Luecken, 2006). Practically, we also consider it to measure how much one's parasympathetic nervous system (PNS) has control over the heart during times of rest (Porges, 2007). Porges (2007) has proposed

that higher resting HRV, or more PNS-mediated control of the heart, should be associated with more positive outcomes, while lower resting HRV, or less PNS-mediated control of the heart, should be associated with more negative outcomes. The PNS engages to bring the individual to a "rest and digest" stage after its counterpart, the sympathetic nervous system (SNS), has increased heart rate and respiration in response to a stressor. When the PNS is engaged, heart rate and respiration slow after the individual determines there is no longer a threat.

When an individual is at rest, we again have the expectancy that HRV will be high, indicating that the PNS is engaged. This suggests that an individual at rest is indeed engaging in the "rest and digest" nature of the parasympathetic nervous system. When encountering a stressor, an individual should have a decrease in HRV. The PNS, in this case, has appropriately disengaged to allow for the SNS to increase arousal in response to a threat. Porges (2007) suggests that individuals with low HRV at rest are experiencing atypical functioning of the engagement of the PNS, which indicates a diminished engagement of adaptive emotion regulation mechanisms and risk for poor outcomes. Conversely, high HRV at rest is typically associated with positive outcomes, because it seems to indicate appropriate engagement of the PNS (Porges, 2007; Thayer & Lane, 2000).

Koenig et al. (2016) note that the findings regarding resting HRV and depressive disorder symptoms in this age range are both limited and mixed. For example, one study found a negative association between HRV and depressive disorder symptoms in a large cohort study (n =1781) with 10-11 year-old youth (Bosch et al., 2009). Pang and

Beauchaine (2013) found similar findings in their sample of 207 children (ages 8-12 years) that met the criteria for conduct disorder (*n* =30), MDD (*n* = 28), both conduct disorder and MDD (*n* = 80), or neither disorder (control group; *n* = 69). The results using the entire sample showed a negative relation between resting baseline HRV and depressive disorder symptoms. Further studies of community youth have found a significant association between resting baseline HRV and depressive disorder symptoms for children (El-Sheikh et al., 2001; ages 8-12), while another study only found a negative association for boys and not girls among 10-11 year-old youth (Dietrich et al., 2011). Given the mixed nature of these findings and the limited amount of research specifically within in middle and late childhood (Koenig et al., 2016), further investigation is necessary to elucidate how resting baseline HRV relates to depressive disorder symptoms.

Change in HRV to a Stressor

An alternative method of assessing the physiological components of emotion is to observe changes in HRV from rest to stress, which provides an index of the how the PNS responds to a negative stressor or challenging event (Beauchaine, 2001; Porges, 2007). Porges (2007) postulates that a decrease in HRV from rest to a stressor is optimal and indicative of adaptive emotion regulation, as it allows for arousal and mobilization of attentional and behavioral systems to respond to a threatening event. Conversely, Porges (2007) also suggests that an increase or no change in HRV from resting state to a stressor is a maladaptive response, which may contribute to the development of depressive disorder symptoms (Hammen, 2005). The PNS remains engaged following the stressor

and thus attempts to reduce one's arousal at a time that the SNS needs to prepare the individual for "fight or flight" response to a threatening situation (Hammen, 2005; Porges 2007). However, and to emphasize that increases in HRV is contextual and not always a maladaptive response, Porges (2007) suggests that an increase change in HRV during social engagement is actually adaptive.

Whether there is an association between the change in HRV from resting state to a stressor and depressive disorder symptoms is not clear. To our knowledge, there are only seven studies on child and adolescent change in HRV and depression, and only two utilized community samples (El-Sheikh et al., 2001, El-Sheikh et al., 2013; see Hamilton & Alloy, 2016 for in-depth review). Conversely, El-Sheikh et al. (2001) found that HRV from rest to the stressor did not predict depressive disorder symptoms in a community sample of youth ages 8-12 years. The latter findings of El-Sheikh et al. (2001) are consistent with Scott and Armstrong (in-preparation) who found that, in a community sample of 80 youth ages 11-17 years, HRV change in response to a negative cognitive stressor was not associated with depressive disorder symptoms. It is also important to consider the nature of the findings within non-community samples, such as Pang & Beauchaine's (2013) clinically-based sample of youth. Pang and Beauchaine (2013) found that an increase in HRV from rest to a sadness inducing film-clip stressor was concurrently related to greater depressive symptoms (but not at one- or two-year follow-up) in their sample of youth ages 8-12 years, some meeting the criterion for MDD and/or conduct disorder. The findings showing increases in HRV from rest to a stress task relating to greater depressive disorder symptoms seems to be more consistent

among high-risk samples containing youth already reporting depressive disorder symptoms that qualify them for MDD (see also Cowell et al., 2014). Thus, these limited studies and mixed findings in community samples suggest that further research is needed to elucidate the relation between physiological measures of emotion regulation (HRV) and depressive disorder symptoms in youth.

Change in HRV to a Positive Event

To our knowledge, no prior research has examined the change in HRV from rest to a positive event (Hamilton & Alloy, 2016). However, and theoretically, children with depression may respond maladaptively to the experience of positive emotions. Clark and Watson (1991) have suggested that individuals with greater depressive disorder symptoms exhibit a lack of a positive affect and less physiological arousal as is typically observed in anxious individuals in response to stressful events. We suggest that a depressed individual may not engage with a negative stressor at all, instead choosing to assess a seemingly negative event as a typical event for them (hence the non-significant findings described in previous section). In contrast, depressed youth may respond maladaptively to the experience of positive emotions or a seemingly positive event, as it may be perceived as threatening and they need to prepare for future negative consequences (e.g., “I can’t have fun or be happy too long because something bad will happen eventually”). Thus, we expect an increase or no change in HRV in response to a positive event to be associated with greater depressive disorder symptoms. However, given the lack of extant research investigating this relation, this is an exploratory, working hypothesis.

Statement of the Problem

Developmental psychopathology models of child and adolescent depression (McLaughlin et al., 2013) have consistently postulated that early disruption in the physiological system thought responsible for emotions and emotion regulation is a key mechanism in the development of depressive disorders across the lifespan. Although previous research has provided initial support for this theoretical perspective in adolescents and adults, such that lower resting HRV and augmented change in HRV from a baseline to a stressor is associated with greater depressive disorder symptoms (Hamilton & Alloy, 2016), studies with children are limited, the findings are mixed and inconsistent, and the studies inclusion criteria (e.g., children from two-parent homes) may have reduced variability in both HRV (resting or during stress) and depressive disorder symptoms (El-Sheikh et al., 2001; El-Sheikh et al., 2013). Moreover, relatively few studies with children have shown a relation between lower resting HRV and greater child-reported depressive disorder symptoms (El-Sheikh et al., 2001; El-Sheikh et al., 2013).

The present study expanded upon this past research by reducing exclusion criteria (e.g., children from single parent homes could participate) and thus possibly increasing the variability of HRV (resting or during stress) and depressive disorder symptoms in our sample (e.g. El-Sheikh et al., 2001 & El-Sheikh et al., 2013 required 2-parent families for participation). Additionally, to our knowledge, prior research has mostly utilized child-reports of depressive disorder symptoms (El-Sheikh et al., 2013; El-Sheikh et al., 2005; El-Sheikh, 2001), while the present study will use both child-and-caregiver-reported

depressive disorder symptoms. Similarly, research investigating the change in HRV from traditional resting baseline to the stressor (El-Sheikh et al., 2013) found an increase in HRV from baseline to stressor, but only in females, suggesting possible gender differences.

Uncovering the role of the physiological dysregulation of emotion in the development of a varying depressive disorder symptoms was particularly important within our sample. Many youth experience depressive disorder symptoms, and a steady increase in depressed youth has been emerging (Bitsko et al., 2018). However, some youth experiencing depressive disorder symptoms may not meet all the criterion for a clinical diagnosis for major depressive disorder. This is important to note, as youth who are categorized as experiencing subclinical levels of depressive disorder symptoms still experience depressive disorder symptoms that are pervasive to their ability to interact with their environment, but they are not being treated for major depressive disorder. The present study allowed for the assessment of individuals who are considered to be in the subclinical range, thus widening the observation of youth experiencing a physiological dysregulation of emotion in accordance with depressive disorder symptoms.

There were three aims of the proposed study. Our first aim was to determine whether a physiological index of children's general emotion regulation was related to depressive disorder symptoms. Prior work that has examined the relation between resting HRV and depressive disorder symptoms in children has yielded mixed findings (Hamilton & Alloy, 2016). Moreover, and given the gender differences found for depressive disorder symptoms among youth (i.e., girls tend to report greater depression

than boys; Deng, Chang, Yang, Huo, Zhou, 2016), we explored whether gender of the child would serve as a moderator of the relation between resting HRV and depressive disorder symptoms. Our second aim was to determine whether child and caregiver-reports of depressive disorder symptoms corresponded with an increase or no change in HRV from a video baseline to a stressor and a traditional resting baseline immediately preceding the stressor, and, excluding external factors (e.g., age, gender, mean respiration rate). It is noteworthy, that this study was the first to explore the nature of the relation between both a resting baseline HRV before the stressor and video baseline HRV with HRV during a negative event, providing multiple baselines for HRV change comparisons not found in previous literature. Our third aim was exploratory and sought to determine whether child and caregiver-reports of depressive disorder symptoms corresponded with an increase or no change in HRV from a video baseline to a positive event and to traditional resting baseline immediately preceding the positive event. To our knowledge, no studies have investigated this relation between depression and HRV through the implementation of a positive event. Previous theory suggests that individuals reporting high depressive disorder symptomology may respond unfavorably to a positive event by because it conflicts with their negative affect or exhibition of low positive emotionality (McLaughlin et al., 2013; Clark & Watson, 1991).

Hypotheses

1. Lower resting HRV would be associated with greater depressive disorder symptoms, and this relation would be moderated by gender.

   a. Youths' HRV at traditional and video resting baseline would be negatively associated with child-and caregiver-reported depressive disorder symptoms.
   b. The negative association between youths' HRV at traditional and video resting baseline and child-and caregiver-reported depressive disorder symptoms would be moderated by gender.
2. No change or increases in HRV from baseline to the stress task would be associated with greater depressive disorder symptoms.
   a. No change or increases in youths' HRV from the video baseline or the stress task baseline to the stress task would be negatively associated with the child- and caregiver-reported depressive disorder symptoms.
3. No change or increases in HRV from baseline to the positive task would be associated with greater depressive disorder symptoms.
   a. No change or increases in youths' HRV from the video baseline or the positive task baseline to the positive task would be negatively associated with the child- and caregiver-reported depressive disorder symptoms.

CHAPTER TWO

METHOD

Participants. Data were collected from ninety children ages 7-10 (M_{age} = 8.46, SD_{age} = 1.17; 53.4% male) and their primary caregivers who completed Wave 1 (initial assessment) of a 12-month longitudinal study. Participants were recruited from Bozeman and surrounding communities via flyers, Craigslist, Facebook parenting groups, and advertisement in classes and around campus at Montana State University. Participants were paid $60 per visit, with an allocation of $10 to the child and $50 caregiver. However, caregivers were instructed that the allocation of compensation was at their discretion, as it was given in cash.

Caregivers reported youth's ethnicities as 92.2% European-American (n = 83), 3.4% Hispanic (n = 3), 1.1% Asian (n = 1), and 2.2% reporting "Other" (n = 2). The median family income (n_{family} = 66) was between $50,000 and $79,999 annually and the majority of the child's caregivers had at least completed 4 or more years of college or graduate education (77.6% for mothers and 60% of fathers). Caregivers also reported that 14 children were currently taking a medication which included stimulants (n = 1), antidepressants (n = 3), allergy mediation (n = 3)[1], asthma medication (i.e. inhaler; n = 2)[1], laxative or digestive aid (n=2), Amoxicillin (n =3), or a bedwetting medication (n = 1).

Questionnaires

Demographics. Caregivers were asked to provide personal information regarding their children such as age, gender, ethnicity, family income, and caregiver education. In addition, they were asked to provide information regarding any known medications their child was currently being administered (i.e., what type of medication and last time of administration) [1].

Revised Child Anxiety and Depression Scales (RCADS; Child Version; Chorpita, 2000). Youth were asked to complete the 25-item RCADS to assess both DSM-IV (APA, 2000) anxiety and depressive disorder symptoms. The RCADS asked youth to rate the frequency of experiencing DSM-IV anxiety and depressive disorder symptoms among the youth using a Likert-type scale ranging from 1 (Never) to 4 (Always). Example items from the RCADS depression subscale include, "I feel sad or empty" or "Nothing is much fun anymore". We used the RCADS depression subscale score for this study. Previous studies have demonstrated the reliability of the RCADS depression subscale ($\alpha = .78$ and one-week estimates ranging from $r = .77$; Chorpita, Yim, Moffitt, & Umemoto, 2000; Chorpita, Moffitt, & Gray, 2005). In addition, the RCADS depression subscale has demonstrated concurrent validity with Child Depression Inventory (CDI; $r = .70$, $p < .01$; Chorpita et al., 2005) and acceptable internal consistency estimate in this study ($\alpha = .88$).

Health and Behavior Questionnaire (HBQ; Version 1.0 Parent. MacArthur, 2002). The HBQ is a 164-item, multi-faceted questionnaire that asks caregivers to report on their child's physical health, recreational activities, peer and school experiences, behavior, and

[1] One participant reported taking an allergy medication and using an inhaler.

behavioral impacts on family. We derived the 7-item depression subscale from the HBQ as a caregiver-report measure of child depressive disorder symptoms. Example items include “Your child has a poor appetite or is not hungry” or “Your child prefers to play alone”. Previous research has shown that the HBQ depression subscale is related to other diagnostic measures of depressive disorders in children (Lemery-Chalfant et al., 2007) and acceptable internal consistency estimate in this study ($\alpha = .75$).

Physiological Tasks

Traditional Resting Baseline. Children participated in a 5-minute traditional resting baseline after sensor placement. Research assistants asked the child to remain as still as possible and breathe normally. Heart rate variability was derived from the last 3 minutes of the resting baseline to correspond to the 3-minute subsequent tasks.

Coral Reef Video. A 3-minute film clip of a coral reef scene was presented to the children. The film clip was adapted from the “Coral Sea Dreaming” DVD for use in a previous study with adolescents (Scott & Weems, 2014). The film clip has shown to produce a physiological state (i.e., heart rate and skin conductance) not significantly different from traditional resting baselines and maintain a stable heart rate pattern across the task duration in adolescents and adults (Scott & Weems, 2014; Piferi, Kline, Younger, and Lawler, 2000). The film clip allowed for a standardized collection of a physiological baseline across all participants.

Mirror Star Tracer Task (Lafayette Instrument Company, Mirror Tracer; Feldmen et al., 1999). Children were asked to sit at a desk with the mirror star tracer apparatus in front of them. Children were instructed to trace the star on the star tracer template for 3

minutes looking only in the mirror while tracing. This task has been previously used by Matthews, Nelesen, and Dimsdale (2005) as a reliable stress task after being established by Feldmen et al. (1999).

Hungry Hungry Hippos Task. Children played an electronic version of the Hungry Hungry Hippos game on an iPad Mini (Hasbro Incorporated, 2012; Apple, 2012) for three minutes when instructed by a research assistant. Participants chose the color of their hippo (blue, green, orange, yellow) and played in a single-player mode, with the other hippos not engaging or competing. Participants were given 30 seconds – 1 minute to familiarize themselves with the game following instructions given by trained research staff and continued playing for 3 minutes until told to stop by an RA. The Hungry Hungry Hippos task was utilized to elicit positive emotions in the child. Although we are the first to use the current form of this task to elicit positive emotions in children, the Hungry Hungry Hippos board game has been previously used to assess temperamental positive approach and exuberance in children (Goldsmith, Reilly, Lemery, Longley, & Prescott, 2001).

Manipulation Check of Stressors and Positive Event

The Self-Assessment Manikin (SAM; Bradley & Lang, 1994). The Self-Assessment Manikin was used as a visual assessment of the participants' feelings, specifically ratings of pleasure, arousal, and dominance, corresponding to the previous task. The assessment is comprised of three separate scales ranging in options from 1 to 9, with high numbers reflecting high positive emotional valence, dominance, or arousal. The first scale (positive emotional valence) asked the participant to rate how happy or sad the

participant felt during the film and the second scale asked participants to rate how excited or calm they felt while watching the film (arousal). A third scale asked participants to rate how in control they felt while watching the film (dominance), but this scale will not be utilized in this study.

Several studies have validated the effectiveness of SAM in measuring emotional response. For example, Morris et al. (1993) found that SAM was particularly effective when looking at affective responses to advertisements. A study by Chianeh, Vahedi, Rostami, and Nazari (2012) used a test-retest design to assess the reliability of SAM using 9 researcher-chosen items to evaluate pleasure and arousal, finding significant positive correlations between SAM and their items (r = .89 and r = .83, respectively). We examined the first two scales as a manipulation check for inducing positive or negative emotion and arousal levels during the three tasks.

Physiological Assessment

Three pre-gelled, single electrocardiogram (ECG) sensors were placed by trained research staff on the (1) right side beneath the collar bone, the (2) left side beneath the collar bone, and on the (3) lower abdomen near the base of the ribs on the left side. Three leads were attached to a Biomadix RSP-ECG wireless sensor strapped on the lower abdomen of the participant. Two pre-gelled dual electrocardiogram sensors were placed on (1, 2) either side of the participant's neck and two pre-gelled dual sensors (3, 4) were placed on either side of the ribs to assess cardiac impedance and respiration patterns. A wireless Biomadix cardiac output sensor was strapped to the sternum of the participant and connected to the sensors via eight individual leads. A Biomadix EDA wireless sensor

was placed on the non-dominant wrist of the participant and connected to two single electrodes on the tip of the participant's pointer (1) and middle finger (2) via two leads. The participant was asked to sit in front of a monitor and await further instruction. The participant was shown by research assistants (RAs) how they should be sitting for the protocol and reminded to stay as still as possible for optimal collection of physiological data. Participants were instructed to speak out loud if they needed assistance and were asked to wait for further instruction over the speakers while RAs went into the control room. Physiological signals were checked for functioning by beginning physiological assessment for a minute to observe any discrepancies in the signals. When the signal appears normal, the protocol was started.

The physiological assessment tasks were administered as follows:

1) The RAs instructed the child to remain still and breathe normally to obtain a 5-minute traditional resting baseline.
2) The children then watched the 3-minute Coral Reef Video and completed the SAM immediately following the film clip's conclusion.
3) The RAs instructed the child to remain still and breathe normally to obtain a 3-minute traditional resting baseline to recover from the coral reef film clips and to provide a baseline for the Mirror Star Tracer task.
4) Participants were asked to trace a star for 3 minutes with their dominant hand while keeping the rest of their body still. The SAM ratings were repeated relative to the star tracer to gauge their feelings after tracing the star, followed by another 3-minute baseline.

5) The final task involved the participants playing 3 minutes of the game 'Hungry Hungry Hippos' on an iPad. Participants were given approximately a minute to practice the single-player, no competition game following instruction. They were asked to begin the game when instructor to do so by the RA and to continue playing until told to stop.

Heart Rate Variability and Respiration

Processing Physiological Data. Electrocardiography (ECG) and respiration data from the two baseline conditions (video and traditional resting), Mirror Star Tracer task, and Hungry Hungry Hippos task was processed using the Mindware HRV Analysis 3.1.4 (Mindware HRV 3.1.4; Mindware Inc., Gahanna: OH) software program. Data were split into six separate 30 second epochs before artifact detection and calculation of HRV (power) and respiration rate (breaths per minute) for each of the four tasks.

The program automatically identified R-peaks (and possible extra or missed R-peaks) to determine the inter-beat intervals (IBIs) used in the calculation of HRV. Trained research assistants manually inspected the data to ensure the automatically identified R-peaks were correct (i.e. not misidentified by Mindware) and that the artifacts (possible extra or missed R-peaks) were removed. The artifact-free IBIs were then subjected to a power spectral analysis using a fast Fourier transform algorithm, which produced absolute power (or variance) distribution values for low frequency heart rate variability (HRV; .04 to .12 Hz) and high frequency HRV (.12 to .40 Hz) for each 30 second epoch. The chosen frequency band ranges are consistent with reported standards

for power spectral analysis with children, as they differ from those frequency bands used with adolescents and adults samples (Malik et al., 1996).

Similarly, the program utilized the Zo signal derived from the cardiac impendence sensors to automatically identify each breath peak within the 30 second epoch and provide a calculated respiration rate of breaths per minute (BPM; number of breaths x 2 for each epoch). Trained research assistants manually identified and counted the number of breath peaks for each 30 second epoch and compared them to the automatically calculated respiration rate. If the manual counted respiration rate differed from the automatically calculated respiration rate, the RAs made a note and the authors decided the correct respiration rate (i.e., visually inspected the respiration signal and manually counted respiration peaks within the 30 second epoch) or excluded the data from further analyses (e.g., if data had too many artifacts or unidentifiable breath peaks). Moreover, the respiratory power spectrum using the low and high frequency bands described in the previous section was used to determine whether the breath peak frequency (i.e., the highest peak) was within the high frequency HRV range (.12 to .40 Hz). If the peak was below or above this range, the child may have breathed to slow or fast to derive a valid measure of HRV and thus the HRV value for that epoch was entered as missing data.

High Frequency - Heart Rate Variability. The Mindware HRV Analysis 3.1.4 (Mindware HRV 3.1.4; Mindware Inc., Gahanna: OH) program derived a natural logarithm transformation [ln(HRV)] value of HRV for each 30 second epoch. High frequency-heart rate variability powers are typically severely positively skewed and the natural logarithm transformation allows for a more normal distribution of the data. The

HRV values for each 30 second epoch were summed and averaged within each task (summed HRV divided by 6 epochs) to calculate a mean HRV value for each of the four tasks (video baseline, traditional resting baseline, Star Mirror Tracer, and 'Hungry Hungry Hippos') that were used in the analyses.

Respiration. The respiration rate for each 30 second epoch was summed and averaged within each task (summed respiration rate divided by 6 epochs) to calculate a mean respiration rate value for each of the four tasks (video baseline, traditional resting baseline, Star Mirror Tracer, and 'Hungry Hungry Hippos') that was used in the analyses.

Procedure

The Montana State University Institutional Review Board (IRB) approved all procedures and stimuli presented to children. Children and their caregivers were asked to come to our laboratory at Montana State University. Trained RAs provided caregivers with informed consent forms upon arrival and explained the study in detail to the children as to obtain their assent. The RAs addressed questions and concerns from both the caregiver and child before implementing study procedures. The RAs then escorted caregivers and their child to the physiological assessment room and began the physiological assessment protocol. Afterwards, the RA asked caregivers to complete their packet of questionnaires while the child participated in the physiological assessment. Finally, an RA accompanied the child to a separate room to complete the questionnaires. Questionnaires were read verbatim to the participant upon request and RAs were available for questions or clarifications.

CHAPTER THREE

RESULTS

Data Analysis

We preliminarily examined the data to determine missing data patterns, outliers (univariate and multivariate), and distribution of the variables. Next, we conducted 4 separate paired-samples t-tests to detect differences in subjective reports of valence and arousal between the video baseline, the Mirror Star Tracer task, and the 'Hungry Hungry Hippos' task. Bivariate correlations were conducted to determine the relation between all primary variables of interest in this study. We used a Bonferonni corrected alpha level given the number of paired sample t-tests conducted (.05/6 = .008; Tabachnick & Fidell, 2007). We conducted a series of multiple regression analyses to test each of our main hypotheses. First, we conducted separate multiple regression analyses to test Hypothesis 1 with age, gender, mean respiration rate, and resting HRV (video or traditional baseline) serving as predictors of either child- and caregiver-reported depressive disorder symptoms as the criterion variable. In addition, we conducted multiple regression analyses to test the potential moderating effects of gender on these relations with age, gender, mean respiration rate, resting HRV (video or traditional baseline) and gender by resting HRV interaction term serving as predictors of either child- and caregiver-reported depressive disorder symptoms as the criterion variable. Second, we conducted separate multiple regression analyses to test Hypothesis 2 with age, gender, video baseline or Mirror Star Tracer mean respiration rate, video baseline or Mirror Star Tracer baseline

HRV (Time 1), depressive disorder symptoms, and the interaction term video baseline HRV or Mirror Star Tracer baseline HRV (Time 1) by depressive disorder symptoms as predictors of HRV during the Mirror Star Tracer task (Time 2). Third, we conducted separate multiple regression analyses to test Hypothesis 2 with age, gender, video baseline or 'Hungry Hungry Hippos' mean respiration rate, video baseline or 'Hungry Hungry Hippos' baseline HRV (Time 1), depressive disorder symptoms, and the interaction term video baseline HRV or 'Hungry Hungry Hippos' baseline HRV (Time 1) by depressive disorder symptoms as predictors of HRV during the 'Hungry Hungry Hippos' task (Time 2). [2]

Descriptive Statistics

Preliminary examination of the data showed that one child participant was 6 years and 11 ½ months at the time of participation, and we excluded the child's data from the analyses. Moreover, we examined the frequencies and distribution of our study variables of interest via visual inspection of frequency tables, histograms, and skewness and kurtosis values. We identified one child participant with an RCADS depression scale score that was greater than three standard deviations above the mean and excluded the child's data from all analyses (Tabachnick & Fidell, 2007). We found that all the study variables of interest were normally distributed except for caregiver-reported depression on the HBQ, which had a severe positive skew (*Skew* = 1.13, SE_{skew} = .26). We decided

[2] Performing a linear transformation of caregiver-reported depression did not affect *p*-values or ß, leaving findings identical whether this variable was transformed or untransformed.

not to transform this variable for the analyses, as there was a large number of zero scores and it did not improve the distribution of the variable.[2] The final data set used for analyses thus consisted of 88 youth and their primary caregivers. Pairwise deletion of cases was used to handle missing data, resulting in the sample size varying across each analysis. Means, standard deviations, and correlations between the study variables are summarized in Table 1. Significant positive associations were found among all physiological variables (r ranges from .58 to .88, $p < .01$). A significant positive association was also found between child age and caregiver-reported depressive symptoms ($r = .27$, $p < .05$), and between caregiver-reported depression (HBQ) and the star tracer task ($r = .23$, $p < .05$).

Manipulation Check

We first reversed scored each variable, such that a higher score reflected more positive emotional valence or higher arousal. The results of the paired-sample *t*-tests showed a significant difference between the video baseline emotional valence ($M = 7.16$, $SD = 1.45$) and Mirror Star Tracer task emotional valence ($M = 4.93$, $SD = 1.98$), $t(88) = 9.78$, $p = .00$, with children reporting a higher positive emotional valence for the video baseline. There was also a significant difference found between video baseline arousal ($M = 3.27$, $SD = 2.12$) and Mirror Star Tracer task arousal ($M = 4.43$, $SD = 2.23$), $t(88) = -3.96$, $p = .00$, with children reporting higher arousal for the video baseline. A significant difference was found between video baseline emotional valence ($M = 7.16$, $SD = 1.45$) and Hungry Hungry Hippos task emotional valence ($M = 7.88$, $SD = .17$), $t(88) = -4.34$, $p = .00$, with children reporting higher positive emotional valence at the Hungry Hungry

Hippos task. There was a significant difference between the video baseline arousal (M = 3.27, SD = 2.12) and Hungry Hungry Hippos task arousal (M = 5.02, SD = 2.84), $t(88)$ = -5.36, p = .00, with children reporting lower arousal at the Hungry Hungry Hippos task. The difference between Mirror Star Tracer task emotional valence (M = 4.93, SD = 1.98) and Hungry Hungry Hippos task emotional valence (M = 7.88, SD = .17) was significant $t(88)$ = -12.00, p = .00, with children reporting lower positive emotional valence at the Hungry Hungry Hippos task. Finally, the relation between Mirror Star Tracer task arousal (M = 4.43, SD = 2.23) and Hungry Hungry Hippos task arousal (M = 5.02, SD = 2.84) was not significant, $t(88)$ = -1.91, p = .06, with children reporting lower arousal at the H.H.H. task.

Hypothesis 1: Relations between Both Traditional Resting and Video Baseline HRV and Depressive Disorder Symptoms

As shown in Table 2, the regression models for traditional resting and video baseline HRV predicting the child-reported depressive disorder symptoms were not significant, $F(4, 79)$ = .17 , p = .95 and $F(4, 78)$ = .20, p = .94, respectively. Similarly, and as shown in Table 3, the regression models for traditional resting and video baseline HRV predicting the caregiver-reported depressive disorder symptoms were not significant $F(4, 80)$ = 1.43 , p = .23 and $F(4, 79)$ = .1.47, p = .22, respectively. As such, resting HRV (traditional and video) was not significantly related to child or caregiver-reported depressive disorder symptoms and did not support Hypothesis 1.

Gender As A Moderator. As shown in Table 4, the regression models with traditional resting and video baseline HRV interacting with gender to predict child-

reported depressive disorder symptoms also were not significant, $F(5, 78) = .14$, $p = .98$ and $F(5, 77) = .26$, $p = .93$, respectively. Similarly, the regression models with traditional resting and video baseline HRV interacting with the gender to predict caregiver-reported depressive disorder symptoms were not significant, $F(5, 77) = 1.17$, $p = .33$ and $F(5, 78) = 1.27$, $p = .29$ (Table 5).

Hypothesis 2: Relations Between Child Depressive Disorder Symptoms and Changes In HRV From Baseline (Video or Mirror Star Tracer Task) To Mirror Star Tracer Task

The model testing the interaction between video baseline HRV and child-reported depressive disorder symptoms predicting Mirror Star Tracer task HRV was significant (Table 6), $F(6, 73) = 29.62$, $p = .00$. Moreover, the interaction between child-reported depression and the video baseline HRV was significant (ß = -.29, $p = .00$). We used the simple slope technique to post-hoc probe the interaction term (Aiken & West, 1991) and thus examine the relation between video baseline HRV and Mirror Star Tracer task HRV at +1 standard deviation above the mean, the mean, and -1 standard deviation below the mean for child-reported depressive disorder symptoms. As shown in Figure 1, there was a stronger significant relation, or steeper increase in HRV from the video baseline to the Mirror Star Tracer task on average, for youth at -1 standard deviation below the mean (ß = 1.04, $p < .001$) as compared the significant relation between video baseline HRV and Mirror Star Tracer task HRV for youth at +1 standard deviation above the mean (ß = .47, $p < .001$).

The model testing the interaction between Mirror Star Tracer baseline HRV and child-reported depressive disorder symptoms predicting Mirror Star Tracer task HRV was

significant (Table 6), $F(6, 74) = 14.41$, $p = .00$. Moreover, the interaction between child-reported depression and the Mirror Star Tracer baseline HRV was significant (ß = -.23, $p = .01$). We used the simple slope technique to post-hoc probe the interaction term (Aiken & West, 1991) and thus examine the relation between video baseline HRV and Mirror Star Tracer task HRV at +1 standard deviation above the mean, the mean, and -1 standard deviation below the mean for child-reported depressive disorder symptoms. As shown in Figure 2, there was a stronger significant relation, or steeper increase in HRV from the Mirror Star Tracer baseline to the Mirror Star Tracer task on average, for youth at -1 standard deviation below the mean (ß = .88, $p < .001$) as compared the significant relation between Mirror Star Tracer baseline HRV and Mirror Star Tracer task HRV for youth at +1 standard deviation above the mean (ß = .43, $p < .01$).

As shown in Table 7, the model testing the interaction between video baseline HRV and caregiver-reported depressive disorder symptoms predicting Mirror Star Tracer task HRV was significant, $F(6, 74) = 22.35$, $p = .00$. However, the interaction between caregiver-reported depression and the video baseline HRV was not significant (ß = .06, $p = .44$). The model testing the interaction between the Mirror Star Tracer baseline HRV and caregiver-reported depressive disorder symptoms predicting Mirror Star Tracer task HRV was significant, $F(6, 75) = 14.04$, $p = .00$. However, the interaction between caregiver-reported depression and the video baseline HRV was not significant (ß = -.02, $p = .82$), thereby not supporting our second hypothesis regarding caregiver-reported depressive disorder symptoms. Though we found support for our second hypothesis regarding individuals +1 standard deviation above the mean of child-reported depressive

disorder symptoms, our findings for individuals -1 standard deviation below the mean were not in the expected pattern.

Hypothesis 3: Relations Between Child Depressive Disorder Symptoms and Changes In HRV From Baseline (Video or Hungry Hungry Hippos Task) To Hungry Hungry Hippos Task

As shown in table 8, the model testing the interaction between video baseline HRV and child-reported depressive disorder symptoms predicting Hungry Hungry Hippos task HRV was significant, $F(6, 72) = 7.15$, $p = .00$. However, the interaction between child-reported depression and the video baseline HRV was not significant (ß = -.17, $p = .13$). The model testing the interaction between Hungry Hungry Hippos baseline HRV and child-reported depressive disorder symptoms predicting Hungry Hungry Hippos task HRV was significant, $F(6, 70) = 9.15$, $p = .00$. However, the interaction between child-reported depression and the Hungry Hungry Hippos baseline HRV was not significant (ß = -.18, $p = .09$).

The model testing the interaction between video baseline HRV and caregiver-reported depressive disorder symptoms predicting Hungry Hungry Hippos task HRV (found in Table 9) was significant, $F(6, 73) = 6.67$, $p = .00$. However, the interaction between caregiver-reported depression and the video baseline HRV was not significant (ß = -.04, $p = .74$). The model testing the interaction between Hungry Hungry Hippos baseline HRV and caregiver-reported depressive disorder symptoms predicting Hungry Hungry Hippos task HRV was significant, $F(6, 71) = 7.95$, $p = .00$. However, the interaction between caregiver-reported depression and the Hungry Hungry Hippos

baseline HRV was not significant (ß = -.09, p = .41). As such, there were no relations between child depressive disorder symptoms and changes in HRV from baseline (video or Hungry Hungry Hippos Task) to the Hungry Hungry Hippos task.

CHAPTER FOUR

DISCUSSION

The findings from the present study made an incremental contribution to the current literature on the association between child depressive disorder symptoms and physiological response to a negative stressor. Specifically, and with regard to Hypothesis 2, we found that the change in HRV from multiple baselines (video and pre-task) differed for those children reporting low versus high depressive disorder symptoms. As illustrated in Figures 1 and 2, those children reporting higher depressive disorder symptoms had an augmented HRV response to the Mirror Star Tracing task. This is in line with Porges' polyvagal theory (2007), which suggests that individuals with mental health problems respond in a maladaptive physiological manner to stressful events (i.e. increase or blunted HRV). Moreover, this is the first study to demonstrate that an increase in HRV during a cognitive-motor stressor was associated with higher depressive disorder symptoms in both boys and girls from a community sample, as El-Sheikh et al. only found this relation for girls in a recent study (2013) and no relation for boys or girls in a previous study (2001). Thus, though we found no moderation effect for gender, it is consistent with the findings of previous literature that does not find gender moderates the relation between resting baseline (traditional and video) and depressive disorder symptoms.

It is interesting to note, however, that we found an unexpected relation between change in HRV and child depressive disorder symptoms, as children reporting low depressive disorder symptoms exhibited a more drastic increase in HRV during the

stressor on average (i.e., steeper positive slope). Porges' polyvagal theory (2007) suggests that individuals reporting fewer depressive disorder symptoms should go down from rest to stress, while individuals reporting greater depressive disorder symptoms should increase in HRV from rest to stress. This increase is considered to be maladaptive, because the PNS is engaging in a suboptimal time. Thus, it is unexpected to find that individuals with fewer depressive symptoms are exhibiting this maladaptive change in HRV from rest to stress.

We propose two possible interrelated, but distinct explanations for this unexpected finding. First, and from a developmental perspective, it is possible that how children respond to challenging or stressful event at a physiological level is different from how Porges proposed individuals would respond across the lifespan. Previous research suggests that school-aged children are experiencing rapid maturation in cognitive, motor, and physiological domains (Adolph & Franchak, 2016), such that their emotional responses may reflect their attempts at learning how to modulate emotions or calm oneself down (i.e., an increase in parasympathetic nervous system). However, very little research to date that has investigated these potential developmental differences in HRV response to a stressor in school-aged children with regards to individual variability and rate of development. Second, and from a methodological perspective, we asked the children to engage in a task that requires complex emotional, cognitive, and motor processes. It seems reasonable to assume that school-aged children may be more inclined to reduce arousal during tasks that require such multiple systems to engage with each other and in an effort to bolster performance (Adolph & Franchak, 2016). For example, it

has been shown that both low and high levels of arousal can produce decreased accuracy in performance, while a moderate level of physiological arousal increases task performance. This could suggest that too little or too much stimulation of arousal could be ignored by participants (Berlyne, 1960; Eysenck, 1982). Perhaps it was adaptive for those low in depressive disorder symptoms to engage their parasympathetic nervous system during the task as a physiological emotion regulation strategy that suppresses arousal and potentially increases their task performance. However, perhaps our tasks were too difficult for some children to complete, so they disengaged from the task entirely.

Conversely, we found no support for Hypothesis 1, such that there was no association between either resting baseline (traditional and video) and child depressive disorder symptoms. This finding is inconsistent with Porges' polyvagal theory (2007) and does not coincide with findings from other published studies among community samples of children (El-Sheikh et al., 2001; Dietrich et al., 2011; Koenig et al., 2016), though their samples consisted of children aged 8-12 years. Furthermore, we did not find that gender moderated this relation as found in Dietrich et al.'s (2011) study and thus was non-significant across boys and girls. One potential reason that we did not find support for this hypothesis is that there may be greater individual variability in both resting HRV and depressive disorder symptoms during this developmental period (Gentzler, Santucci, Kovacs, & Fox, 2009; Blood et al., 2015). That is, the maturation of cognitive and biological systems related to the regulation of emotion may vary considerably with these systems developing faster or slower (Scott et al., 2016). Moreover, the level of cognitive

ability (i.e. the access to necessary cognitive tools used for complex emotional processing and development) needed for understanding and verbally expressing depressive disorder symptomology may not be as advanced for some children as compared to others. Taken together, this individual variability may make it quite difficult to detect relations between resting HRV and child depressive disorder symptoms in school-aged children.

We also did not find support for our exploratory Hypothesis 3. That is, we found no relation between change in HRV to the Hungry Hungry Hippos task from the baseline and child depressive disorder symptoms. However, we did find that children overall rated the task as more positive than both the Coral Reef video and Mirror Star Tracer tasks, but just as arousing as the Mirror Star Tracer task. Therefore, suggesting the Hungry Hungry Hippos tasks was an engaging, positive event for the children and may be useful in future psychophysiological studies. Based on Clark and Watson (1991), we theorized that those children with increased depressive disorder symptoms would respond in a maladaptive manner at the physiological level to a positive event. It is possible that children who are more depressed do not interpret a positive situation as threatening or aversive and thus simply do not engage to diminish the experience of positive emotions. Moreover, Clark and Watson (1991) suggested that depressed individual have a dispositional lack of positive affect, but that does not necessarily mean that they lack the ability to engage or respond appropriately to situational positive emotion. We need future research to better understand how children in general respond physiologically to positive situations, as well as children with mental health problems.

Although the present study added to our knowledge of child depressive disorder symptoms and physiological regulation of emotion, it is not without limitations. This study had a small sample size (n = 88) that limited our ability to detect small effects, especially interactive effects, and could result in a Type II error. However, it does provide more confidence that our significant findings were not spurious. Another consideration is the limited diversity within our sample, which limits the generalization of this study to most other communities in the United States. For example, the average annual family income level was between $50,000 and $79,999, the majority of caregivers (> 60%) had completed 4 or more years of college, and most of children were European American (> 90%). Nevertheless, this seems to be a representative of the community from which the sample was recruited and provides further knowledge about the relation between depressive disorder symptoms and physiological regulation of emotion among children living in mostly middle- to upper-class communities. The design of this study is a limitation in two ways. First, it is cross-sectional and prevents us from making causal inferences about significant relations among variables. Second, the non-randomization of the stressor and positive task could have introduced order effects such that change in HRV to the positive task were inflated or diminished. Randomizing the order of the Mirror Star Tracer and Hungry Hungry Hippos tasks would ensure that no task has a performance advantage by always appearing late in the test. The video could also be randomized, as it produced high positive ratings from SAM, but there was no increase in arousal suggesting that it could also be considered as a positive event for future studies. Future studies will need to consider randomizing before the physiological assessment

begins to avoid these potential effects. In addition, future studies should further examine whether there is, in fact, a significant difference in performance and arousal based on task order.

In summary, our findings showing an increase in HRV from resting baseline (traditional and video) for both individuals reporting greater and fewer depressive symptoms is a significant point of interest going forward, especially because the expectation for those reporting fewer depressive symptoms was that their HRV would decrease. Future research is also needed to examine our exploratory hypothesis, specifically identifying positive tasks that may show an increase in HRV from baseline (video and stress) for those reporting greater depressive disorder symptoms. Though the relation found between resting baseline (traditional and video) HRV and child-reported depressive disorder symptoms was not observed to be in the typical pattern that theory would suggest (Hypothesis 1; Porges, 2007), similar findings in the literature are not consistent (El-Sheikh et al., 2001). Further, we did not observe gender being a moderator for our first hypothesis, which seems to be consistent with previous research (Pang & Beauchene, 2013; El-Sheikh et al., 2001). Ultimately, we believe this research is contributing to a larger body of research designed to provide information used to better the experience of others and opens the door for new questions regarding positive tasks, potential gender differences, and unexpected results regarding HRV change from baseline (traditional and video) to a positive or negative task.

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Table 1. Correlations, Means, and Standard Deviations for Youth's HRV (Baseline and Change), Child and Caregiver Depressive Symptomology, and Demographics.

	1	2	3	4	5	6	7	8	9	*M*	*SD*
Youth Demographics											
1. Age	-									8.47	1.14
2. Gender	.08	-								1.47	.50
Child HRV											
3.Traditional Resting Baseline HRV	.17	.05	-							7.03	1.21
4. Video Baseline HRV	.15	.02	.88**	-						6.80	1.28
5. Mirror Star Tracer Baseline HRV	.17	.06	.79**	.75**	-					6.88	1.10
6. Mirror Star Tracer Task HRV	.19	.15	.79**	.77**	.68**	-				6.39	1.05
7. Hungry Hungry Hippos Baseline HRV	.18	-.01	.83**	.83**	.79**	.73**	-			6.97	1.19
8. Hungry Hungry Hippos Task HRV	.13	.02	.59**	.58**	.60**	.70**	.62**	-		5.70	1.06
Depressive Disorder Symptoms											
9. RCADS Depression (Child)	.07	.06	.07	.03	-.10	-.13	-.01	.02	-	8.54	4.09
10.HBQ Depression (Caregiver)	.27*	.03	.09	.13	.14	.23*	.20	.17	.06	1.80	2.07

Note. ** $p < .01$, * $p < .05$; HRV = Heart Rate Variability.

Table 2. Summary of Multiple Linear Regression Final Model with Resting Baseline HRV (Traditional and Video) Predicting Child-Reported Depressive Symptoms

	R^2	B	SE	ß	$\lvert t \rvert$	*p*
Resting Baseline HRV	.01					
Age		.19	.42	.05	.50	.65
Gender		.33	.92	.04	.36	.72
Resting Baseline HRV		.22	.41	.07	.53	.60
Mean Respiration Resting Baseline		.04	.22	.03	.20	.84
Video Baseline HRV	.01					
Age		.20	.41	.06	.48	.63
Gender		.54	.94	.07	.57	.57
Video Baseline HRV		.19	.40	.06	.46	.64
Mean Respiration Video Baseline		.12	.21	.08	.57	.57

Notes: HRV = Heart Rate Variability.

Table 3. Summary of Multiple Linear Regression Final Model with Resting Baseline HRV (Traditional and Video) Predicting Caregiver-reported Depressive Symptoms.

	R^2	B	SE	ß	$\lvert t \rvert$	*p*
Resting Baseline HRV	.07					
Age		.43	.20	.25	2.16	.034
Gender		-.18	.44	-.05	-.42	.68
Resting Baseline HRV		.09	.19	.05	.46	.65
Mean Respiration Resting Baseline		.01	.10	.01	.11	.92
Video Baseline HRV	.26					
Age		.40	.19	.24	2.12	.04
Gender		-.07	.43	-.02	-.17	.86
Video Baseline HRV		.16	.19	.11	.86	.39
Mean Respiration Video Baseline		.02	.10	.03	.23	.82

Notes: HRV = Heart Rate Variability.

Table 4. Summary of Multiple Linear Regression Final Model with Resting Baseline HRV (Traditional and Video) Predicting Child-reported Depressive Symptoms with Gender as a Moderator.

	R^2	B	SE	ß	$\|t\|$	*p*
Resting Baseline HRV	.01					
Age		.19	.12	.05	.44	.66
Gender		.33	.11	.04	.36	.72
Mean Respiration Resting Baseline		.04	.13	.03	.20	.84
Resting Baseline HRV		.22	.12	.06	.53	.60
Resting Baseline HRV x Gender		.08	.11	.01	.10	.92
Video Baseline HRV	.02					
Age		.22	.11	.06	.54	.59
Gender		.54	.12	.07	.58	.56
Mean Respiration Video Baseline		.13	.13	.08	.60	.55
Video Baseline HRV		.16	.13	.05	.36	.72
Video Baseline HRV x Gender		-.51	.12	-.08	-.69	.49

Notes: HRV = Heart Rate Variability.

Table 5. Summary of Multiple Linear Regression Final Model with Resting Baseline HRV (Video and Resting) Predicting Caregiver-reported Depressive Symptoms with Gender as a Moderator.

	R^2	B	SE	ß	$\|t\|$	*p*
Resting Baseline HRV	.07					
Age		.44	.11	.24	2.18	.03
Gender		-.18	.11	-.04	-.42	.68
Mean Respiration Resting Baseline		.01	.12	.01	.07	.94
Resting Baseline HRV		.08	.11	.05	.43	.67
Resting Baseline HRV x Gender		-.16	.11	-.05	-.44	.66
Video Baseline HRV	.08					
Age		.41	.10	.23	2.17	.03
Gender		-.07	.11	-.02	-.17	.87
Mean Respiration Video Baseline		.02	.12	.03	.25	.80
Video Baseline HRV		.15	.12	.09	.77	.44
Video Baseline HRV x Gender		-.24	.11	-.07	-.70	.50

Notes: HRV = Heart Rate Variability.

Table 6. Summary of the Relation Between Video Baseline HRV and Mirror Star Tracer task Baseline HRV Relative To Differences In Child-Reported Depressive Symptoms.

	R^2	B	SE	ß	$\lvert t \rvert$	*p*
Video Baseline HRV	.71					
Age		.08	.06	.08	1.29	.20
Gender		.26	.07	.13	1.91	.06
Mean Respiration Video Baseline		.02	.07	.05	.64	.52
Video Baseline HRV		.62	.07	.75	10.13	.00
RCADS Depression		-.03	.07	-.13	-1.98	.05
RCADS Depression x Video Baseline HRV		-.06	.07	-.29	-3.94	.00
Mirror Star Tracer task Baseline HRV	.56					
Age		.08	.08	.08	1.07	.29
Gender		.27	.08	.13	1.61	.11
Mean Respiration Mirror Star Tracer task		.05	.08	.12	1.38	.17
Mirror Star Tracer task Baseline HRV		.63	.09	.66	7.48	.00
RCADS Depression		-.03	.08	-.11	-1.34	.19
RCADS Depression x Mirror Star Tracer task Baseline HRV		-.05	.08	-.23	-2.70	.01

Notes: HRV = Heart Rate Variability.

Table 7. Summary of the Relation Between Video Baseline HRV and Mirror Star Tracer task Baseline HRV Relative To Differences In Caregiver-Reported Depressive Symptoms.

	R^2	B	SE	ß	$\lvert t \rvert$	*p*
Video Baseline HRV	.64					
Age		.06	.07	.06	.82	.41
Gender		.30	.07	.14	2.01	.05
Mean Respiration Video Baseline		.02	.08	.06	.73	.47
Video Baseline HRV		.65	.08	.79	9.76	.00
HBQ Depression		.08	.08	.16	2.13	.04
HBQ Depression x Video Baseline HRV		.03	.08	.06	.77	.44
Mirror Star Tracer task Baseline HRV	.53					
Age		.03	.08	.03	.42	.67
Gender		.27	.08	.13	1.62	.11
Mean Respiration Mirror Star Tracer task		.07	.09	.18	2.08	.04
Mirror Star Tracer task Baseline HRV		.69	.09	.71	8.28	.00
HBQ Depression		.10	.09	.19	2.16	.03
HBQ Depression x Mirror Star Tracer task Baseline HRV		-.01	.09	-.02	-.23	.82

Notes: HRV = Heart Rate Variability.

Table 8. Summary of the Relation Between Video Baseline HRV and Hungry Hungry Hippos Baseline HRV Relative To Differences In Child-Reported Depressive Symptoms.

	R^2	B	SE	ß	$\lvert t \rvert$	*p*
Video Baseline HRV	.37					
Age		.01	.10	.01	.11	.91
Gender		.03	.10	.01	.15	.88
Mean Respiration Video Baseline		.01	.11	.03	.29	.77
Video Baseline HRV		.49	.11	.59	5.57	.00
RCADS Depression		-.01	.10	-.02	-.20	.84
RCADS Depression x Video Baseline HRV		-.04	.11	-.17	-1.52	.13
Hungry Hungry Hippos Baseline HRV	.44					
Age		.01	.09	.01	.10	.92
Gender		-.01	.09	-.00	-.03	.97
Mean Respiration Hungry Hungry Hippos Baseline		-.01	.10	-.01	-.13	.90
Hungry Hungry Hippos Baseline HRV		.54	.10	.61	6.40	.00
RCADS Depression		-.01	.10	-.03	-.31	.76
RCADS Depression x Hungry Hungry Hippos Baseline HRV		-.04	.10	-.18	-1.70	.09

Notes: HRV = Heart Rate Variability.

Table 9. Summary of the Relation Between Video Baseline HRV and Hungry Hungry Hippos Baseline HRV Relative To Differences In Caregiver-Reported Depressive Symptoms.

	R^2	B	SE	ß	$\lvert t \rvert$	*p*
Video Baseline HRV	.35					
Age		-.00	.10	-.00	-.01	.99
Gender		.09	.10	.04	.43	.67
Mean Respiration Video Baseline		.02	.11	.05	.45	.65
Video Baseline HRV		.49	.11	.59	5.44	.00
HBQ Depression		.07	.11	.14	1.27	.21
HBQ Depression x Video Baseline HRV		-.02	.13	-.04	-.34	.74
Hungry Hungry Hippos Baseline HRV	.40					
Age		.00	.10	.00	.05	.96
Gender		.04	.10	.02	.24	.81
Mean Respiration Hungry Hungry Hippos Baseline		.01	.10	.03	.34	.74
Hungry Hungry Hippos Baseline HRV		.55	.10	.62	6.19	.00
HBQ Depression		.04	.10	.09	.82	.42
HBQ Depression x Hungry Hungry Hippos Baseline HRV		-.04	.11	-.09	-.83	.41

Notes: HRV = Heart Rate Variability.

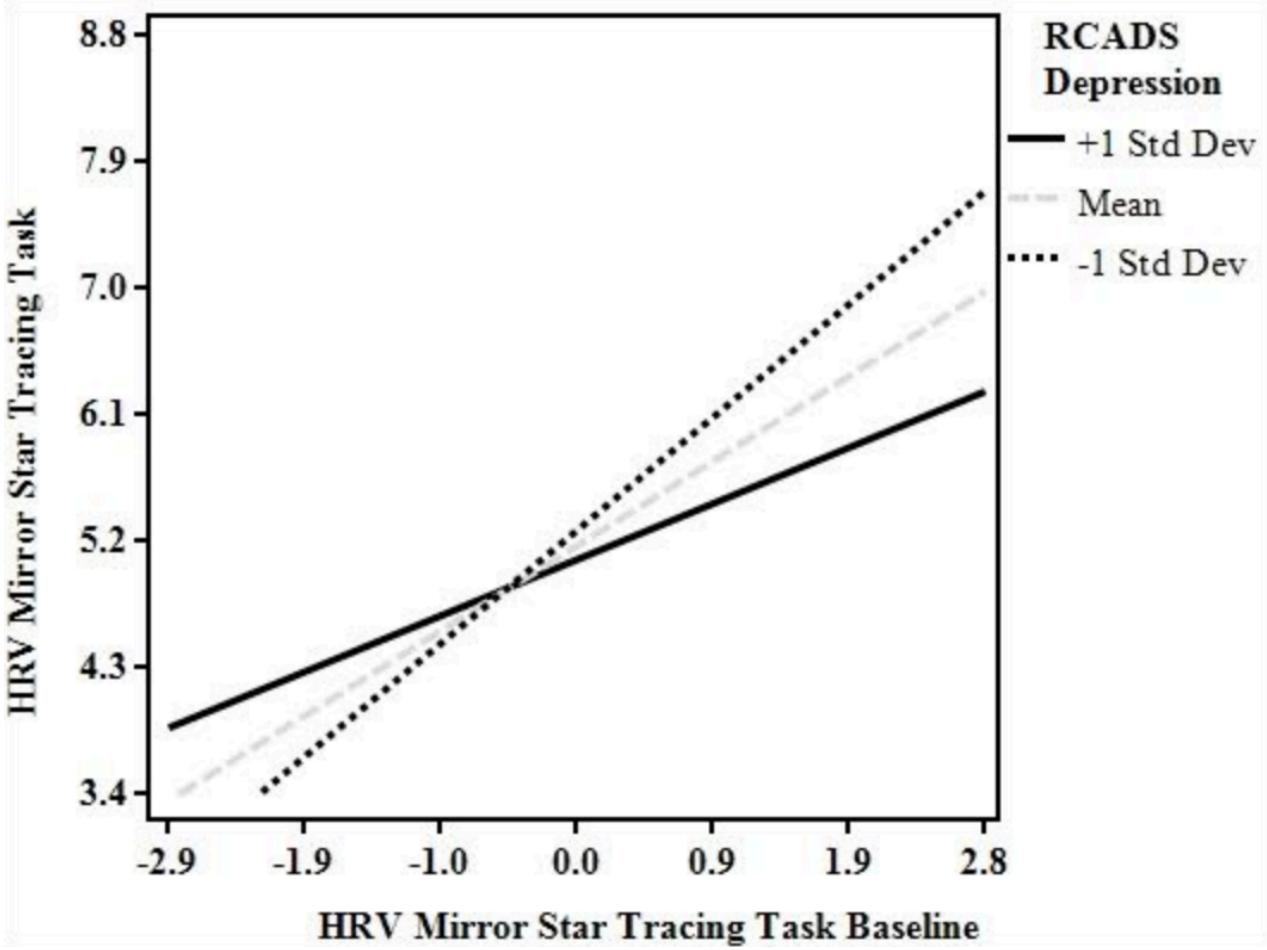


Figure 1. Child-Reported Depressive Symptoms For Participants +1 SD Above The Mean, At The Mean, And -1 SD Below The Mean For Mirror Star Tracer task Baseline RSA To Mirror Star Tracer task RSA.

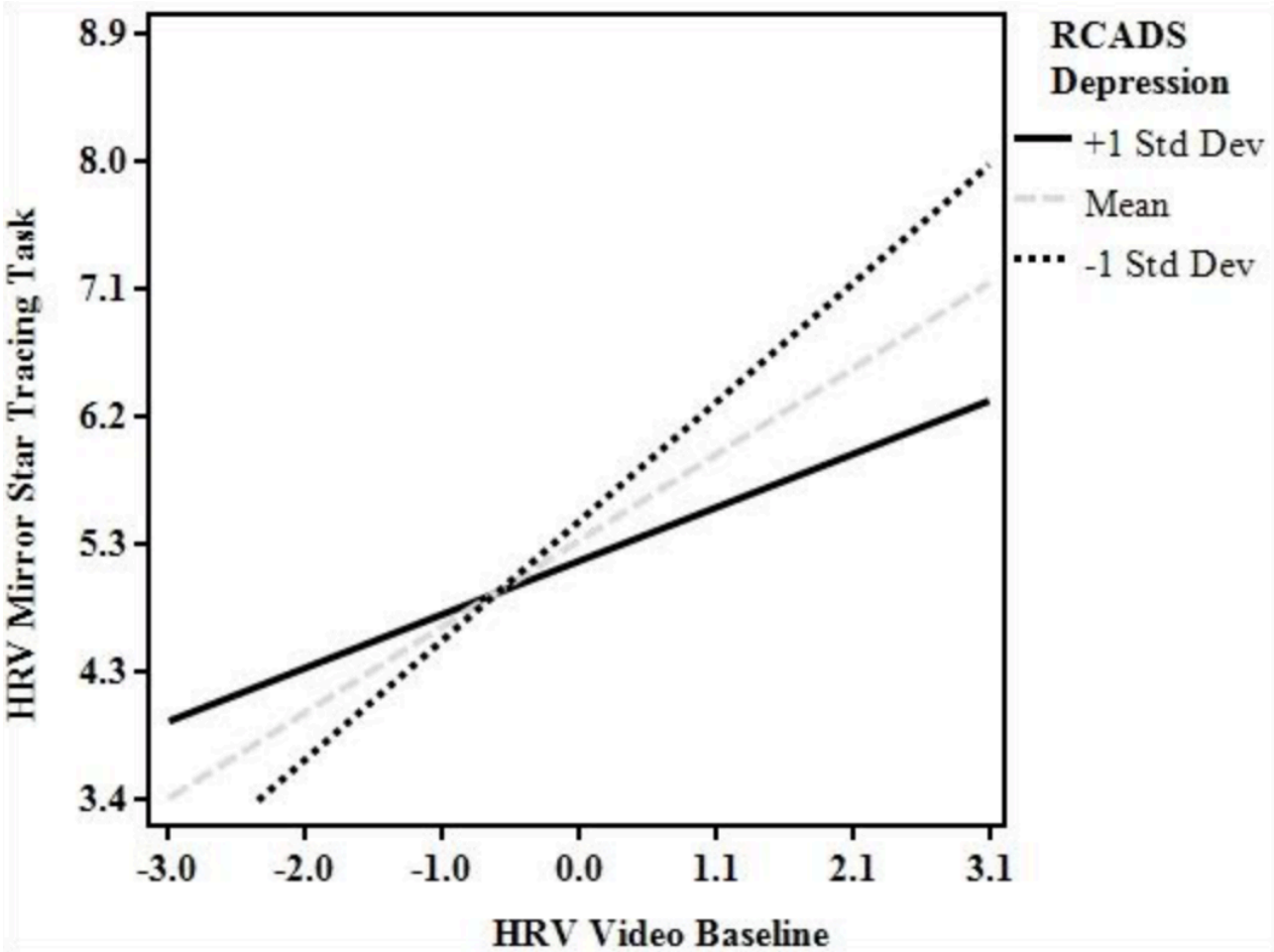


Figure 2. Child-Reported Depressive Symptoms For Participants +1 SD Above The Mean, At The Mean, And -1 SD Below The Mean For Video Baseline RSA To Mirror Star Tracer task.