The Role of Siblings in Emotion Reactivity for Preschool-Aged Children

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Abstract

Background: Emotion reactivity and regulation are underlying mechanisms of social-emotional functioning. Social learning theory and family systems theory suggest that sibling relationships may contribute to emotion processing development via repeated opportunities to engage in emotion expression and modification during frequent interactions. The present study aimed to elucidate how siblings influence emotion processing by examining children's emotion reactivity via intra-individual patterns of dynamic change in Respiratory Sinus Arrhythmia (RSA), a physiological biomarker of emotion regulation, while preschool-aged children experienced an emotion-eliciting stressor in the presence of a sibling, in comparison to experiencing the stressor while alone and in the presence of a novel adult. **Methods:** Participants included 48 sibling dyads (target M_{age}=3.89, SD = 0.48; sibling M_{age}=6.40, SD =0.91) and their caregiver. The younger sibling wore a heart rate monitor throughout data collection procedures and mean RSA values were calculated for each 30-second epoch across the baseline and emotion eliciting segments. A two-level growth curve model was employed to examine intra-individual patterns in RSA reactivity across the three conditions. **Results:** Results indicated that the level-2 random slope model significantly fit the data, suggesting that a significant proportion of variance in reactivity can be attributed to individual differences. However, there were no changes in RSA reactivity on average. Hypothesis testing indicated that there was no significant difference in RSA reactivity across the three conditions, which suggests that sibling presence did not significantly impact physiological reactivity. **Discussion:** Findings offer important methodological considerations, measurement implications, and future directions for understanding the role of sibling relationships on emotion processing development.

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Emotion reactivity and regulation are key components of human emotional processing and integral to management of environmental stimuli. Difficulties with effectively responding and regulating one's emotions is an underlying mechanism that contributes to the development of behavior problems in youth (i.e., emotion dysregulation; Cole et al., 2004; Thompson et al., 2008). While emotion regulation is a multifaceted construct involving physiological, behavioral, and cognitive processes "responsible for monitoring, evaluating, and modifying emotional reactions… to accomplish one's goals" (Thompson, 1994, pp 27-28), emotion theory and research suggest that emotion reactivity is a distinct, yet interrelated domain of emotion processing (Gross et al., 2011). Research on the development of emotion processing skills in children has primarily focused on the influence of caregivers (Cole et al., 2004; Cole et al., 2009; Enlow et al. 2011; Rasmussen et al., 2017; Thompson & Meyer, 2007), with little attention to other relational partners that may influence emotional responding, namely the sibling relationship.

In early childhood, young siblings tend to provide frequent opportunities to practice varying reactions to conflictual and positive exchanges. Examining potential factors that contribute to emotion reactivity, such as the sibling relationship, is particularly important during preschool years—a developmental period when emotion regulation processes are rapidly developing (Gross, 2007; Harden et al., 2017; Hill et al., 2006). Previous methodologies examining emotion reactivity and regulation of preschool-aged children have employed caregiver report or observational measures (for a review see Adrian et al., 2011); however, polyvagal theory suggests that emotional responding or reactivity actually begins with internal shifts in physiology (Beauchaine et al., 2007). Thus, external observation may not accurately assess an individual’s emotional response, particularly if emotion regulation processes are being deployed to inhibit emotional expression. Research that has used physiological methods to examine emotion regulation processes in preschoolers, typically evaluate the parent-child relationship and caregiver behaviors on children’s physiological responses during stress tasks (Hastings et al., 2008). Emotion reactivity processes emerge in infancy and involve infant temperament and basic self-regulatory capacity for managing emotions with varying effectiveness (Cole et al., 2004). Through early childhood, children begin to develop an array of emotion regulation strategies (Cole et al., 2004), which are likely influenced by more than just parent-child interactions. Thus, the present study aims to expand on this work by examining how the sibling relationship influences a preschool-age child’s physiological reactivity.

Emotion reactivity and regulation

Within the last 20 years the field has identified a multi-system approach involving a series of complex, co-occurring processes, including emotion reactivity (also referred to as emotion generation) and the management or mismanagement of the emotions generated (i.e., regulation) to understand emotion processing (Campos et al., 2004; Gross et al., 2011). Emotional reactivity is when “a person-situation transaction compels attention, has a valanced meaning to an individual, and gives rise to a coordinated yet malleable multi-system response to the ongoing person-situation transaction” (pp.766, Gross et al., 2011), whereas emotion regulation is defined as “how individuals influence which emotions they have, when they have them, and how they experience and express them” (pp. 271, Gross, 1998). For instance, if someone tells you a sad story, you may have an initial feeling of sadness (i.e., emotion reactivity), and then you either allow or withhold tears (i.e., emotion regulation). While this is an overly simplified description of a two-step process, others have argued that there is no clear distinction between the two processes (Campos et al., 2004; Kappas, 2011; Thompson, 2011). As Gross et al. (2011) explains, “the more one looks at this distinction, however, the harder it seems to draw a bright line between emotion generation and emotion regulation” and that these processes are “conjoined in nearly every instance” (pp. 766). Further, physiological and brain systems appear to overlap for both emotion reactivity and regulatory processes (Ochsner et al., 2009), providing greater support for a one-factor unitary model that involves concurrent processes (Campos et al., 2004).

The complexity of these constructs stems from an inability to define or describe a pure emotion that exists or stands alone in an unregulated manner (Campos et al., 2004). The field has yet to present any facial, vocal, gestural, physiological, or cerebral indexes that definitively explain an emotional state (Davidson et al., 2000), because many behaviors can serve a single emotion, and the same behavior can serve multiple emotions (e.g., crying due to sadness vs. happiness vs. anger; Campos et al., 2004). Further, emotions are heterogeneous in their duration and intensity. For instance, some are so mild that they are rarely detected (e.g., annoyance), while others require higher levels of cognitive processing (e.g., guilt or shame), and some emotions are relatively brief (e.g., fear), while others are more prolonged (e.g., grief) (Gross et al., 2011). Furthermore, “emotions are moving targets that are usually unseen (and unfelt)” and are “most surely micromomentary” (Cole et al., 2004, pp. 320).

Despite these challenges, the emotion – response trajectory involves a few key features, namely a situation (stimulus), attending to or orienting toward the ongoing environmental experience (attending), evaluating the situation (appraising), and inclining toward particular actions that are driven by one’s active goals (action readiness) (Cole et al., 2004; Gross et al., 2011; Gross & Thompson, 2007). According to Gross et al. 2011, “it is ultimately the situational-meaning-in-relation-to-a-goal that gives rise to an emotion" (p. 767). This suggests that the situational context is integral to the individual's generation of an emotional response, and that environmental factors (e.g., individuals in the environment) directly impact their reactivity.

Gross et al. (2011) attempted to clarify distinguishing features between emotion reactivity and emotion regulation. For instance, the goal of emotion regulation always involves management of emotion reactivity (i.e., how to modify or maintain the current emotional state), whereas the goal of emotion reactivity involves responding to the internal and external environment cues (i.e., response to a stimulus). Unfortunately, it is unclear when the emotion regulation process has been activated, and both processes are often co-occurring. Further, emotion regulation processes involve situation modification and selection (i.e., efforts to influence the situation to increase or decrease certain emotions), attentional deployment (i.e., directing attention that alters the emotion-response trajectory), cognitive change (i.e., altering the situation's meaning to influence the emotional response), and response modulation (i.e., targeting the experiential, behavioral, or physiological components of an activated emotional response to elicit change). Given the complexity of emotion processing, the present study refers to the emotional responding of participants as *emotion reactivity* or *emotion responsivity* for the purposes of clarity. The decision to use this term rather than emotion regulation was due to the nature of the study design and research questions (i.e., examining factors that contribute to participants response to stressful stimuli), and yet it is acknowledged that regulation processes are likely contributing to the emotional response and may explain some of the variance in outcomes. Importantly, previous literature frequently uses the term emotion regulation to encompass all processes involved in responding to environmental stimuli, and few distinguish between the various systems involved in emotional processing. Thus, the subsequent literature review involves theoretical and empirical research that identify both emotional reactivity and regulation constructs.

Influences on the development of emotion processing

According to social learning theory (Bandura, 1977), emotional behaviors are learned through observing how others express and describe feelings and by observing consequences that occur as a result of these displays. In early childhood, youth learn appropriate emotional responses from their caregivers by identifying patterns of reactions and making inferences about others' emotional states (Arsenio et al., 2000; Thompson & Meyer, 2007). While emotion reactivity partially emerges from internal processes involving neural activity, young children also learn about emotional responding by inferring from the evidence of their surrounding environment (Cole et al., 2004). Further, social signals from the environment and caregiver's appraisals (e.g., enthusiasm, applause, vocalizations, praise) play a role in emotion reactivity and the development of emotional responses (Campos et al., 2004).

Most of the research on emotion reactivity and emotion regulation development has focused on the influence of parenting behaviors, which include caregivers' response to children's emotion expressions (e.g., acceptance, diminishing, physical touch), parent-child discussion of emotion, and the caregiver's modeling of emotion expression (Eisenberg et al., 1998; Gudmundson & Leerkes, 2012; Kiel et al., 2020; Kohlhoff et al., 2016). In this work, emotion reactivity is measured via observations of children's emotional expression or parent-report of children's exhibition of emotions. Early research found that mothers and their preschool-aged children exhibited mutual emotion expression, particularly for positive emotions, which suggests that the dyad may be sensitive to each other's emotional signals and modulate their own emotions to match each other (Cole et al., 2003). In addition to synchronized emotion expression among parents and children, parent socialization of emotions (i.e., describing emotions) and caregiver behaviors in response to environmental stimuli (e.g., distraction, attention, reappraisal) are important precursors for children's emotion reactivity, expression, and regulatory processes (Cabecinha-Alati et al., 2020; Morris et al., 2011). Parents who exhibited unsupportive responses to children's emotion expression of anger, sadness, and anxiety predicted higher levels of emotional inhibition in children (Cabecinha-Alati et al., 2020). Moreover, maternal use of emotion regulation strategies during mother-child lab-based tasks was significantly associated with children's emotion reactivity measured via observed emotional expression (Morris et al., 2011). Results indicated that mothers' use of attention refocusing (i.e., shift child's attention away from emotion eliciting stimuli) and mother-child cognitive reframing (i.e., interpreting the situation differently) were associated with less anger and sadness expression from children. Findings showed that attention refocusing was more useful for younger children, whereas cognitive reframing was more effective for older children (Morris et al., 2011). Additionally, parents' responsivity to children's emotion expression influences youths' regulatory processes, as evidenced by Cole et al. (2009) who found that caregivers who respond with support and structure (e.g., redirecting child's attention, labeling the situation in emotion terms) were more likely to have children who generated more strategies for emotion regulation when encountering a lab-based stressor on their own. These findings suggest that when caregivers react to children's emotion reactivity (e.g., distraction, refocusing, reframing, labeling the emotion), children learn how to respond and regulate in the context of an environmental stimulus.

Although observation and caregiver-report can provide initial information about emotion processing, reactivity to environmental stimuli involve changes in autonomic activity (Gross et al., 2011). Caregiver socialization has been linked to children's physiological responsivity (Cole et al., 2004; Hastings & De, 2008). For example, caregivers who employed more negative control had children with lower changes in respiratory sinus arrythmia from baseline to frustration tasks, which was indicative of worse emotion regulation and psychopathology (Hastings et al., 2008). These findings suggest that experiences of parental socialization may influence internal processes that provide a proxy for emotion reactivity and regulation.

Although much of the research on emotion reactivity and regulation development in early childhood has focused on parent behaviors and parent-child interactions, caregivers may not be the only contributing factor to the emotion-response trajectory. Interactions with playmates (i.e., siblings and peers) may also provide opportunities to learn ways to appropriately express emotions and cope with distress by modeling emotion reactivity and regulation strategies in early childhood (Kramer, 2014; Lindsey & Colwell, 2003). Through pretend play, children learn how to communicate about the motivations, thoughts, and feelings of the characters they are portraying (Kramer, 2014). Acknowledging emotions of pretend characters and taking the perspective of others are components of emotion processing that are learned through play. Negotiation of the pretend play “script” allows children to work through conflict and practice different emotional responses and strategies (Kramer, 2014). Lindsey and Colwell (2003) examined preschoolers during same-sex dyadic pretend play with a peer and found that high levels of pretend play were positively associated with parent-report of emotional understanding and parent-report of emotion regulation for girls. Gottman and Mettetal (1986) proposed that children gain skills necessary for emotion regulation as a result of the increasingly complex demands placed on them by social interactions with peers. Together, these studies suggest that pretend play with same-age peers allows children to learn and practice appropriate emotion expression and emotion regulation skills. Interactions with peers are often likened to sibling relations, given that they may provide another opportunity to engage in pretend play, particularly if they are close in age (Kennedy & Kramer, 2008). Thus, children may also learn emotion processing skills when interacting with a sibling; however, there is very little research on siblings and emotion regulation in preschool-aged children. The sibling relationship could provide opportunities for modeling (mal)adaptive emotion expression and regulation strategies and provide opportunities to practice various emotional responses with another child whose relationship is resistant to dissolution.

The sibling relationship and emotion processing

Hypotheses rooted in social learning theory and family systems theory suggest that sibling relationships may also contribute to emotion processing development via repeated opportunities to engage in emotion expression and modification during frequent interactions (Kramer, 2014). Consistent with social learning theory, siblings may serve as models for emotion responsivity through their roles as playmates, antagonists, teachers, and caregivers (Whiteman et al., 2011). Family systems theory recognizes the importance of the sibling relationship within the context of the larger family system (Minuchin, 1974). Siblings are considered integral to family functioning, particularly in times of stress and change when siblings can become primary sources of support and assistance to one another. Unlike friendships, sibling relationships are involuntary and permanent; thus, they are resistant to dissolution in the face of conflict, particularly during early childhood. This attribute can make sibling relationships a stable context for learning about diverse emotional experiences (Campione-Barr & Smetana, 2010; Kramer, 2014).

Initial studies suggest that interactions among siblings influence various aspects of the emotion regulation process, such as emotion identification, emotion expression, and perspective taking; however, much of the literature in this area is theoretical (for reviews and critical analyses see Dunn, 2007; Kramer, 2014; McHale et al., 2012). Siblings engage in ongoing and frequent play-based activities over time that can induce rapid shifts in positive and negative emotions necessary for learning emotion reactivity and regulation strategies. Kindergarteners who engaged in more pretend play with their older sibling were observed discussing their feelings with one another more frequently than those without siblings or those with younger siblings (Howe et al., 2005), suggesting that emotion identification may be learned within the context of sibling interactions. Additionally, a short-term longitudinal study examined the relation between pretend play and social understanding among preschool-aged youth and their younger siblings (Youngblade & Dunn, 1995). Results suggested that total pretend play participation (e.g., instances of role playing, number of turns speaking) at baseline assessment was positively correlated with the younger siblings' understanding of the cause for someone's emotions during a lab-based puppet task seven months later. Taken together, initial studies suggest that sibling interactions influence constructs related to emotion reactivity and regulation (e.g., emotion identification, perspective taking). However, this literature has not yet examined emotion reactivity processes when a child experiences a stressor in *the presence of a sibling*. Siblings are permanent members of the family system and are frequent playmates in early childhood, especially for dyads that are close in age, making this understudied population an important avenue for examining emotion reactivity in preschool-aged children. Whether the focus is on parents, siblings, or peer influences, researchers have employed several methods to assess emotion reactivity and regulation in children.

Measurement of emotional reactivity

Emotion reactivity and regulation are multifaceted constructs that involve the navigation of multiple systems, such as physiological arousal, behavioral expressions, cognitive processes, motivations, and inter- and intra-personal goals (Adrian et al., 2011; Gross et al., 2011; Thompson, 1994). Despite all of these components, researchers examining preschool-aged children's emotion reactivity and regulation processes have mostly measured this construct via another informant report (i.e., parent or teacher) or observational methods. Other informant methodologies (e.g., standardized questionnaires) are often used to measure emotion regulation, because parents or teachers are able to observe a child's reactivity and regulation strategies across multiple settings. For behavioral observation methodology, researchers code body gestures, tone of voice, and facial expressions while youth participate in lab-based tasks designed to elicit emotional reactions. Coding systems can be adapted to capture the antecedents, reactions, and consequences of emotion expression (Adrian et al., 2011). However, these observation methodologies only capture some aspects of emotional responding and do not measure internal, unobservable processes.

Emotion expression and regulation involve neurophysiological systems that are continuously changing (Cole et al., 2004; Curtis & Cicchetti, 2007). Encounters with environmental stressors initiates a cascade of physiological reactions in the autonomic nervous system (ANS; Beauchaine et al., 2007). Internal systems are frequently responding to new information being processed as the individual adapts to changing environmental demands and often these brief shifts are unobservable (Pattyn, 2009). For example, when an individual is watching a scary movie, their facial features may remain neutral even though their heart rate increases. Therefore, methodology that can assess rapid shifts in internal physiological responses is necessary to fully understand emotion reactivity and factors that contribute to it.

Physiological biomarkers of emotion reactivity: Heart rate variability

The ANS plays an important role in responding to stimuli and regulating emotions during social interactions. Functional organization of the ANS encompasses the integration of cognitive, emotional, and physiological responses. According to polyvagal theory (Porges, 1995, 2007), when an individual is in a threatening situation, a physiological response is triggered to promote survival in which the parasympathetic branch is inhibited while the sympathetic branch is activated resulting in an increase in heart rate and blood flow to limbs. In general, when an individual experiences rage or panic, the vagus nerve withdraws, which allows for a large increase in cardiac output by the sympathetic nervous system (e.g., fight or flight). To prevent the sympathetic arousal from becoming too extreme for the body to handle, the parasympathetic system is reinitiated, which will inhibit the continued acceleration of the sympathetic system. When an individual is in an environment that is deemed safe the “vagal brake” is applied, which allows for the parasympathetic nerve fibers to control the heart rate. This allows for sustained attention and/or social engagement. The reduction in cardiac output promotes relaxation, social behavior, homeostatic functions, and repair. Importantly, the two branches simultaneously work together to allow for adaptation to environmental demands (e.g., everyday social interactions) to promote emotion reactivity and regulation skills. Sympathetic activity tends to increase heart rate, whereas parasympathetic activity decreases heart rate (Beauchaine et al., 2007; Pattyn, 2009; Porges, 1995, 2007; Quintana et al., 2012).

Given that the sympathetic and parasympathetic branches of the ANS are involved in regulating stress responsivity (Scheeringa et al., 2004), measures of the ANS are designed to quantify that response. In particular, heart rate variability (HRV) has emerged as an objective and sensitive marker of one’s ability to respond and recognize emotional cues within appropriate timing and magnitude (Appelhans & Lucken, 2006). HRV is a non-invasive measure of changes in time intervals between consecutive heart beats (Shaffer & Ginsberg, 2017). For example, when someone is in a threating situation their heart begins to beat faster so the time between beats becomes shorter, thus their HRV will be lower than if they were in nonthreatening situation. Appelhans and Lucken (2006) provide a review of theoretical and empirical rational for the use of HRV as an index of emotion reactivity and regulation. Within the cardiac vagal literature, the most prevalent component of HRV is the respiratory sinus arrhythmia (RSA), which is the variation in heart rate the occurs in synchrony with respiration (Berntson et al., 1997). RSA is an index of parasympathetic control, which indicates less cardiac output and promotion of relaxation and homeostatic functions (Berntson et al., 1997; Quintana et al., 2012). RSA scores are expected to decrease when one experiences distress. A decrease in RSA during threatening or challenging situations from one's baseline RSA, is often referred to as RSA suppression or RSA withdrawal. RSA suppression represents inhibition of the parasympathetic system, which involves allocation of metabolic resources away from maintaining homeostasis and toward activating resources to meet environmental demands (Porges, 2007). The proposed study will utilize RSA reactivity as a physiological biomarker of internal emotion reactivity processes.

HRV reactivity

High RSA suppression during challenging tasks has been linked to appropriate self-regulatory processes (i.e., greater decrease in RSA from baseline; Beauchaine, 2001; Porges, 2007), whereas lower RSA suppression in response to difficult tasks is often linked to poor emotion regulation, due to the under-regulation of sympathetic activity (Beauchaine et al., 2007; Calkins & Keane, 2004). Calkins and Keane (2004) examined the stability of RSA reactivity in participants at 2 years old and then at 4.5 years old. In the study, researchers utilized age-appropriate baseline and "challenge episodes," including lab-based tasks requiring or eliciting attention, empathy, frustration, and problem-solving. Mean RSA scores were calculated during baseline and each challenge episode, and change scores (commonly referred to as 'mean difference scores') were calculated for each task. Researchers found significantly decreased mean RSA during each of the challenge episodes (i.e., inhibition of parasympathetic system) compared to the baseline episode for participants at both ages, which suggests an increased emotion reactivity during the challenge episodes from baseline. Additionally, researchers found that the type of challenge episode influenced the degree of physiological response, with the problem solving and frustration tasks eliciting a greater decrease in RSA from baseline (i.e., greater RSA suppression) than the attention and empathy tasks, which provides evidence that environmental demands influence the degree of cardiac output. It is likely that the attention and empathy tasks were less challenging behaviorally and emotionally and thus required less cardio output (i.e., less change in RSA from baseline).

RSA reactivity was also examined in a study of children 4-7 years old while they observed videos meant to elicit various emotional reactions (i.e., anger, fear, sad, happy; Gatzke-Kopp et al., 2015). Similarly, results indicated that the anger and fear videos elicited significantly greater arousal (i.e., high RSA suppression) than the sad and happy videos, which is consistent with these emotions representing "fight or flight" activation. Notably, all emotion videos evidenced lower mean RSA than the mean RSA at baseline, indicating that RSA is capturing a physiological response to an emotion eliciting stimulus. These studies provide support for the use of RSA as a measure of physiological reactivity when examining emotion reactivity in preschool-aged children.

Physiological assessments are an objective measure of the frequent shifts in internal processes related to emotion reactivity and regulation processes. HRV measures subtle shifts in emotional reactivity that are likely unnoticeable in an observation of behaviors, and yet a majority of literature examining RSA reactivity collapses all data points into an overall mean RSA value for the baseline task and each emotion eliciting task. Then, researchers calculate an overall mean difference score (i.e., RSA suppression) to determine how reactivity during the emotion eliciting tasks differs from other stress tasks or relates to other variables being studied. Several critics suggest that regulatory processes may be more accurately depicted if current physiological methods were used to measure the dynamic change over time (Brooker & Buss, 2010; Cole et al., 2004). *Dynamic change* is the within-person variation of patterns of reactivity in response to environmental stressors (Brooker & Buss, 2010; Creaven et al., 2014). To detect these patterns, averages of RSA are calculated for smaller epochs within the baseline phase and emotion eliciting phase(s). Thus, a series of averages is calculated across a short period of time so the trajectory of emotion reactivity can be examined. For example, past studies have collapsed a 3-minute baseline phase into one RSA score, but when examining dynamic change the physiological data can be divided into RSA means calculated for each 30 second epoch of the baseline phase (i.e., 6 occasions). In these past studies, Creaven et al (2014) examined co-regulation between mother-child dyads and found that mothers' mean resting HR was associated with dynamic changes in children's RSA reactivity at rest. Additionally, Brooker and Buss (2010) found that positive affect and boldness during a *Stranger Approach* task were associated with toddler's dynamic shifts in RSA during the emotion eliciting task. The present study aimed to expand on these past studies by examining physiology via shorter epochs across *both* the baseline and emotion eliciting tasks, which will allow for examination of individual differences in physiological reactivity over time.

Methods for measuring emotion reactivity

To examine the internal emotion reactivity process, previous literature has administered baseline and stress-provoking paradigms with preschool-aged children while measuring physiological reactivity. Researchers typically measure the children's HRV during a calm activity, such as watching a neutral video or coloring (i.e., baseline), and then administer a paradigm that is mildly stressful but developmentally appropriate in order to elicit an emotional and physiological response from the preschool-aged children (e.g., Calkins & Keane, 2004; Scheeringa et al., 2004).

To assist researchers with selecting an emotion-eliciting task, the National Institute of Health has compiled the Laboratory Temperament Assessment Battery, a series of tasks that have been validated to elicit various emotional responses from preschool-aged children (LAB TAB; Goldsmith & Rothbart, 1996). For example, to elicit anger/frustration in preschoolers there is a task called "attractive toy in a transparent box," in which a desirable toy is placed into a locked, transparent box and the child has to unlock the box with the wrong keys. Most tasks are designed for use with one child, but there are a few validated options that are aimed to elicit an emotional response from two children at the same, such as a 5-min sharing task (i.e., peers told to play with Play Doh; McElwain & Volling, 2005), a sibling free-play session (Volling et al., 2002), or having caregivers provide differential attention to each child to elicit jealousy from the other sibling (Volling et al., 2002). Although promising, these tasks require that the dyad interact with each other, thus making the quality of their relationship a possible confound in the assessment. In order to examine how the presence of a sibling influences emotion reactivity, the lab tasks needed to sustain the attention of preschool-aged children, elicit emotional reactivity in the context of a sibling, and reduce the need for interactions among the dyad. Recent research has found support for emotion eliciting videos in samples of preschool-aged children (Davis et al., 2016; Gatzke-Kopp et al., 2015; Mikolajewski & Scheeringa, 2018). Thus, the present study employed these tasks in the context of a sibling dyad. Accordingly, the current study measured emotion reactivity while youth watched emotion eliciting videos across three conditions (i.e., alone, with their sibling, with a novel adult) to examine whether there were significant differences in reactivity when in the presence of a sibling versus the other conditions.

Factors that may influence RSA

Quality of the sibling relationship. As mentioned, it is possible that the quality of sibling relationship may impact how youth respond to emotion-inducing experiences. Youth who have a history of affection and cooperation may respond differently in stress tasks than youth who have a more conflictual relationship (Garner et al., 1994; Gass et al., 2007). Although the present study utilized an emotion eliciting stressor that minimized the need for interactions among siblings, the quality of the sibling relationship was also assessed via caregiver report to examine whether this factor influenced physiological reactivity.

Behavior problems. High RSA suppression is often associated with appropriate, adaptive functioning in typically developing children (Cooper-Vince et al., 2017), whereas low RSA suppression has been linked to internalizing problems, externalizing problems, and poor self-regulation skills (Beauchaine et al., 2013; Boyce et al., 2001; Hastings et al., 2008). However, some studies have shown that preschool-aged children with severe behavioral problems may also exhibit a high RSA suppression in response to neutral and challenging tasks (Beauchaine et al., 2013; Gatzke-Kopp et al., 2015). It is suggested that these children are easily aroused or reactive to environmental stimuli, and have difficulties returning to baseline physiologically. For youth with significant behavior problems, their physiological response systems may be more reactive to typical lab stress tasks, suggesting a potentially altered physiological response. For example, children with high (possibly excessive) RSA suppression had significantly higher internalizing symptoms than those with low internalizing symptoms (Boyce et al., 2001). Thus, youth who exhibit behavioral or emotional problems may display altered physiological reactivity, but there is no clear distinction between normative and excessive levels of behavioral problems that may influence physiological reactivity. Therefore, behavioral concerns of the present sample were examined in relation to physiological reactivity.

Adverse life events. Blair and Raver (2012) suggest that exposure to adverse events may be positively associated with emotion dysregulation. Exposure to chronic or acute trauma can significantly impact the central nervous system (Heim & Nemeroff, 2002; Kaufman & Charney, 2001). Frequent or intense exposure to adversity can lead to abnormal development of regulatory processes and a maladaptive fear response (Perry et al., 1995). A previous study showed a significant difference in HRV between the trauma-exposed and the control group when preschool-aged participants were prompted with a trauma-related stimulus (Scheeringa et al., 2004). Participants in the trauma group showed a significant increase in heart rate compared to participants in the control group. This study provides preliminary evidence that trauma exposure may predispose some youth to be more physiologically reactive to typical lab stress tasks. Therefore, the present study assessed for exposure to adverse life events among the current sample.

The Current Study

The current study aimed to provide greater understanding of how siblings may influence emotional processing systems, by examining emotion reactivity while preschool-aged children experienced an emotion-eliciting stressor in the presence of a sibling, in comparison to experiencing the stressor while alone and in the presence of a novel research staff member (henceforth referred to as “adult”). Additionally, the present study examined emotion reactivity via physiological biomarkers (i.e., RSA) to objectively capture internal regulatory processes in real-time. Furthermore, emotion reactivity was operationalized to examine intra-individual patterns of dynamic change in RSA across the baseline and emotion eliciting stress tasks. It was hypothesized that the target children’s physiological reactivity, measured via dynamic change in RSA, would be significantly different for each condition (i.e., alone, with sibling, with adult), and that the sibling condition would exhibit no change in physiological reactivity trajectory. Further, to provide a means of understanding the current findings in the context of the existing literature, the present study also compared mean difference scores for RSA across the three conditions.

Methods

Participants

Participants included 48 sibling dyads and a biological caregiver living in the Midwest. The target child was 3.89 years old (*SD* = 0.48) with 52.1% of the sample female, and a majority Black or African American (83.3 %), followed by 10.4% Multiracial, 4.2% White or Caucasian, and 2.1% Other ethnicity. The sibling participant was approximately 6.40 years old (*SD* = 0.91), 39.6% were female, and a majority were Black or African American (79.2%), followed by 10.4% Multiracial, 4.2% White or Caucasian, 4.2% American Indian/Alaska Native, and 2.1%

Other ethnicity. Regarding caregiver participants (*M* = 30.70 years old, *SD* =4.52), 95.8 % identified as the participants' biological mother, one identified as grandmother, and another identified as Other. All caregivers in the study were the legal guardian of the participating children. Approximately 79.2% of caregivers identified as Black or African American, 8.3% were Multiracial, 6.3% were White or Caucasian, 2.1% were American Indian/Alaska Native, and 2.1% identified as Other. Notably, a large proportion of the sample reported an annual income the fell below 2021 poverty guidelines with 66% of the sample endorsing a household income of less than $20,000 per year and approximately 76.6% of families having three or more children in the home. See Table 1 for additional participant descriptive characteristics.

Participants were recruited from childcare facilities (i.e., Operation Breakthrough; Richardson Early Learning Center; Ervin Early Learning Center) and public libraries in a Midwestern city. Caregivers were informed about the study during pick-up times at the childcare facilities or during events in the community (e.g., Head Start registration; Christmas present sign-up). Some participants were recruited after they completed the Preschoolers' Adjustment and Intergenerational Risk (PAIR) project, a longitudinal, NIH-funded study based in Kansas City which aimed to examine the intersection of trauma exposure and parent-child emotion regulation development. During their final data collection with PAIR, families were offered information about the present study and asked to fill out a form that included their current contact information if interested in participating. Lastly, participants of the present study were given a flyer for the study and asked to share the information with family and friends who may be interested in participating. Through the various recruitment efforts, fifty-one sibling dyads were enrolled in the study (i.e., completed the consent/assent process, caregiver completed study measures, initiated study protocol). Of those enrolled, two of the target children were not able to tolerate wearing the heart rate monitor, and one child refused to separate from their caregiver. These three participants were excluded from the present analyses. Regarding eligibility criteria, youth participants had to be biological siblings who were between 3-7 years old with the younger child aged 3 or 4, living in the same household, and were English-speaking. Children were excluded if they did not have a sibling within the age range, if they were in foster care, if they were diagnosed with Autism, or if they had a serious medical condition (e.g., heart condition; seizure disorder).

Procedures

Pilot study. A pilot study was conducted in the fall of 2017 at a nearby childcare facility to develop the study procedures. Due to the novelty of using existing emotion eliciting tasks within a dyadic context with preschool-aged children, the pilot study aimed to test possible study procedures (i.e., feasibility of administration; order of protocol; observations of behavioral responsivity). Regarding testing of the emotion eliciting stimuli, we aimed to observe whether the tasks sustained the attention of the preschool-aged dyad, initiated an emotional response, and altered the interactions among participants. Caregivers provided written consent for 4 sibling dyads and 4 non-sibling peers to participate in the pilot study (N = 12; M_{age} = 5.39 years, 58% female). Due to children leaving the childcare facility and absences, only 3 sibling dyads and two peers (n = 8) participated in pilot study procedures. The target child (i.e., younger sibling) completed study procedures with their sibling and then with a randomly assigned peer. Each dyad watched a 3-minute neutral baseline video. The target child completed one stress inducing task with their sibling and a different stress inducing task with an unfamiliar peer (i.e., emotion eliciting video clip and suspenseful story; Davis et al., 2016; Rifkin et al., 2016). The order of each emotion eliciting task was counterbalanced to minimize order effects. After each stress task, a neutral recovery video was shown to the dyad.

Quantitative data was not obtained from the pilot study, but observations and procedural processes informed the methods for the current study. First, it was expected that the suspenseful story would elicit an emotional response from participants. However, the suspenseful story did not sustain participants attention (i.e., looking around the room; trying to talk to study staff while the story was being read), nor did it elicit an observed or reported emotional response from any of the participants during the pilot study. Second, it was expected that the peer participant would serve as a novel individual in contrast of the sibling participant. However, during the data collection procedures, it became clear that the target child and peer participants knew each other despite researchers intentionally matching children from different classes, possibly due to playing on the playground together. This was concerning because a potential relationship between the target child and peer could have had an unanticipated impact on their emotion responsivity to the stimulus (i.e., peer could serve as a comfort or conflict for some but not others during the emotion eliciting task). Additionally, the pilot testing showed that various interactions occurred between the target child and peer participant (e.g., some peers did not acknowledge the other participant's presence; other peer dyads were talkative and initiated play together). Although it was unclear why some peer dyads interacted more than others (e.g., possibly participants knew each other; temperament and personality of peer participants may differ), the variability in interactions among dyads led to the decision to use a comparison group that researchers had more control over (i.e., a novel adult). Based on these findings, a number of modifications were made, namely eliminating the suspenseful story, obtaining other emotion-inducing video clips that were equivalent in content (i.e., cartoon video clips from G-rated movies), and replacing the peer component with a research staff member (i.e., novel adult) so that procedures could be standardized.

Data collection procedures. Data collection took place at public county libraries in a quiet, private room away from the public. Researchers obtained informed consent from caregivers and verbal assent from youth participants. The younger child, henceforth referred to as the "target child." Caregivers completed the assessment measures for the target child and then the sibling participant while the children participated in the lab-based activity.

After the consent and assenting process, the research staff secured a telemetry-based heart monitor on the target child's chest to measure physiological reactivity during the lab-based tasks, which involved watching emotion eliciting videos during three different conditions (i.e., alone, with their sibling, and with an adult). The conditions were counterbalanced to minimize order effects and the videos were counterbalanced to minimize video effects. Prior to the conditions, the child(ren) were instructed to stay seated and watch the videos to reduce physical activity that could interfere with physiological data. The target child was present for each condition, whereas the sibling participant was only present for the sibling condition. Each condition began with a 2-minute neutral baseline video to examine HRV while at rest. Next, an emotion eliciting video was introduced, which involved animated video clips from common children's movies (i.e., *The Secret of NIMH; The Lion King; The Rescuers;* see more information below). After each emotion eliciting video, the target child (and sibling during the sibling condition) watched a 1-minute recovery video to initiate physiological recovery (i.e., videos depicted nature, space, and landscape scenes). A previous study indicated that a recovery video of at least 30s is necessary to reduce carry-over effects of the previous emotion (Gatzke-Kopp et al., 2015). Data collection procedures are depicted in Figure 1 below.

The older child participant, henceforth referred to as “the sibling” or the “sibling participant,” did not wear a heart monitor and was only present during the sibling condition. During the alone and adult condition, the sibling participant was provided quiet activities to play with (i.e., coloring, stickers, iPad games, books) in a separate room with their caregiver and a research staff member. A research staff member was present during each of the conditions. Only one sibling dyad engaged in physical and verbal aggression during the baseline video of the sibling condition. This dyad was redirected to keep their hands to themselves and quietly observe the videos. The sibling dyad was compliant with research staff instructions and were able to remain in the study. All data collection procedures were videotaped for accurate timestamps for HRV.

Measures

Demographics. Caregivers provided information on age, gender, race/ethnicity, and health conditions of each child participant. Additionally, caregivers disclosed information about their own age, gender, race/ethnicity, number of children living the home, education level of biological parents, and household income.

Emotion induction videos. Previous research with children has demonstrated the effectiveness of inducing emotions using excerpts from animated films (Davis et al., 2016; Gatzke-Kopp et al., 2015). The three clips used in the present study were from *The Secret of NIMH* (a mouse enters an owl’s lair to seek help; approximately 5 minutes), *The Lion King* (Simba and Nala enter the elephant graveyard; approximately 4 minutes), and *The Rescuers* (two detective mice help the protagonist find a diamond ring in a cave; approximately 4 minutes). Although the videos differed for each condition, they were expected to elicit a similar emotional response (i.e., depicted scary/suspenseful scenes to elicit a fear response). Despite differences in lengths of emotion induction videos, the first six-30s epochs in each video were used to calculate the dynamic change in RSA reactivity during stress-inducing task. Additionally, a total mean RSA score across the six epochs was calculated for each emotion eliciting video.

Baseline videos were presented before each of the emotion eliciting videos. The baseline clips did not contain any emotional content (i.e., screensavers from Windows computers in the 1990s). The first four-30s epochs from each baseline video were used to calculate the dynamic change in RSA at baseline. Additionally, a total mean RSA score was calculated for each baseline video.

Heart rate reactivity. The target children wore a heart rate monitor throughout data collection procedures. Heart activity data was continuously recorded via a 1-lead electrocardiogram (ECG; Berntson et al., 1997). The Actiwave Cardio was used for data collection procedures (CamNtech Ltd and CamNtech Inc., 2017). This heart rate monitor is a single channel ECG waveform recorder that consists of two electrodes connected by a short lead that clips onto two standard ECG pads. The electrode pads were worn on the target participants' chests. The heart rate monitor transferred data from the recorder to a computer via a USB cable and the Actiwave software program.

To assess heart rate reactivity, physiological data was timestamped based on video recordings from data collection conditions. Heart activity data was edited for artifacts and then analyzed using the CardioEdit/CardioBatch Plus program by Keri Heilman, Ph.D., Assistant Professor in the Department of Psychiatry at the University of North Carolina School of Medicine. Dr. Heilman is an expert in polyvagal theory and HRV. She leads the CardioEdit/CardioBatch Plus Training Workshop for researchers across the country. The Porges (1985) method for calculating HF-HRV was utilized, which applies an algorithm to the sequential heart period data (i.e., each 30 second segment). The Cardio Batch/Cardio Edit utilizes this method of calculation when analyzing the heart activity data to produce the RSA values for each time period indicated by the researcher. RSA scores are indicative of parasympathetic functioning in the ANS.

For the current study, RSA values for each 30-s epoch across the baseline and emotion eliciting videos were calculated, which resulted in four 30-s epochs for the baseline video and six 30-s epochs for the emotion provoking video. Each condition consisted of 10 epochs; therefore, each target child had 30 occasions of RSA. To examine RSA reactivity via 30-s epochs for hypothesis testing, the present study compared changes in RSA slope from the baseline to the emotion eliciting video segments (see data analytic plan for details).

To understand the findings in the context of the existing literature, the present study also calculated an overall mean RSA score for each baseline and emotion eliciting video segment for the post hoc analyses. Mean difference scores were calculated to examine RSA reactivity from baseline to emotion eliciting video for each condition. For these scores, positive values are indicative of RSA suppression or withdrawal (increased arousal) and negative values indicate RSA augmentation (decreased arousal). The overall mean difference scores in each condition were all positive (i.e., $M_{Alone} = 0.281$, $SD = 0.903$; $M_{sibling} = 0.0028$, $SD = 0.683$; $M_{Adult} = 0.269$, $SD = 0.960$), which suggests that there was an increase in arousal from baseline to fear stimulus for each condition.

Child behavioral concerns. Caregivers’ perceptions of the target child and their siblings’ behavior problems were assessed with the Devereux Early Childhood Assessment – Clinical Form (DECA-C; LeBuffe & Naglieri, 2003). The DECA-C is a standardized and norm-referenced 62-item rating scale that evaluates the social and emotional resilience and concerns of children ages two- to five-years,11 months. The DECA-C consists of the Total Protective Factors domain scale with three subscales (i.e., initiative, self-control, and attachment) and the Behavioral Concerns (BC) domain scale. In the current study, child behavior problems were evaluated via the BC scale, which includes subscales for Withdrawal/Depression (i.e., emotional or social withdrawal from reciprocal interactions with peers or adults), Emotional Control Problems (i.e., difficulty modifying overt expression of negative emotions), Attention Problems (i.e., child's ability to focus while ignoring other stimuli), and Aggression (i.e., hostile or destructive acts toward others or things). The child participants were rated by their caregiver on a Likert scale ranging from 0 ("never") to 4 ("very frequently"). T-scores were used to examine descriptive statistics and bivariate correlations. A t-score of 60 and above indicates a potential problem area. In a review of social and emotional measures for early childhood, the DECA-C was identified as having strong reliability and validity (Halle & Darling-Churchill, 2016) with internal consistencies in the acceptable range for parent report of ethnically diverse preschool-aged children (α = .71-.94; Crane et al., 2011). For the present study, data were screened for violations of normality. One item on the Withdrawal/Depression subscale for the sibling participants fell beyond the recommended guidelines for skewness (i.e., 3.523; "have no reaction to children/adults?"). This item was omitted from all subsequent analyses. The internal consistencies for the present study were in the good (α = .89; target child) and the excellent range (α = .93; sibling child). While the measure was normed on a sample of children 2-5 years, the DECA-C was administered to all children in the current study, including the sibling participants who ranged in age from 4-7 years old. Past literature has used this measure in a sample of 4-7-year-old children (Anticich et al., 2013) and the internal consistency of the BC scale for the siblings fell in the excellent range.

Sibling relationships. Caregivers rated the target child and the sibling participant on their quality of engagement with their sibling via the Sibling Relationships in Early Childhood questionnaire (Volling, 1997). On this 18-item measure, caregivers provided responses on a 5-point Likert scale from 0 (never) to 4 (always). The Positive Involvement subscale was 8-items (e.g., “has fun or a good time with sibling”) and the Conflict/Rivalry subscale consisted of 7-items (e.g., “has physical fights with older sibling, not just for fun”). The Avoidance subscale consisted of 3-items and it was not used in the current analyses. Sum scores for the Positive Involvement and Conflict/Rivalry subscales were used to examine descriptive statistics and bivariate correlations. All items were screened for violations of normality. The internal consistency for the present study was in the good range for the sibling participant (i.e., $\alpha = .82$ for Positive Involvement; $\alpha = .83$ for Conflict/Rivalry). The internal consistencies were slightly lower for the target child and fell in the questionable and acceptable range ($\alpha = .61$ for Positive Involvement; $\alpha = .78$ for Conflict/Rivalry, respectively).

Exposure to Adverse Life Events. Exposure to lifetime adversity was measured via caregiver report on The Childhood Trust Events Survey, a 26-item checklist, which was adapted from the Traumatic Stress Survey (Baker et al., 1998). Item response options include 0 = “no” or 1 = “yes.” The sum of the items endorsed as “yes” were examined for descriptive statistics and bivariate correlations.

Data Analytic Plan

Power analysis. A power analysis was conducted to determine the minimum sample size needed for examining intra-individual differences in physiological reactivity via a multivariate model. Previous studies that measured RSA suppression in preschool-aged children while completing challenging activities that elicit frustration yielded small effect sizes ($d = .253$;

Brooker & Buss, 2010). An a priori power analysis was completed for a repeated measure, within factors ANOVA with $\alpha = .05$, power = .80, and small effect size, which indicated that a sample size of 24 dyads is required. As a repeated measures ANOVA, this power analysis provides a conservative estimate for the sample size since it only allows one mean per participant, whereas the multilevel multivariate model estimates more data per participant (i.e., running averages across baseline and emotion eliciting phase). The present study included 48 participants, which was sufficient power to run the subsequent analyses and detect the fixed and random effects.

Descriptive statistics. Correlation analyses were estimated to evaluate the bivariate associations among the target children's and sibling participants' caregiver-report study variables. Independent t-tests were completed to examine differences between target children and sibling participants' study variables. Next, bivariate associations were examined between the target children's study variables (i.e., demographics, behavior concerns, positive involvement subscale, conflict/rivalry subscale, adverse life events) and the target children's mean RSA values for each emotion eliciting and baseline video segments across the three conditions.

Hypothesis testing. A two-level growth curve model was used to examine the hypothesis that the target children's physiological reactivity, measured via 30s epochs in RSA from baseline to emotion eliciting condition, will be significantly different for each condition (i.e., alone, with sibling, with adult). Individual differences in RSA reactivity was examined in a series of multivariate multilevel models (i.e., general linear mixed models). The target child's dynamic RSA epochs (i.e., 4 epochs for baseline and 6 epochs with the emotion-eliciting stressor) at Level-1 were nested within each participant at Level-2. As mentioned, the videos and conditions were counterbalanced to reduce order effects, which means that reactivity from each baseline video and emotion eliciting video for the three conditions retained their own intercept and slope, resulting in six separate conditions that were examined in the models (i.e., Alone-baseline, Alone-stimulus, Sibling-baseline, Sibling-stimulus, Adult-baseline, Adult-stimulus). To reduce confusion, these six conditions will be referred to as *segments.* The slopes from these six segments (3 baseline, 3 emotion eliciting) were modeled simultaneously as multivariate predictors. Model parameters were estimated using restricted maximum likelihood (REML) and the PROC MIXED procedure in SAS (University Edition; SAS Institute Inc., 2014). The significance of random effects was tested with likelihood ratio tests, whereas the significance of fixed effects was evaluated by their individual Wald tests *p* values using Satterthwaite denominator degrees of freedom. This method appropriately models the error structure associated with repeated observations over time and accounts for missing outcomes (Hoffman, 2015). The current study consisted of very little missing data (0.7%). Effect sizes are reported using pseudo-R^2, or the proportion reduction in each variance component, as well as total-R^2, the squared correlation between the original outcome and the outcome predicted by the model fixed effects.

Multilevel models were built using a hierarchical approach. First, a saturated means, unstructured variance model was estimated to determine the best fit for both sides of the model (i.e., means and variance side). Then, an empty means model was estimated to partition the variance in RSA across levels, and a level-2 random intercept variance for segment was added to the model. Next, the fixed effects of intercept and a linear slope for each segment was added to the model to determine if there were significant changes in RSA on average across the segments. Finally, a level-2 random slope variance was added to the model. Likelihood ratio tests were used to determine best model fit. Estimate statements were examined for hypothesis testing.

Post hoc Testing. Past research has examined RSA reactivity by calculating a mean difference score from baseline to emotion eliciting stimulus. A one-way ANOVA was completed to examine significant differences between the conditions using mean difference scores. Finally, pairwise-samples *t*-tests were used to determine whether physiological reactivity occurred, by examining whether mean RSA during emotion eliciting videos was statistically different than mean RSA at baseline.

Results

Descriptive Statistics

Means, standard deviations, and independent t-test results comparing the target child and sibling child's caregiver-report of study variables are found in Table 2. There were no statistically significant differences between the child participants on any of the study variables. Regarding the BC scale, 27.1% of the target children and 25% of sibling participants across the sample had T-scores of 60 or higher, which is indicative of a potential problem area. There were six caregivers (12.5%) who endorsed scores in the potential problem area for both of their children in the study. The bivariate correlations describing associations between the target children's and sibling children's study variables are presented in Table 3.

The bivariate correlations describing associations between caregiver-report of the target child's study variables and mean RSA values were used to determine possible covariates and are presented in Table 4. The target child's Positive Involvement subscale was the only construct that showed significant positive associations with mean RSA during the sibling and adult emotion eliciting segments. Therefore, this construct was included in the model as a covariate. Due to the number of parameters being estimated in the multilevel model, Positive Involvement was the only covariate entered into the model.

Multilevel Models

RSA reactivity was examined in 48 target children when they were watching emotion eliciting videos alone, with their sibling, and with a novel adult. Intraclass correlations calculated from an empty means, random intercept model was .66 for RSA, such that 66% of the variance in the outcome was between persons, respectively. The saturated means model was used to determine the best model fit for the data. RSA for each epoch was graphed. There was a slight reactivity observed at the first epoch (See Panel A from Figure 2). To account for this deviation from the linear trajectory, the second occasion became the reference point and a deflection was modeled at the first occasion. The predicted fixed effects for slope were graphed in comparison to the saturated means model and a linear fit was determined as most appropriate for the data. See Panel B from Figure 2. As observed in the graph, the predicted means, with the modeled deflection, closely resemble the saturated means, particularly for the slope of the alone and adult condition.

Random Slope Effects

The random slopes for each segment were simultaneously entered into an omnibus model to estimate the variance attributed to the outcome. Compared to the level-2 random intercept model, results indicated that the addition of the level-2 random slope variance for each of the segments resulted in an improvement in model fit $-2\Delta LL(57) = 108.994$, $p < .001$. A significant random effects model means that the variances around the intercept and slope suggest that the parameter estimates varied across participants and represent individual differences in linear change that occurred across the conditions for the baseline and emotion eliciting segments.

The effects for intercept and linear slope for each segment were entered into the random slope model, along with the Positive Involvement covariate. Adding fixed effects for each segment resulted in a total-$R^2 = 0.004$ for the Alone-baseline, total-$R^2 = 0.002$ for the Alone-stimulus, total-$R^2 = 0.005$ for the Sibling-baseline, total-$R^2 = 0.0008$ for the Sibling-stimulus, total-$R^2 = 0.001$ for the Adult-baseline, and total-$R^2 = 0.002$ for the Adult-stimulus. Although the fixed effects for slope at each segment were nonsignificant, the slopes for the baseline segment with the sibling ($\beta = -0.114$, $p = 0.054$) and alone ($\beta = -0.121$, $p = 0.074$) were approaching significance. See Table 5 for fixed effects. These findings suggest that there was no change in reactivity on average for any of the segments. Due to the limitation of power, other fixed effect factors could not be entered into the model, as the model would not converge with the additional parameters to estimate.

For hypothesis testing, contrast statements were used to examine RSA reactivity (i.e., comparing change in slope from baseline segment to emotion eliciting segment) across the three conditions (i.e., alone, sibling, adult). Results indicated that there was no statistically significant difference in RSA reactivity $F(2, 118) = 0.63$, $p = 0.535$. Additional results showed that there were no statistically significant differences in RSA reactivity when directly comparing the alone condition to the sibling condition $t(98.1) = -0.57$, $p = 0.572$, the alone condition to the adult condition, $t(129) = 0.46$, $p = 0.646$, and the sibling condition to the adult condition $t(122) = 1.12$, $p = 0.266$. Results indicate that the null hypothesis is retained, as the target participants physiological reactivity was not significantly different during the sibling condition.

Given that there were no changes in RSA reactivity across the three conditions, contrast and estimate statements were used to compare differences in slope trajectory between the alone, sibling, and adult conditions for each of the baseline and emotion eliciting segments, separately (i.e., examining whether the slopes were statistically different during the emotion eliciting segment when participants are with their sibling vs. the other two conditions). Results showed that there were no statistically significant differences between the three segments at baseline F(2, 111) = 0.24, *p* = .788, nor for the emotion eliciting video segments F(2, 84.7) = 1.57, *p* =.215. To compare two segments directly, estimate statements were examined between each of the baseline and emotion eliciting segments. None of the comparisons were significant (see Table 6 for results). This finding suggests that the RSA trajectory exhibited per segment did not statistically differ from the other segments for the target children regardless of whether they were alone, with their sibling, or with an adult.

Testing for physiological reactivity from baseline. Estimate statements were examined to determine if there was a statistically significant difference between the baseline trajectory and emotion eliciting trajectory within each condition. Results suggest that there was no significant difference between the baseline trajectory and emotion eliciting trajectory for the alone condition *t*(115) = −1.20, *p* = 0.232, the sibling condition *t*(96.8) = −1.96, *p* = 0.053, or the adult condition *t*(144) = −0.71, *p* = 0.479. Findings suggest that the physiological trajectory exhibited during the emotion eliciting segments by the target children was not statistically different than the physiological trajectories at baseline. Importantly, the baseline and emotion eliciting videos were counterbalanced across conditions, thus results indicate that the emotion eliciting videos were not taxing enough to elicit a physiological arousal that was significantly different than the physiological response occurring during baseline.

Post-hoc testing

The analytic approach to examine differences in physiological reactivity via dynamic change was nonsignificant across the three conditions. While this is a robust way to examine RSA reactivity, it is less common than utilizing mean difference scores for examining reactivity (i.e., difference between overall mean from stress induction task and overall mean from baseline). To interpret the findings in the context of the existing literature, a one-way ANOVA was used to compared mean difference scores in RSA reactivity across the three conditions to evaluate whether results are similar to the comparison tests using dynamic changes in RSA reactivity. Results from the one-way ANOVA analyses indicated that there were no significant differences in RSA reactivity across the three conditions, F (2, 139) = 1.589, p =0.208. Pairwise-samples t-tests were used to examine direct comparisons across the three conditions on differences in mean RSA reactivity. There were no significant differences in mean RSA reactivity between the alone condition and the sibling condition $t(46) = 1.01$, $p = 0.318$, between the sibling and adult condition $t(46) = -1.61$, $p = 0.114$, and between the alone and adult condition $t(47) = 1.00$, $p = 0.323$. Findings are consistent with the comparison tests from the multilevel model, indicating that there were no significant differences in reactivity across the three conditions (i.e., alone, sibling, adult), which confirms the null hypothesis that sibling presence does not influence statistically significant changes in RSA reactivity.

Testing for physiological reactivity from baseline via mean scores. Pairwise-samples t-tests were used to examine if there was a statistically significant difference between the mean RSA during the emotion eliciting video compared to the baseline video within each condition. Results indicate that there was a statistically significant difference between baseline and emotion eliciting video for the alone condition $t(46) = -2.136$, $p = 0.038$, and the adult condition was approaching significance $t(47) = -1.944$, $p = 0.058$. There was no significant difference between the baseline and emotion eliciting video for the sibling condition $t(46) = -0.028$, $p = 0.978$. Given that the videos were counterbalanced across the conditions, these findings suggest that there may have been an increase in physiological reactivity (increase in arousal) for the alone condition, but not the other two conditions (albeit the adult condition was approaching significance).

Discussion

Theoretical perspectives and previous research suggest that siblings may contribute to the development of emotion reactivity and regulation processes. Social learning theory and family systems theory suggest that siblings offer a stable context to learn about diverse emotion expression through opportunities to model emotional behaviors, serve as playmates, and provide a source of support or assistance (Bandura, 1977; Campione-Barr & Smetana, 2010; Kramer, 2014; Minuchin, 1974; Whiteman et al., 2011). However, a majority of the research on emotion reactivity and emotion regulation development for youth has focused on parenting behaviors (Cole et al., 2003; Eisenberg et al., 1998; Gudmundson & Leerkes, 2012; Kiel et al., 2020; Kohlhoff et al., 2016). Furthermore, theoretical reviews of emotion processes, suggests that emotions and emotion reactivity involve micromomentary shifts in internal, neurophysiological processes inferring and responding to new evidence being processes by the changing environmental demands (Cole et al., 2004; Curtis & Cicchetti, 2007; Gross et al., 2011; Pattyn, 2009). The present study expanded the current literature by examining the influence of sibling presence on intra- and inter-individual fluctuations in emotion reactivity via physiological methodology.

Results from the current study indicate that a significant proportion of variance in reactivity can be attributed to individual differences. Inconsistent with the proposed hypothesis, results indicated that there were no significant differences in the target children’s physiological reactivity across the conditions. Additionally, there were no significant fixed effects of slope for each of the segments in the multilevel model, suggesting that there was no change in RSA on average across persons.

Bivariate associations among factors that influence emotion reactivity

Although the primary aim of the current study was to examine the dynamic change in RSA reactivity, extant literature has identified constructs that influence how youths respond to environmental stimuli, such as quality of the sibling relationship, behavioral problems, and exposure to adverse life events. Bivariate correlations were examined among these factors. To provide some context of the present sample, associations were examined between the target child and the sibling participant. First, the sibling dyad's age, race, and total number of adverse life events were positively associated with each other. These findings were expected as the children were close in age (i.e., between 3-7 years old), were biologically related, and were living in the same family context so likely experienced similar adverse experiences. Next, the target children's behavioral concerns were positively associated with the sibling participants' behavioral concerns. Although these are cross-sectional correlations and thus not causal relations, the significant association is consistent with past research that suggests that children who engage in problematic behavior often have siblings who also exhibit behavior problems (*siblings as key pathogens theory*, Buist et al., 2013; Slomkowski et al., 2001).

Regarding qualities of the sibling relationship, the average scores for the Positive Involvement subscale for the target children and sibling participants in the present study were consistent with average scores from prior studies (i.e., sum score = 28.70; Volling et al., 2002), whereas scores for the Conflict/Rivalry subscale in the present study (i.e., sum scores = 10.42, 9.96) were lower than previous samples (i.e., sum score = 15.51; Volling et al., 2002). Participants in Volling et al., (2002) were slightly younger (ranged from 16 months to 6 years), lived in maritally intake families, and the average family income was $73,607. Discrepancies between the average scores on the Conflict/Rivalry scales may be due to the prior sample including much younger children, who may have been ranked higher on items of physical aggression (i.e., "Has physical fights with sibling") or facial cues (i.e., "Frowns or pouts when sibling has to be with him/her") due to their limited verbal abilities and skills to vocalize frustration. Additionally, it is possible that siblings from the current sample exhibited less conflict towards each other than previous studies.

Bivariate correlations in the current study indicate that the Conflict/Rivalry subscale was positively related, and the Positive Involvement subscale was negatively associated with Behavioral Concerns for both participants. These findings are consistent with a meta-analysis which found significant associations between externalizing problems, sibling conflict, and sibling warmth (Buist et al., 2013). However, it is important to note that the mean score for Behavior Concerns fell in the typical range for the target children and sibling participants in the present study (i.e., T-scores = 53, 52, respectively). Further, the results from the current study showed a moderate positive association between the target children's Conflict/Rivalry subscale and the sibling participants' Conflict/Rivalry subscales. Past literature has shown that older sibling's reactive aggression was positively associated with the younger sibling's reactive aggression (Frazer et al., 2018). Next, the target child's Positive Involvement subscale was positively associated with the sibling participant's Positive Involvement subscale, which is consistent with attachment theory and affectional bond among siblings (Berlin et al., 2008; Fraley & Tancredy, 2012). Findings suggest that target children's prosocial engagement toward their siblings is related to higher values of sibling participants' exhibition of positive, prosocial involvement. Although these results are not predictive, it appears that warmth displayed among siblings may be reciprocal. Additionally, Positive Involvement with a sibling was negatively associated with the Conflict/Rivalry subscale for both participants. These findings are supported by past research which suggests sibling dyads who engage in higher levels of conflict are less likely to display warmth towards one another (Slomkowski et al., 2001). Interestingly, the Conflict/Rivalry subscale for the target children was positively associated with sibling participant's age. It is certainly possible that when siblings get older, they may start to gain more independence and engage in less activities with their younger sibling, which could elicit the younger child to engage in more conflict and aggression. Finally, independent t-tests revealed that there were no statistically significant differences between the child participants on any of the study variables. Results indicate that caregivers endorsed similar rates of behavior problems, sibling relationship characteristics, and adversity across target children and sibling participants. While correlations may show potential trends in the data between the participants, there were no systematic differences between the older siblings and younger target children.

Regarding exposure to childhood adversity, age of the child was positively associated with the total number of adverse life events for both participants. This association is expected since children who are older have higher adversity scores, because they have had more opportunities to encounter adversity. For the present study, 61.7% - 66.7% of the child participants experienced at least one adverse life event, with over 20% of the sample having experienced 4 or more childhood adversities. To put this in perspective, past research indicates that approximately 62-66% of adults have experienced at least one adverse childhood experience (Felitti et al., 1998; Merrick et al., 2018), and yet that same prevalence rate exists for the current sample except the children in this study were all under 8 years old. Additionally, some of the participants in the present study have experienced as many as 8 or 9 different adverse life events, which equates to more than one per year since they were born. The high degree of adverse life events in the present sample may be due to the high rates of poverty and economic disadvantage endorsed by participants' caregivers. Recent work suggests that poverty contributes to the accumulation of adversity, and that those living in poverty are more likely to experience frequent and intense childhood adversity compared to their peers (Anda et al. 2010; Hughes & Tucker, 2018; Steele et al., 2016).

In examining the bivariate correlations between physiological reactivity and the constructs that are thought to influence emotion reactivity, the only significant indicator associated with mean RSA values was the target child's Positive Involvement subscale. In particular, positive involvement showed small positive associations with RSA from the sibling emotion eliciting segment and the adult emotion eliciting segment. While previous literature has found associations between a positive sibling relationship and healthy emotion regulation (Kennedy & Kramer, 2008), the present study extends this work by finding a link between positive involvement with a sibling and youths' physiological reactivity during an emotion eliciting stressor. Finally, the mean RSA values for each segment were positively associated with each other, which was expected given that the data was clustered within individual. Given the high degree of relatedness among the RSA values, the results provided additional support for the decision to examine these constructs within a multilevel model.

Examinations of physiological reactivity across conditions: Hypothesis testing

The present study aimed to examine preschool-aged children's physiological reactivity when they are experiencing an emotion eliciting stressor with their sibling compared to the other conditions. Inconsistent with the proposed hypothesis, results from the multilevel modeling tests of linear functions indicated that there was no significant difference in physiological reactivity when participants were with their sibling, in comparison to being alone and with an adult. Findings suggest that the mere presence of a sibling may not necessarily influence young children's physiological reactions to stimuli. Additional comparison testing that examined physiological trajectory during baseline-only and emotion eliciting-only segments also indicated no statistically significant differences across the conditions. Social learning theory and family systems theory suggest that the sibling relationship is integral to emotional processing and emotion regulation development. While there have been review articles (Kramer, 2014) and book chapters (Dunn, 2015; Kramer et al., 2019; Maynard et al., 2016) devoted to theorizing how siblings contribute to the socialization of emotions, the present study contributes to this body of work by providing evidence that youths' physiological reactivity is not statistically different when encountering a stress inducing stimuli *in the presence* of a sibling.

There may be a couple of explanations for these findings. First, internal response systems are thought to be innate in nature, such that they are responding to environmental stimuli prior to conscious and cognitive appraisal processes (Campos et al., 2004; Gross et al., 2011). It is possible that initial emotional reactivity may have been solely due to the attention directed at the emotion eliciting stressor with little regard for other environmental factors, such as others in the room. However, this unconscious responsivity explanation is likely only plausible for the first milliseconds of a lab-based task, as emotion reactivity and regulation processes are initiated. Emotion processing literature suggest that these co-occurring systems (i.e., reactivity and regulation) involve attention, appraisal, inhibition, and response (Gross & Thomas, 2007; Gross et al., 2011), ensuring that youth likely integrate the presence of other individuals into their regulation and reactivity processing at some point. The existing methodological approaches used within the field are unable to detect exactly when awareness of environmental factors enter consciousness and how this new information is synthesized and integrated into one's regulation processes (Gross et al., 2011). Thus, there is an assumption that target participants integrated the environmental conditions (i.e., whether their sibling was present, or a novel adult was sitting near them, or they were alone) at some point during the task, and the results showed that others present in the participants' environment did not differentially influence their reactivity to the stimulus. Given what is known about emotional processing systems, it is more likely that 1) the sibling presence has minimal influence on youths' RSA or 2) the tasks were not taxing enough to make the presence of a familiar individual impactful on RSA.

Although the null hypothesis was retained, findings contribute to the literature by providing first-time evidence that the presence of a sibling during an emotion inducing stressor does not significantly influence physiological reactivity over and above the comparison conditions. The current study used a methodological approach that involved passive engagement in an emotion eliciting stimuli to understand whether having one's brother or sister nearby when encountering a potentially stressful stimuli impacted a physiological response. Sibling influence on emotion processing may instead involve a series of complex, interactive experiences over time. In fact, much of the past work examining the sibling influence on emotion regulation development suggests that interactions during pretend play with siblings is associated with increased discussions about feelings (Howe et al., 2005) and better social understanding (Youngblade & Dunn, 1995). Further, engagement in sibling conflict has been linked with learning ways to regulate intense emotions (Conger et al., 2009; Kramer, 2014). Additionally, the quality of the sibling relationship, particularly those characterized as exhibiting greater warmth and closeness, has been associated with greater levels of emotional understanding (i.e., Kramer, 2014; Stocker et al., 2002; Volling et al., 2002). Thus, this body of work suggests that interactive behaviors among siblings has a stronger influence on emotion regulation processes. The influence of a sibling during stress evoking situations, may require more than just having the sibling sit near them while it happens. The influence of a sibling on emotion reactivity and regulation processes may involve more active engagement among the dyad, such as comforting statements, physical touch, modeling of calm composure, or problem solving efforts to obtain additional resources (e.g., “let’s go find an adult”). Although sibling presence may not directly influence changes in physiological reactivity, the variance in reactivity may also be driven by individual differences across participants.

Individual differences in physiological reactivity

Multivariate analyses indicated that the random slope model offered a significantly better fit to the data. Findings indicate that there were individual changes in physiological trajectory during the conditions (i.e., reactivity differed between participants so a model that allows all participants to have their own slope trajectory fits the data better). These results are consistent with previous studies on physiological reactivity of children (Blandon et al., 2008; for reviews, Kreibig, 2010; Smith et al., 2020), which suggests that individual differences in physiological reactivity exist. The present study builds on this work by finding that individual differences in reactivity remain even when examining momentary shifts in RSA trajectory (i.e., dynamic changes) across baseline and emotion eliciting segments, as past studies have primarily used total mean scores during induction tasks or examined reactivity via change score from baseline to stimulus. Further, two prior studies measured incremental changes in RSA and set the foundation for this methodological approach (Brooker & Buss, 2010; Creaven et al., 2014). The present study expanded on this work by examining dynamic changes across both baseline and emotion inducing task within the same model to capture a true snapshot of emotion reactivity, as past work measured dynamic changes in RSA when participants were at rest (Creaven et al., 2014) or during a stress task (Brooker & Buss, 2010). To truly understand emotion reactivity and regulation via physiological measures, it is crucial to examine how RSA changes from baseline to the emotion inducing stimulus.

By examining trajectories in RSA across 30s epochs of the baseline and emotion eliciting stimuli, the present study accounted for unique variance attributed to individual fluctuations in reactivity across the segments. However, results from the present study also found nonsignificant fixed effects of slope, which suggest that there were no on average changes in physiological reactivity (i.e., no within-person change in physiology on average). Although the present study provided first time examination of momentary changes in RSA reactivity across the baseline and emotion eliciting segments, results suggest that examining physiological reactivity via momentary changes in RSA may not be necessary, as there were not enough within-person changes in RSA over the course of the baseline or emotion eliciting segments.

Emotion inducing stimuli

The present study aimed to examine emotion reactivity and regulation processes via physiological methodology while participants were exposed to emotion inducing stimuli. Results from the multilevel model comparison testing indicated that there were no statistically significant differences in RSA slope trajectory between the baseline and the emotion eliciting segments for any of the conditions (i.e., no significant change in physiology from the emotion eliciting slope compared to the baseline slope). These findings suggest that the emotion eliciting videos may not have been stimulating enough to yield a significant change in slope trajectory during the emotion eliciting segments. The methodological design was built on past studies that have tested similar stress provoking videos with preschool-aged children (Davis et al., 2016; Gatzke-Kopp et al., 2015). The videos used in these studies were also used in the present study. In Davis et al. (2016), paired-samples *t*-test showed that there was a significant difference between the baseline and fear video (i.e., *The Secret of NIMH*). Gatzke-Kopp et al. (2015) calculated a mean difference score from baseline to the emotion eliciting video; however, they did not report any analyses that assessed for significant differences in reactivity from baseline to fear video (i.e., *The Lion King*). Each of these studies used mean scores from the baseline and emotion eliciting videos in their analyses, thus the present study extended this past work by comparing RSA trajectories (i.e., slope from 30-s epochs) during baseline and emotion eliciting segments.

One possibility for this discrepancy in reactivity may be due to the differences in populations sampled. For example, Davis et al., (2016) sampled children from a rural area in the northeastern region of the United States, who were 90.1% White and 64.9% of the sample had a household income over $60,000. Given the high adversity exposure of the participants in the current study, it is possible that their life experiences require a higher threshold for emotion eliciting lab-based tasks than those commonly used in the literature. Exposure to frequent environmental adversity may be related to less emotional and physiological reactivity in general. For some of these children who have experienced adversities, such as abuse and conflict within the home, watching a short clip from a children’s movie may not be taxing enough to trigger a physiological reaction.

Interestingly, results from the post hoc analyses that compared mean RSA at baseline to mean RSA during emotion eliciting video for each condition via paired-samples *t*-tests showed that there were significant differences for the alone condition, and the adult condition was approaching significance. Results indicate that there was significant reactivity occurring in the emotion eliciting segment that differed from baseline during the alone condition, which is consistent with past studies that also compared mean RSA scores across baseline and emotion inducing videos (Davis et al., 2016). These results differed from the multilevel analyses, which compared RSA trajectory across the baseline and emotion eliciting segments and accounted for nesting within individual. While the multilevel model is a more robust way of examining momentary shifts in RSA trajectory during the segments, it is certainly less commonly used in the physiological literature. It is possible that participants could exhibit similar slope trajectories for baseline and emotion eliciting videos, which indicate that there was no difference between the segments. However, it is also important to note that multilevel modeling accounts for the individual differences that exist within physiological reactivity. When the RSA scores across the 30-s epochs are aggregated, the individual fluctuations in RSA are no longer accounted for. Further, in looking at the graphed slopes in Panel B of Figure 2, the trends in the data suggest that RSA reactivity does appear to be occurring during the emotion eliciting segments of the alone and adult condition, particularly between in the first couple of epochs (i.e., E1-E2). However, there seems to be a habituating effect during the emotion eliciting segment over time, which shows a decrease in arousal after the second epoch. This may be reducing the slope coefficient so that is not statistically different than the baseline slope trajectory. Despite this potential habilitation or reduction in arousal, the RSA values during the emotion eliciting segments remained higher than the baseline RSA values, which suggest that some arousal likely occurred during the emotion eliciting segments.

Measurement of RSA: Dynamic change vs. average score

Measuring dynamic changes in RSA allows for examining short incremental changes in physiological reactivity, which is a less common and more robust method of examining physiology in a short period of time. However, as mentioned, this approach may not be necessary. Comparison testing of RSA reactivity from baseline to emotion eliciting video across the three conditions yielded the same information whether researchers used dynamic change in RSA reactivity (i.e., hypothesis testing) versus mean difference RSA scores (i.e., post hoc testing). Given the similarity in findings, one may question which measurement approach is preferred. Importantly, the methodological approach should be driven by the research question.

Using mean difference scores for analyzing physiological reactivity limits the number of parameters that need to be estimated, which allows for opportunities to consider other factors that may be contributing to reactivity. However, if one wants to understand what is physiologically happening during a particular stressor, examining incremental changes in RSA may be a better route, as you can graph trends overtime and assess for factors that may contribute to the micromomentary changes in RSA. As previously described, the findings from the current study indicated that there may have been some habituation happening during the emotion induction segment for the alone and adult conditions, which would not have been divulged if RSA mean scores were used to capture emotion reactivity. Using dynamic changes in RSA may allow researchers to start pinpointing how and when emotion reactivity vs. regulation processes are occurring. Further, this type of methodological approach may be comparable to biofeedback therapy, which allows individuals to see how therapeutic techniques influence their physiological arousal in real-time. Just as individuals begin to see their heart rate start to decrease while deep breathing, similar precision could be used in understanding how factors contribute to emotion processing when measuring momentary shifts in RSA during a particular stimulus.

Limitations and Conclusions

Although the present study provides preliminary evidence about the nonsignificant effect of sibling presence on physiological reactivity during a stress inducing experience and provides noteworthy considerations for measurement and analyses of RSA reactivity for future studies, the current study should be interpreted in the context of several limitations. First, the present study found inconsistent evidence regarding whether the emotion eliciting videos initiated physiological arousal from baseline, thus reducing the ability to detect outcomes. Some of the post hoc pairwise t-tests did indicate a significant mean difference between the baseline and emotion eliciting videos, and the slope trends graphed in Figure 2 indicate some reactivity occurring. Thus, it is possible that the data generally supports the occurrence of reactivity. It is also possible that the fear stimulus did not initiated enough of a response to elicit statistically significant changes in reactivity from baseline. Second, the sample size limited the number of factors that could be included in the model to explain the variance in participants' physiological reactivity (i.e., accounting for multiple covariates within the multilevel model), albeit the sample size was sufficient for hypothesis testing. Finally, the internal consistency for the target child's Positive Involvement subscale on the Sibling Relationships in Early Childhood questionnaire was in the questionable range despite the items and the scale reflecting a normal distribution. Although the internal consistency was lower for this scale, it was imperative to use a well-known and validated measure aimed at assessing qualities of the sibling relationship for children in early childhood.

Despite these limitations, the present study expanded the literature in a number of ways. One, results showed that sibling presence during an emotion eliciting stressor was not a particularly salient factor for emotion reactivity and regulation processes. Two, results indicated that there were no changes in RSA reactivity on average; however, the results provide additional evidence of individual differences in physiological reactivity when examining dynamic shifts in RSA during the baseline and emotion eliciting segments. Third, findings suggest that the existing emotion eliciting stimuli did not initiate a significant difference in physiological reactivity from baseline, suggesting that different lab-based stress-provoking tasks are needed, particularly for adversity exposed populations who may require a heightened level of induction to exhibit an emotional response. Finally, results from the current study offer considerations for various methodological approaches to examining RSA reactivity, given the consistency in results from comparison testing via dynamic shifts in RSA and mean difference RSA scores. Researchers should consider each approach to analyzing RSA reactivity based on the research questions.

Implications and Future directions

Based on the findings from this study there are a number of implications and future directions that should be considered. First, given that sibling presence did not significantly impact physiological reactivity, suggests that encountering a stressful event with a sibling is not inherently protective in nature. It is likely that other sibling factors may be contributing to emotion reactivity and regulation development. Thus, it will be important for future studies to pinpoint which factors contribute to emotion processing during stress provoking situations, such as comfort statements, physical touch, and problem solving. Further, sibling relationships are thought to promote emotion regulation and well-being, and yet the current study provides evidence that having a sibling present is likely not enough to influence children’s responsivity. Thus, intervention efforts need to focus more on the interactive nature of the sibling relationship to develop emotion regulation skills and foster positive relationships. One such prevention intervention is The More Fun with Sisters and Brothers program, which is thought to help siblings between 4-8 years old strengthen their relationship and develop emotional competencies and prosocial behaviors (Kennedy & Kramer, 2008; Kramer & Radey, 1997). This program involves a dyadic approach to target specific competencies (e.g., initiating play with a sibling, methods of acceptance, appropriately declining invitation for play, perspective taking, identifying and discriminating among emotions, regulating emotions, problems solving, and conflict management) and transfer learning to spontaneous interactions. These intervention efforts may have important implications for families and youth living in high stress environments, such as exposure to poverty, maltreatment, community violence, or foster care, so that the sibling can become a source of support and comfort during frequent stressful situations.

Second, examining the presence of a sibling in a variety of stressful encounters, overtime and with a larger, generalizable sample may provide additional evidence about the protective effects of sibling presence, and increase the power to detect other effects on emotion reactivity. Although results from the present study indicate that there was no significant difference in reactivity regardless of the condition (i.e., alone, sibling, adult), the sibling trajectory graphed in Figure 2 did show less of a physiological reaction to the emotion eliciting stressor compared to the slopes from the adult and alone conditions, which may suggest that there was some influence of sibling presence on physiological reactivity. Due to the bidirectional, ongoing nature of sibling relationships (Dunn, 2015; Kramer, 2014; Kramer et al., 2019; Maynard et al., 2016), it will also be important to utilize prospective longitudinal studies that examine the complex interactions that exist among siblings during play, conflict resolution, stressors, and neutral situations in order to identify concreate constructs that are driving the influence of siblings on emotion regulation development.

Third, results from the present study indicated inconsistent findings regarding the effect of the emotion eliciting task on physiological arousal, suggesting that the emotion inducing videos were not taxing enough to elicit a statistically significant difference in physiology from baseline for this sample. Given that the sample was recruited specifically based on exposure to adversity, it is possible that children who have been exposed to many adverse events and live in low income communities, may need stress provoking lab-based tasks that are more appropriately matched with their level of exposure to previous stressors. Many of the existing research-based, NIMH- approved, validated tasks (LAB-TAB) have been normed on primarily white samples (93%), who have a household family incomes above $50,000 (43%), and who live in two-caregiver households (Gagne et al., 2011; Goldsmith & Rothbart, 1996). These demographics are considerably different than the breakdown of the current sample. As previously mentioned, discrepancies also exist between the demographics from the current study and those that utilized emotion eliciting videos as lab-based stressors (Davis et al., 2016; Gatzke-Kopp et al., 2015).

It would be important for future research to focus on the development and validation of lab-based emotion inducing activities with high adversity-exposed families so that examinations of physiological reactions can perhaps be better captured in lab tasks. These tasks provide opportunities to identify adaptive and maladaptive factors that can be used for intervention efforts to facilitate growth for vulnerable children and families. Interestingly, there were few dyadic lab-based stressors that were appropriate for preschool-aged children. Those that do exist involve a sharing task, free-play session, or having caregivers provide differential attention to siblings (McElwain & Volling, 2005; Volling et al., 2002). Future research should also consider validating additional dyadic emotion eliciting lab-based tasks that involve passive (i.e., listening to a story, watching a video clip) and interactive (i.e., conflict resolution, puzzle activity) engagement among the preschool-aged dyads.

References

Adrian, M., Zeman, J., & Veits, G. (2011). Methodological implications of the affect revolution: A 35-year review of emotion regulation assessment in children. *Journal of Experimental Child Psychology, 110*(2), 171-197. https://doi.org/10.1016/j.jecp.2011.03.009

Anda, R. F., Butchart, A., Felitti, V. J., & Brown, D. W. (2010). Building a framework for global surveillance of the public health implications of adverse childhood experiences. *American Journal of Preventive Medicine, 39*(1), 93-98. http://dx.doi.org/10.1016/j.amepre.2010.03.015

Anticich, S. A. J., Barrett, P. M., Silverman, W., Lacherez, P., & Gillies, R. (2013). The prevention of childhood anxiety and promotion of resilience among preschool-aged children: A universal school based trial. *Advances in School Mental Health Promotion, 6*(2), 93-121. https://doi.org/10.1080/1754730X.2013.784616

Appelhans, B. M., & Luecken, L. J. (2006). Heart rate variability as an index of regulated emotional responding. *Review of General Psychology, 10*(3), 229-240. https://doi.org/10.1037/1089-2680.10.3.229

Arsenio, W. F., Cooperman, S., & Lover, A. (2000). Affective predictors of preschoolers' aggression and peer acceptance: Direct and indirect effects. *Developmental Psychology, 36*(4), 438-448. https://doi.org/10.1037/0012-1649.36.4.438

Baker, D. G., Boat, B. W., Grinvalsky, H. T., & Geracioti, Jr., T. D. (1998). Interpersonal trauma and animal related experiences in female and male military veterans: Implications for program development. *Military Medicine, 163*(1), 20-25. PMID: 9465567.

Bandura, A. (1977). *Social learning theory*. Englewood Cliffs, NJ: Prentice Hall.

Beauchaine, T. P. (2001). Vagal tone, development, and Gray's motivational theory: Toward an integrated model of autonomic nervous system functioning in psychopathology. *Development and Psychopathology, 13*(2), 183-214. https://doi.org/10.1017/S0954579401002012

Beauchaine, T. P., Gatzke-Kopp, L. M., & Mead, H. (2007). Polyvagal theory and developmental psychopathology. Emotion dysregulation and conduct problems from preschool to adolescence. *Biological Psychology, 74*, 174–184. https://doi.org/10.1016/j.biopsycho.2005.08.008

Beauchaine, T. P., Gatzke-Kopp, L., Neuhaus, E., Chipman, J., Reid, M. J., & Webster-Stratton, C. (2013). Sympathetic- and parasympathetic-linked cardiac function and prediction of externalizing behavior, emotion regulation, and prosocial behavior among preschoolers treated for ADHD. *Journal of Consulting and Clinical Psychology, 81*(3), 481-493. https://doi.org/10.1037/a0032302

Berlin, L. J., Cassidy, J., & Appleyard, K. (2008). The influence of early attachments on other relationships. In J. Cassidy, & P. R. Shaver (Eds.), *2nd ed.; handbook of attachment: Theory, research, and clinical applications (2nd ed.)* (2nd ed. ed., pp. 333-347, Chapter xix, 1020 Pages) The Guilford Press, New York, NY.

Berntson, G. G., Bigger, J. T., Eckberg, D. L., Grossman, P., Kaufmann, P. G., Malik, M., . . . van, d. M. (1997). Heart rate variability: Origins, methods, and interpretive caveats. *Psychophysiology, 34*(6), 623-648. https://doi.org/10.1111/j.1469 8986.1997.tb02140.x

Blair, C., & Raver, C. C. (2012). Child development in the context of adversity: Experiential canalization of brain and behavior. *The American Psychologist, 67*(4), 309. Retrieved from https://search-proquest com.www2.lib.ku.edu/docview/1014161136?accountid =14556

Blandon, A. Y., Calkins, S. D., Keane, S. P., & O'Brien, M. (2008). Individual differences in trajectories of emotion regulation processes: The effects of maternal depressive symptomatology and children's physiological regulation. *Developmental Psychology, 44*(4), 1110-1123. http://dx.doi.org/10.1037/0012-1649.44.4.1110

Boyce, W. T., Quas, J., Alkon, A., Smider, N. A., Essex, M. J., Kupfer, D. J., . . . Steinberg, L. (2001). Autonomic reactivity and psychopathology in middle childhood. *British Journal of Psychiatry, 179*, 144–150. https://doi.org/10.1192/bjp.179.2.144

Brooker, R. J., & Buss, K. A. (2010). Dynamic measures of RSA predict distress and regulation in toddlers. *Developmental Psychobiology, 52*(4), 372-382. https://doi.org/10.1002/dev.20432

Buist, K. L., Deković, M., & Prinzie, P. (2013). Sibling relationship quality and psychopathology of children and adolescents: A meta-analysis. *Clinical Psychology Review, 33*(1), 97-106. http://dx.doi.org/10.1016/j.cpr.2012.10.007

Cabecinha-Alati, S., Malikin, H., & Montreuil, T. C. (2020). Emotion regulation and personality as predictors of mothers' emotion socialization practices. *Family Relations: An Interdisciplinary Journal of Applied Family Studies*, *69*(5), 1055-1072. http://dx.doi.org/10.1111/fare.12501

Calkins, S. D., & Keane, S. P. (2004). Cardiac vagal regulation across the preschool period: Stability, continuity, and implications for childhood adjustment. *Developmental Psychobiology*, *45*, 101–112. https://doi.org/10.1002/dev.20020

Campione-Barr, N., & Smetana, J. G. (2010). "Who said you could wear my sweater? Adolescent siblings conflicts and associations with relationship quality. *Child Development*, 81(2), 464–471. https://doi.org/10.1111/j.1467-8624.2009.01407.x.

Campos, J. J., Frankel, C. B., & Camras, L. (2004). On the nature of emotion regulation. *Child Development, 75*(2), 377-394. http://dx.doi.org/10.1111/j.1467-8624.2004.00681.x

Cole, P. M., Dennis, T. A., Smith-Simon, K. E., & Cohen, L. H. (2009). Preschoolers' emotion regulation strategy understanding: Relations with emotion socialization and child self regulation. *Social Development, 18,* 324–352. https://doi.org/10.1111/j.1467 9507.2008.00503.x.

Cole, P. M., Martin, S. E., & Dennis, T. A. (2004). Emotion regulation as a scientific construct: Methodological challenges and directions for child development research. *Child Development, 75*(2), 317-333. https://doi.org/10.1111/j.1467-8624.2004.00673.x

Cole, P. M., Teti, L. O., & Zahn-Waxler, C. (2003). Mutual emotion regulation and the stability of conduct problems between preschool and early school age. *Development and Psychopathology, 15,* 1-18. PMID: 12848432

Conger, K. J., Williams, S. T., Little, W. M., Masyn, K. E., & Shebloski, B. (2009). Development of mastery during adolescence: The role of family problem-solving. *Journal of Health and Social Behavior, 50,* 99–114. https://dx.doi.org/10.1177/002214650905000107

Cooper-Vince, C. E., DeSerisy, M., Cornacchio, D., Sanchez, A., McLaughlin, K. A., & Comer, J. S. (2017). Parasympathetic reactivity and disruptive behavior problems in young children during interactions with their mothers and other adults: A preliminary investigation. *Developmental Psychobiology, 59*(4), 543-550. http://dx.doi.org/10.1002/dev.21511

Crane, J., Mincic, M. S., & Winsler, A. (2011). Parent-teacher agreement and reliability on the Devereux Early Childhood Assessment (DECA) in English and Spanish for ethnically diverse children living in poverty. *Early Education and Development*, *22*(3), 520-547. https://doi.org/10.1080/10409289.2011.565722

Creaven, A., Skowron, E. A., Hughes, B. M., Howard, S., & Loken, E. (2014). Dyadic concordance in mother and preschooler resting cardiovascular function varies by risk status. *Developmental Psychobiology*, *56*(1), 142-152. https://doi.org/10.1002/dev.21098

Curtis, W. J., & Cicchetti, D. (2007). Emotion and resilience: A multilevel investigation of hemispheric electroencephalogram asymmetry and emotion regulation in maltreated and nonmaltreated children. *Development and Psychopathology*, *19*(3), 811-840. https://doi.org/10.1017/S0954579407000405

Davidson, R. J., Jackson, D. C., & Kalin, N. H. (2000). Emotion, plasticity, context, and regulation: Perspectives from affective neuroscience. *Psychological Bulletin, 126*(6), 890-909. http://dx.doi.org/10.1037/0033-2909.126.6.890

Davis, E. L., Quiñones-Camacho, L. E., & Buss, K. A. (2016). The effects of distraction and reappraisal on children’s parasympathetic regulation of sadness and fear. *Journal of Experimental Child Psychology, 142*, 344-358. https://doi.org/10.1016/j.jecp.2015.09.020

Dunn, J. (2007). Siblings and socialization. In J. E. Grusec & P. D. Hastings (Eds.), *Handbook of socialization: Theory and research* (pp. 309 – 327). New York: Guilford Press.

Dunn, J. (2015). Siblings. In J. E. Grusec & P. D. Hastings (Eds.), *Handbook of socialization: Theory and research* (pp. 182–201). The Guilford Press.

Eisenberg, N., Cumberland, A., & Spinrad, T. L. (1998). Parental socialization of emotion. *Psychological Inquiry, 9*, 241–273. PMID: 16865170

Enlow, M. B., Kitts, R. L., Blood, E., Bizarro, A., Hofmeister, M., & Wright, R. J. (2011). Maternal posttraumatic stress symptoms and infant emotional reactivity and emotion regulation. *Infant Behavior & Development, 34*(4), 487-503. http://dx.doi.org/10.1016/j.infbeh.2011.07.007

Felitti, V. J., Anda, R. F., Nordenberg, D., Williamson, D. F., Spitz, A. M., Edwards, V., . . . Marks, J. S. (1998). Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults: The adverse childhood experiences (ACE) study. *American Journal of Preventive Medicine, 14*(4), 245-258. http://dx.doi.org/10.1016/S0749-3797(98)00017-8

Fraley, R. C., & Tancredy, C. M. (2012). Twin and sibling attachment in a nationally representative sample. *Personality and Social Psychology Bulletin, 38*(3), 308-316. http://dx.doi.org/10.1177/0146167211432936

Frazer, A. L., Fite, P. J., Stone, K. J., & Clinkenbeard, J. (2018). Parental criticism moderates sibling influence on proactive and reactive aggression. *Journal of Child and Family Studies, 27*(12), 4025-4032. http://dx.doi.org/10.1007/s10826-018-1210-5

Gagne, J. R., Van Hulle, C. A., Aksan, N., Essex, M. J., & Goldsmith, H. H. (2011). Deriving childhood temperament measures from emotion-eliciting behavioral episodes: Scale construction and initial validation. *Psychological Assessment, 23*(2), 337-353. http://dx.doi.org/10.1037/a0021746

Garner, P. W., Jones, D. C., & Palmer, D. J. (1994). Social cognitive correlates of preschool children’s sibling caregiving behavior. *Developmental Psychology*, 30, 905–911. https://doi.org/10.1037=0012-1649.30.6.905

Gass, K., Jenkins, J., Dunn, J. (2007). Are sibling relationships protective? A longitudinal study. *Journal of Child Psychology and Psychiatry, 48*(2), 167-175. https://doi.org/10.1111/j.1469-7610.2006.01699.x

Gatzke-Kopp, L. M., Greenberg, M., & Bierman, K. (2015). Children's parasympathetic reactivity to specific emotions moderates response to intervention for early-onset aggression. *Journal of Clinical Child and Adolescent Psychology, 44*, 291–304. https://doi.org/10.1080/ 15374416.2013.862801

Goldsmith, H.H., & Rothbart, M.K. (1996). The laboratory temperament assessment battery: Locomotor version 3.0. Technical manual. Madison, WI: University of Wisconsin.

Gottman, J. M., & Mettetal, G. (1986). Speculations about social and affective development: Friendship and acquaintanceship through adolescence. In J. M. Gottman & J. G. Parker (Eds.), *Studies in emotion and social interaction. Conversations of friends: Speculations on affective development* (pp. 192-237). New York, NY, US: Cambridge University Press.

Gross, J. J. (1998). The emerging field of emotion regulation: An integrative review. *Review of General Psychology, 2*(3), 271-299. http://dx.doi.org/10.1037/1089-2680.2.3.271

Gross, J. J. (Ed) (2007). Handbook of emotion regulation. New York, NY: Guilford Press, p. 654, xvii.

Gross, J. J., Sheppes, G., & Urry, H. L. (2011). Cognition and emotion lecture at the 2010 SPSP emotion preconference: Emotion generation and emotion regulation: A distinction we should make (carefully). *Cognition and Emotion, 25*(5), 765-781. http://dx.doi.org/10.1080/02699931.2011.555753

Gross, J. J., & Thompson, R. A. (2007). Emotion regulation: Conceptual foundations. In J. J. Gross (Ed.), *Handbook of emotion regulation; handbook of emotion regulation* (pp. 3-24, Chapter xvii, 654 Pages) The Guilford Press, New York, NY.

Gudmundson, J. A., & Leerkes, E. M. (2012). Links between mothers' coping styles, toddler reactivity, and sensitivity to toddler's negative emotions. *Infant Behavior & Development, 35*(1), 158–166. https://doi.org/10.1016/j.infbeh.2011.07.004

Halle, T. G., & Darling-Churchill, K. (2016). Review of measures of social and emotional development. *Journal of Applied Developmental Psychology, 45*, 8-18. https://doi.org/10.1016/j.appdev.2016.02.003

Harden, B. J., Panlilio, C., Morrison, C., Duncan, A. D., Duchene, M., & Clyman, R. B. (2017). Emotion regulation of preschool children in foster care: The influence of maternal depression and parenting. *Journal of Child and Family Studies, 26*(4), 1124-1134. https://doi.org/10.1007/s10826-016-0636-x

Hastings, P. D., & De, I. (2008). Parasympathetic regulation and parental socialization of emotion: Biopsychosocial processes of adjustment in preschoolers. *Social Development*, *17*(2), 211-238. https://doi.org/10.1111/j.1467-9507.2007.00422.x

Hastings, P. D., Nuselovici, J. N., Utendale, W. T., Coutya, J., McShane, K. E., & Sullivan, C. (2008). Applying the polyvagal theory to children's emotion regulation: Social context, socialization, and adjustment. *Biological Psychology, 79*(3), 299-306. https://doi.org/10.1016/j.biopsycho.2008.07.005

Heim, C., & Nemeroff, C. B. (2002). Neurobiology of early life stress: Clinical studies.

Seminars in Clinical Neuropsychiatry 7, 47–59.

Hill, A. L., Degnan, K. A., Calkins, S. D., & Keane, S. P. (2006). Profiles of externalizing behavior problems for boys and girls across preschool: The roles of emotion regulation and inattention. *Developmental Psychology, 42*(5), 913-928. https://doi.org/10.1037/0012 1649.42.5.913

Hoffman, L. (2015). Longitudinal analysis: Modeling within-person fluctuation and change. New York, NY: Routledge Academic.

Howe, N., Petrakos, H., Rinaldi, C., & LeFebvre, R. (2005). ‘‘This is a bad dog, you know . . .’’: Constructing shared meanings during sibling pretend play. *Child Development*, 76, 783 794. https://doi.org/10.1111=j.1467-8624.2005.00877.x

Hughes, M., & Tucker, W. (2018). Poverty as an Adverse Childhood Experience. *North Carolina Medical Journal, 79*(2), 124-126. https://doi.org/10.18043/ncm.79.2.124.

Kappas, A. (2011). Emotion and regulation are one! *Emotion Review, 3*(1), 17-25. http://dx.doi.org/10.1177/1754073910380971

Kaufman, J., & Charney, D. (2001). Effects of early stress on brain structure and function: Implications for understanding the relationship between child maltreatment and depression. *Development and Psychopathology, 13*(3), 451-471. https://doi.org/10.1017/S0954579401003030

Kennedy, D. E., & Kramer, L. (2008). Improving emotion regulation and sibling relationship quality: The more fun with sisters and brothers program. *Family Relations: An Interdisciplinary Journal of Applied Family Studies, 57*(5), 567-578. https://doi.org/10.1111/j.17413729.2008.00523.x

Kiel, E. J., Price, N. N., & Premo, J. E. (2020). Maternal comforting behavior, toddlers' dysregulated fear, and toddlers' emotion regulatory behaviors. *Emotion*, *20*(5), 793-803. http://dx.doi.org/10.1037/emo0000600

Kohlhoff, J., Hawes, D. J., Mence, M., Russell, A. M. T., Wedgwood, L., & Morgan, S. (2016). Emotion regulation strategies and parenting practices among parents of children with clinic-referred conduct problems. *Parenting: Science and Practice*, *16*(4), 302-319. http://dx.doi.org/10.1080/15295192.2016.1184942

Kramer, L. (2014). Learning emotional understanding and emotion regulation through sibling interaction. *Early Education and Development, 25*(2), 160-184. https://doi.org/10.1080/10409289.2014.838824

Kramer, L., Conger, K. J., Rogers, C. R., & Ravindran, N. (2019). Siblings. In B. H. Fiese, M. Celano, K. Deater-Deckard, E. N. Jouriles, & M. A. Whisman (Eds.), *APA handbook of contemporary family psychology: Foundations, methods, and contemporary issues across the lifespan* (pp. 521–538). American Psychological Association. https://doi.org/10.1037/0000099-029

Kramer, L., & Radey, C. (1997). Improving sibling relationships among young children: A social skills training model. *Family Relations: An Interdisciplinary Journal of Applied Family Studies*, *46*(3), 237-246. http://dx.doi.org/10.2307/585121

Kreibig, S. D. (2010). Autonomic nervous system activity in emotion: A review. *Biological Psychology, 84*(3), 394-421. http://dx.doi.org/10.1016/j.biopsycho.2010.03.010

LeBuffe, P. A., & Naglieri, J. A. (2003). *Devereux early childhood assessment clinical form (DECA-C-C): A measure of behaviors related to risk and resilience in preschool children*. Lewisville, NC: Kaplan Press.

Lindsey, E. W., & Colwell, M. J. (2003). Preschoolers' emotional competence: Links to pretend and physical play. *Child Study Journal, 33*(1), 39-52. Retrieved from https://search proquest-com.www2.lib.ku.edu/docview/620188567?accountid=14556

Maynard, A. E. (2016). Sibling interactions. In U. P. Gielen & J. L. Roopnarine (Eds.), *Childhood and adolescence: Cross-cultural perspectives and applications* (pp. 241–262). Praeger/ABC-CLIO.

McElwain, N. L., & Volling, B. L. (2005). Preschool children's interactions with friends and older siblings: Relationship specificity and joint contributions to problem behavior. *Journal of Family Psychology, 19*(4), 486-496. https://doi.org/10.1037/0893 3200.19.4.486

McHale, S. M., Updegraff, K. A., & Whiteman, S. D. (2012). Sibling relationships and influences in childhood and adolescence. *Journal of Marriage and Family, 74*(5), 913 930. https://doi.org/10.1111/j.1741-3737.2012.01011.x

Merrick, M. T., Ford, D. C., Ports, K. A., & Guinn, A. S. (2018). Prevalence of Adverse Childhood Experiences from the 2011-2014 Behavioral Risk Factor Surveillance System in 23 States. *JAMA Pediatrics*, *172*(11),1038-1044. https://doi.org/10.1001/jamapediatrics.2018.2537.

Mikolajewski, A. J., & Scheeringa, M. S. (2018). Examining the prospective relationship between pre-disaster respiratory sinus arrhythmia and post-disaster posttraumatic stress disorder symptoms in children. *Journal of Abnormal Child Psychology, 46*(7). 1535 1545. https://doi.org/10.1007/s10802-017-0396-0

Minuchin, S. (1974). Families and family therapy. London, UK: Tavistock.

Morris, A. S., Silk, J. S., Morris, M. D. S., Steinberg, L., Aucoin, K. J., & Keyes, A. W. (2011). The influence of mother–child emotion regulation strategies on children's expression of anger and sadness. *Developmental Psychology, 47*(1), 213-225. https://doi.org/10.1037/a0021021

Ochsner, K. N., Ray, R. R., Hughes, B., McRae, K., Cooper, J. C., Weber, J., . . . Gross, J. J. (2009). Bottom-up and top-down processes in emotion generation: Common and distinct neural mechanisms. *Psychological Science, 20*(11), 1322-1331. http://dx.doi.org/10.1111/j.1467-9280.2009.02459.x

Pattyn, N. (2009). On the persistance of dualism in our so-called unified neurosciences: The case of the autonomic nervous system. *Psychologica Belgica, 49*(2-3), 101-110. https://doi.org/10.5334/pb-49-2-3-101

Perry, B. D., Pollard, R. A., Blakley, T. L., Baker, W. L., & Vigilante, D. (1995). Childhood trauma, the neurobiology of adaptation, and “use-dependent” development of the brain: How “states” become “traits.” *Infant Mental Health Journal, 16,* 271–291. https://doi.org/10.1002/1097-0355(199524)16:4<271::AID-IMHJ2280160404>3.0.CO;2

Porges, S. W. (1985). *Method and Apparatus for Evaluating Rhythmic Oscillations in Aperiodic Physiological Response Systems* (U.S. Patent No. 4,510,944). U.S. Patent and Trademark Office. https://patft.uspto.gov/netacgi/nphParser?Sect1=PTO1&Sect2=HITOFF&d=PAL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=4,510,944.N.&OS=PN/4,510,944&RS=PN/4,510,944

Porges, S. W. (1995). Orienting in a defensive world: Mammalian modifications of our evolutionary heritage: A polyvagal theory. *Psychophysiology, 32*(4), 301-318. https://doi.org/10.1111/j.1469-8986.1995.tb01213.x

Porges, S. W. (2007). The polyvagal perspective. *Biological Psychology, 74*(2), 116–143. https://doi.org/10.1016/j.biopsycho.2006.06.009

Quintana, D. S., Guastella, A. J., Outhred, T., Hickie, I. B., & Kemp, A. H. (2012). Heart rate variability is associated with emotion recognition: Direct evidence for a relationship between the autonomic nervous system and social cognition. *International Journal of Psychophysiology, 86*(2), 168-172. https://doi.org/10.1016/j.ijpsycho.2012.08.012

Rasmussen, H. F., Borelli, J. L., Smiley, P. A., Cohen, C., Cheung, R. C. M., Fox, S., . . . Blackard, B. (2017). Mother-child language style matching predicts children's and mothers' emotion reactivity. *Behavioural Brain Research, 325*, 203-213. http://dx.doi.org/10.1016/j.bbr.2016.12.036

Rifkin, L. S., Schofield, C. A., Beard, C., & Armstrong, T. (2016). Adaptation of a paradigm for examining the development of fear beliefs through the verbal information pathway in preschool-age children. *Behaviour Research and Therapy, 87*, 34-39. https://doi.org/10.1016/j.brat.2016.08.013

Scheeringa, M. S., Zeanah, C. H., Myers, L., & Putnam, F. (2004). Heart period and variability findings in preschool children with posttraumatic stress symptoms. *Biological Psychiatry, 55*(7), 685-691. https://doi.org/10.1016/j.biopsych.2004.01.006

Shaffer, F. & Ginsberg, J. P. (2017). An overview of Heart Rate Variability metrics and norms. *Front Public Health, 5*, 258. https://doi.org/10.3389/fpubh.2017.00258.

Slomkowski, C., Rende, R., Conger, K. J., Simons, R. L., & Conger, R. D. (2001). Sisters, brothers, and delinquency: Evaluating social influence during early and middle adolescence. *Child Development, 72*(1), 271-283. http://dx.doi.org/10.1111/1467 8624.00278

Smith, T. W., Deits-Lebehn, C., Williams, P. G., Baucom, B. R. W., & Uchino, B. N. (2020). Toward a social psychophysiology of vagally mediated heart rate variability: Concepts and methods in self-regulation, emotion, and interpersonal processes. *Social and Personality Psychology Compass, 14*(3), 24. http://dx.doi.org/10.1111/spc3.12516

Steele, H., Bate, J., Steele, M., Dube, S. R., Danskin, K., Knafo, H., . . . Murphy, A. (2016). Adverse childhood experiences, poverty, and parenting stress. *Canadian Journal of Behavioural Science, 48*(1), 32-38. http://dx.doi.org/10.1037/cbs0000034

Stocker, C. M., Burwell, R. A., & Briggs, M. L. (2002). Sibling conflict in middle childhood predicts children's adjustment in early adolescence. *Journal of Family Psychology, 16*(1), 50-57. http://dx.doi.org/10.1037/0893-3200.16.1.50

Thompson, R. A. (1994). Emotion regulation: A theme in search of definition. *Monographs for the Society for Research in Child Development, 59*, 25–52. https://doi.org/10.2307/1166137

Thompson, R. A. (2011). Emotion and emotion regulation: Two sides of the developing coin. *Emotion Review, 3*(1), 53-61. http://dx.doi.org/10.1177/1754073910380969

Thompson, R. A., Lewis, M. D., & Calkins, S. D. (2008). Reassessing emotion regulation. *Child Development Perspectives, 2*(3), 124-131. https://doi.org/10.1111/j.1750 8606.2008.00054.x

Thompson, R. A., & Meyer, S. (2007). Socialization of emotion regulation in the family. In J. J. Gross (Ed.), *Handbook of emotion regulation* (pp. 249–268). New York, NY: Guilford.

Volling, B. L. (1997). The family correlates of maternal and paternal perceptions of differential treatment in early childhood. *Family Relations, 46*, 1–9. https://doi.org/10.2307/585120

Volling, B. L., McElwain, N. L., & Miller, A. L. (2002). Emotion regulation in context: The jealousy complex between young siblings and its relations with child and family characteristics. *Child Development, 73*(2), 581-600. https://doi.org/10.1111/1467 8624.00425

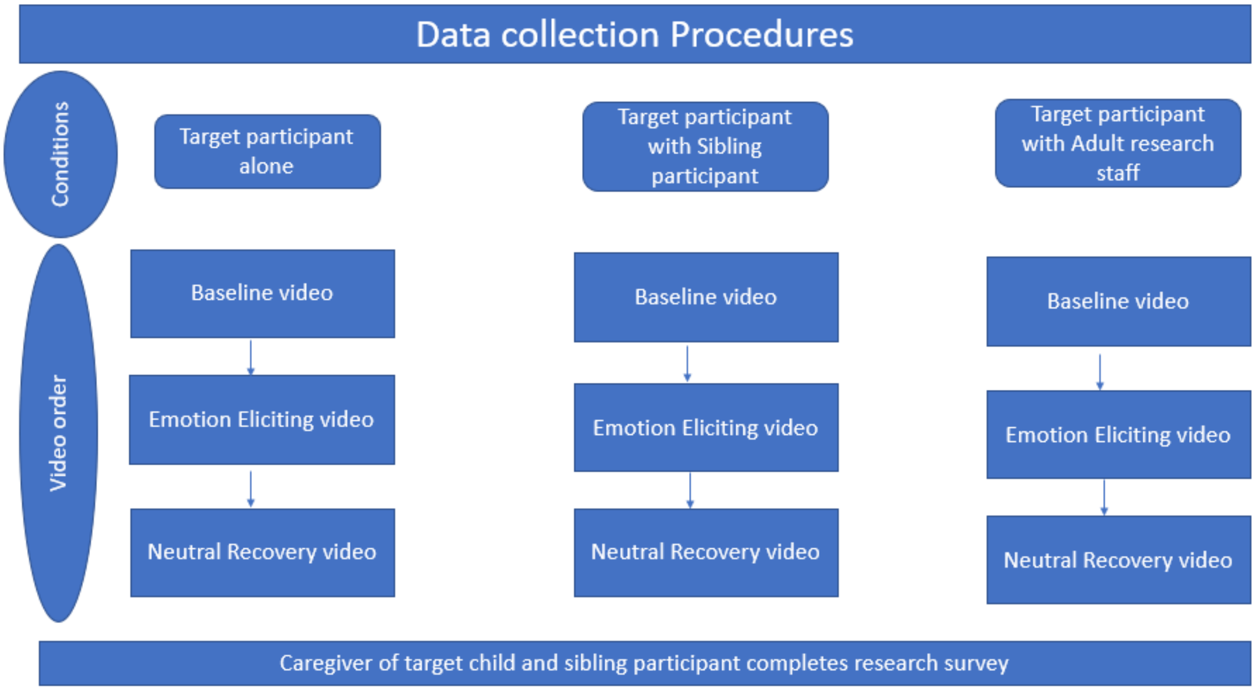
Whiteman, S. D., McHale, S. M., & Soli, A. (2011). Theoretical perspectives on sibling relationships. *Journal of Family Theory and Review, 3*, 124–139. https://doi.org/10.1111/j.1756-2589.2011.00087.x

Youngblade, L. M., & Dunn, J. (1995). Individual differences in young children's pretend play with mother and sibling: Links to relationships and understanding of other people's feelings and beliefs. *Child Development*, *66*(5), 1472-1492. http://doi.org/10.2307/1131658

Table 1. Descriptive statistics for all study variables.

Variable	Target child %	Sibling %
Ethnicity – Hispanic	4.2%	4.2%
Caffeine		
0 cups	56.3%	52.1%
1-3 cups	39.6%	39.6%
4-6 cups	4.2%	8.3%
Psychiatric Disorder	0%	4.2%
Adverse Life Events		
Range	0-9	0-8
0	38.3%	33.3%
1	19.1%	22.9%
2	12.8%	8.3%
3	8.5%	10.4%
4	10.6%	16.7%
5+	10.7%	8.4%
Household Variables		
Number of Biological siblings		
1	14.6%	
2	20.8%	
3	25%	
4	16.7%	
5+	22.9%	
Number of children in the home		
1	22.9%	
2	27.1%	
3	20.8%	
4	16.7%	
5+	12.5%	
Caregiver Marital Status		
Single	78.7%	
Married	17%	
Divorced	4.3%	
Household Income		
$10,000 or less	46.6%	
$10,001- $20,000	23.4%	
$20,001- $30,000	19.1%	
$30,001- $40,000	10.6%	
$40,001- $50,000	0%	
$50,001- $60,000	2.1%	
$60,001 or more	2.1%	
Education level (parents)		
Some high school	22.6%	
High school graduate/ GED	37.6%	
Trade School or Community College	14%	
Some College	23.7%	
Four Year Degree	1.1%	
Graduate or Professional School	1.1%	

Figure 1. Data Collection Procedures



Note. Order of the Conditions and Videos counterbalanced

Table 2. Mean differences of study variables between target child and sibling

Variable	Target (n=48)	Sibling (n=48)	
	Mean (SD)	Mean (SD)	*t-test*
Sibling Behavior			
Positive Involvement	28.00 (2.78)	27.88 (3.86)	.245
Conflict/ Rivalry	10.42 (4.32)	9.96 (4.72)	.735
DECA			
Withdrawal/Depression	5.98 (5.01)	5.75 (5.14)	0.359
Emotional Control Problems	12.65 (5.65)	11.35 (6.78)	1.199
Attention Problems	11.08 (5.18)	12.06 (6.51)	-1.076
Aggression Problems	5.44 (3.65)	4.69 (3.20)	1.221
Total Behavior Concerns	35.27 (14.30)	33.85 (16.98)	0.565
Adverse Childhood Event	1.79 (2.09)	1.89 (1.92)	-0.759

$^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 3.

Correlations, means, and standard deviations of study variables ($N = 96$)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Age of T	-													
2. Gender of T	-0.113	-												
3. Race of T	0.125	-0.165	-											
4. Age of S	0.323*	0.242	-0.118	-										
5. Gender of S	0.089	0.179	-0.115	0.082	-									
6. Race of S	0.128	-0.140	0.791**	-0.053	0.064	-								
7. Positive Involv T	0.248	0.000	-.123	0.097	-0.108	-0.170	-							
8. Conflict Riv T	-0.076	0.064	0.022	0.308*	-0.198	-0.174	-0.308*	-						
9. Positive Involv S	-0.048	-0.173	0.020	-0.088	0.093	0.054	0.470**	-0.205	-					
10. Conflict Riv S	-0.037	0.036	-0.087	0.203	-0.066	-0.275	-0.210	0.546**	-0.341*	-				
11. Beh Concerns T	-0.210	-0.115	0.083	-0.006	-0.078	-0.023	-0.406**	0.478**	-0.005	0.200	-			
12. Beh Concerns S	0.132	0.027	0.037	0.122	-0.102	-0.048	-0.242	0.396**	-	0.506**	0.472**	-		
13. Adversity T	0.378**	0.171	0.047	0.120	0.043	-0.021	-0.011	0.172	-0.083	0.086	0.036	0.168	-	
14. Adversity S	0.313*	0.167	-0.011	0.231	0.107	0.000	-0.079	0.192	-0.060	0.145	0.118	0.210	0.889**	-

$^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Note: T = Target, S = Sibling, Involv = Involvement, Riv = Rivalry, Beh = Behavioral, Adversity = Adverse Life Events

Table 4.

Correlations, means, and standard deviations of target child's study variables and RSA reactivity (N = 48)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Age of T	-												
2. Gender of T	-0.113	-											
3. Race of T	0.125	-0.165	-										
4. Positive Involv T	0.248	0.000	-0.123	-									
5. Conflict Rivalry T	-0.076	0.064	0.022	-0.308*	-								
6. Beh Concern T	-0.210	-0.115	0.083	-0.406**	0.478**	-							
7. Adversity T	0.378**	0.171	0.047	-0.011	0.172	0.036	-						
8. RSA B Alone	0.146	-0.063	-0.115	0.281	0.004	-0.094	0.172	-					
9. RSA B Sibling	0.058	0.035	0.056	0.179	-0.080	-0.102	0.052	0.645**	-				
10. RSA B Adult	0.058	-0.095	-0.036	0.122	-0.021	-0.118	0.076	0.622**	0.599*	-			
11. RSA EE Alone	0.070	-0.124	-0.124	0.210	-0.013	-0.194	0.060	0.809**	0.689**	0.631**	-		
12. RSA EE Sibling	0.044	-0.018	0.032	0.288*	-0.189	-0.225	0.037	0.687**	0.885**	0.644**	0.747**	-	
13. RSA EE Adult	0.215	-0.099	0.004	0.291*	-0.167	-0.210	0.061	0.723**	0.713**	0.764**	0.775**	0.743**	-

$^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Note: T = Target, Involv = Involvement, Beh = Behavioral, Adversity = Adverse Life Events, B = Baseline, EE = Emotion Eliciting

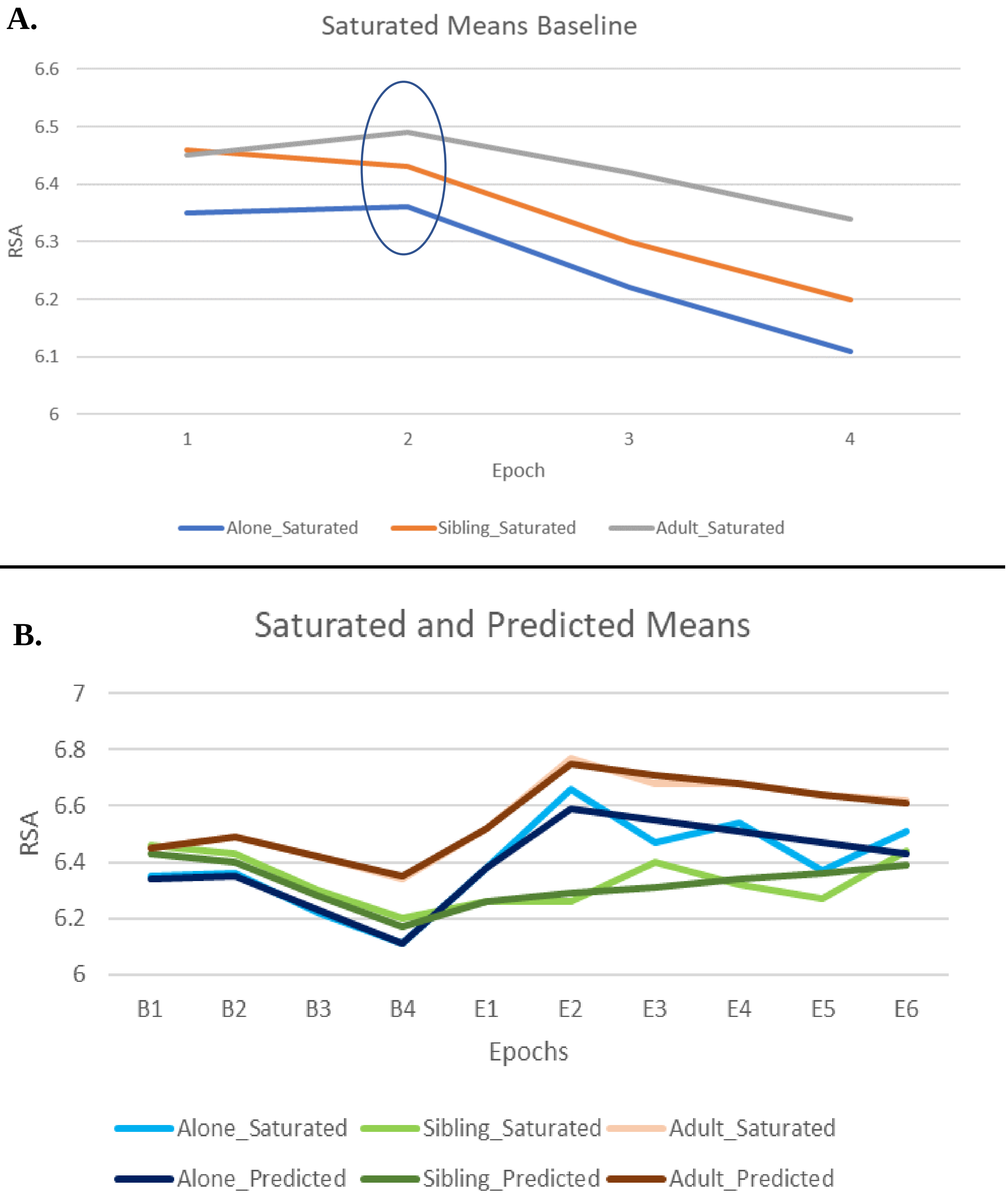


Figure 2**.** Panel A depicts the Saturated means during the baseline segments for each condition. The circle represents the slight reactivity that occurred at B2. Panel B depicts the means from the Saturated model and the Predicted model for the baseline and emotion eliciting segments for each of the conditions.

Table 5. Regression effects to predict RSA reactivity from multilevel model

Predictors	B	SE	*P*
Alone Baseline Intercept	3.299	1.692	0.057
Alone Fear Intercept	3.525	1.693	0.043
Sibling Baseline Intercept	3.358	1.693	0.053
Sibling Fear Intercept	3.224	1.691	0.063
Adult Baseline Intercept	3.426	1.693	0.049
Adult Fear Intercept	3.680	1.691	0.035
Alone Baseline Slope	-0.121	0.067	0.074
Alone Fear Slope	-0.041	0.029	0.161
Sibling Baseline Slope	-0.114	0.058	0.054
Sibling Fear Slope	0.024	0.028	0.391
Adult Baseline Slope	-0.074	0.049	0.129
Adult Fear Intercept	-0.035	0.029	0.243
Positive Involvement	0.109	0.060	0.074

Table 6. Mean differences in RSA trajectory across segments and RSA reactivity from baseline to emotion eliciting segment

Segment comparisons	*T*
Baseline	
Alone-baseline vs. Sibling-baseline	$t(91.6) = 0.07$, $p = 0.941$
Alone-baseline vs. Adult-baseline	$t(116) = 0.56$, $p = 0.579$
Sibling-baseline vs. Adult-baseline	$t(126) = 0.54$, $p = 0.591$
Emotion Eliciting	
Alone-emotion vs. Sibling-emotion	$t(92.1) = 1.68$, $p = 0.096$
Alone-emotion vs. Adult-emotion	$t(79.3) = 0.14$, $p = 0.890$
Sibling-emotion vs. Adult-emotion	$t(81.8) = -1.30$, $p = 0.199$
RSA reactivity	
Alone vs. Sibling	$t(98.1) = -0.57$, $p = 0.572$
Sibling vs. Adult	$t(122) = 1.12$, $p = 0.266$
Adult vs. Alone	$t(129) = 0.46$, $p = 0.646$