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The Association Between Sociodemographic Risk, Parental Substance Use, And Child Emotion Regulation Capabilities

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The Association Between Sociodemographic Risk, Parental Substance Use, and Child Emotion Regulation Capabilities

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ABSTRACT

Emotion regulation, defined as the ability to modulate one's emotional experiences in order to navigate social interactions successfully and attain goals, has been associated with social competence, adjustment, and resilience during early childhood and beyond. Family-level risk factors have been linked to differences in emerging emotion regulation skills, measured at both the behavioral and physiological level. The current study investigated two familial risk factors, sociodemographic risk and parental substance use, as predictors of toddlers' emotion regulation. Participants were 117 parent-toddler dyads recruited across a range of sociodemographic risk. Dyads completed a structured series of parent-child interaction tasks, including a resting baseline and a mildly frustrating task, in which toddlers were asked to wait for toys and their parents' attention. Emotion regulation was assessed through observational coding of the frustration episode and through measurement of respiratory sinus arrhythmia (RSA), an indicator of parasympathetic nervous system functioning associated with physiological regulation. Contrary to hypotheses, parent-reported sociodemographic risk and recent substance use were not significantly related to children's emotion regulation, whether measured behaviorally or physiologically, in the current sample. However, RSA response to challenge was significantly associated with behavioral regulation, such that children who maintained higher RSA across the transition from resting baseline to frustration (i.e., withdrew less or augmented) showed better behavioral regulation than those who withdrew more. Consistent with prior literature, older age was associated with higher RSA across tasks, and non-White toddlers tended to have higher resting RSA than their White peers. In conclusion, this study did not find expected associations linking sociodemographic risk and parental substance use with child emotion regulation. However, results clarified links between behavioral and physiological regulation, finding that maintaining higher RSA during mild frustration was associated with better behavioral regulation among socioeconomically diverse toddlers. These findings begin to clarify mixed results regarding the association between RSA withdrawal to challenge and child emotion regulation capabilities.

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The Association Between Sociodemographic Risk, Parental Substance Use, and Child Emotion Regulation Capabilities

Emotion regulation is defined as the ability to monitor and modulate one's emotional experiences to successfully navigate social interactions and attain goals (Thompson & Meyer, 2007). Building adaptive and effective emotion regulation skills at young ages can help children to thrive in a variety of circumstances later in life. For example, effective emotion regulatory skills have been tied to children's social competence, adjustment, and resilience (Denham et al., 2003; Eisenberg et al., 2002). Conversely, ineffective regulation has been associated with lower social competence and more internalizing and externalizing symptoms (Frick & Morris, 2004; Zeman et al., 2006).

The early development of effective emotion regulation is a social, interactive process that is strongly molded by one's parents, particularly during toddlerhood, a robust period of regulatory development (Eisenberg et al., 2010; Morris et al., 2007). Many family-related factors, such as being raised in low sociodemographic status household and having parents who misuse substances, have been related to emotion regulation development. Specifically, previous research has independently linked both poverty and maternal substance use with higher levels of child emotional dysregulation (Kim et al., 2013; Shadur & Hussong, 2020). However, these studies are typically conducted after the age of three and focus on single measures of emotion regulation at the behavioral level. This multimethod study begins to elucidate mixed findings regarding adaptive patterns of autonomic regulation during challenge by linking behavioral and physiological outcomes (Alkon et al., 2003). Additionally, the current study fills gaps in the literature by examining both behavioral and physiological measures of emotion regulation in the context of familial-level risk factors such as sociodemographic status and parental substance use during toddlerhood.

1.2 Emotion regulation development at multiple levels of analysis

Emotion regulation is a multifaceted construct that encompasses both internal (i.e., physiological, cognitive) and external (i.e., expressions, reactions, and behaviors) processes to manage the type, duration, and intensity of emotional experiences (Gratz & Gomer, 2004). Historically, research on emotion regulation has relied heavily on self- and proxy-reports of individuals' use of regulatory strategies and/or perceived success in managing strong emotions (Cole et al., 2004). More recently, researchers have increasingly taken a multi-level perspective, incorporating both behavioral and physiological measures to capture multiple dimensions of emotion regulatory processes across the lifespan.

1.2.1 Behavioral regulation

The external, observable components of emotion regulation are often characterized through overt behavior, including regulatory strategies and choices about when and how to express emotions (Saarni, 1999; Spinrad et al., 2007). Behavioral regulatory strategies such as self-comforting and distraction have been regarded by previous researchers as adaptive in helping young children regulate effectively during frustrating situations, as evidenced by well-modulated emotional expression (e.g., minimizing intensity and duration of negative affect) (Denham et al., 1997; Gottman et al., 1996; Stifter & Braungart, 1995). Conversely, high levels of distress, venting frustration, and aggressive behavior are interpreted as evidence of less effective emotion regulation (Calkins, 1997; Cicchetti et al., 1991; Cole et al., 1994; Stifter et al., 1999).

Importantly, research on behavioral regulation of emotion is complicated by methodological concerns regarding the inherent difficulty of separating emotional reactivity (i.e., the intensity of emotional experiences arising in a given situation) from the modulation of those experiences to attain goals (Cole & Deater-Deckard, 2009; Gross & Thompson, 2007). For example, compared to a child showing unrestrained negative emotion, a child who appears outwardly calm in a frustrating situation may have lower emotional reactivity (i.e., feel less frustrated), more effective strategies for modulating frustration, or both. However, researchers do agree that, in theory, regulation is separate in that it serves to modulate reactivity, and that although it is challenging to separate them empirically, doing so is clinically meaningful (Cole & Deater-Deckard, 2009; Gross & Barrett, 2011; Rothbart et al., 2006).

The early development of emotion regulation typically occurs in the context of the parent-child relationship through parental socialization of emotion via strategies such as labeling emotions, teaching regulatory strategies, and modeling of their own emotion regulation (Eisenberg et al., 1998; Morris et al., 2007). For example, previous research has demonstrated links between positive emotion socialization and child observed emotion regulation (Brophy-Herb et al., 2010). Parental support of healthy regulatory development seems to be particularly important during the first five years of life, a time frame some researchers consider to be a sensitive period for emotion regulation development (Denham, 1998; Shonkoff & Phillips, 2000). This highlights early childhood as an especially relevant developmental stage for investigations of emotion regulation and its correlates. However, children in this age range may not yet be able to fully communicate about emotional experiences or how they manage them, requiring investigators to utilize other methods to capture these constructs (Davidson, 2001). According to Perry and colleagues (2018), laboratory assessment of behavioral emotion regulation from ages one to three is an important and age-appropriate measure as visible indicators of emotional expression and regulation are more informative than in later development, when emotion regulatory processes become more internalized and normative beliefs begin to influence behavior. Additionally, these behavioral indications can be substantially strengthened by the additional inclusion of autonomic nervous system responding as a physiological component of regulation (Cole et al., 2009; Berntson et al., 1994)

1.2.2. Autonomic regulation

Emotion regulation may be characterized biologically using the autonomic nervous system as a physiological indicator. Specifically, the sympathetic and parasympathetic branches have been conceptualized as a two-part system reflecting differential control of physiological arousal coinciding with emotional experience (Berntson et al., 1994). The sympathetic nervous system is utilized in fight or flight situations to help mobilize resources for a response to acute threat. In contrast, the parasympathetic system helps maintain bodily systems during periods of rest and balance the distribution of resources between internal (i.e. homeostatic) and external demands (i.e. social engagement, emotion regulation) (McCorry, 2007). The parasympathetic nervous system is believed to be particularly relevant for physiological regulation during everyday challenges (Porges, 2001), including tasks that involve emotion regulation, mild levels of stress, and sustained attention (Buss et al., 2005).

Parasympathetic nervous system activation is often indexed using respiratory sinus arrhythmia (RSA), which reflects heart rate variability associated with respiratory cycles (Porges, 1991). Higher RSA indicates more parasympathetic influence on the heart. In general, higher resting baseline RSA has been associated with better emotional regulatory abilities whereas lower baseline RSA has been linked to greater difficulty regulating in challenging situations (Demaree et al., 2004; Thayer & Lane, 2000; Volokhov & Demaree, 2010). Physiological levels of emotion regulation are also characterized using RSA response from resting baseline to a challenging task, where parasympathetic reactivity to challenge is expected to reflect dynamic regulation of autonomic activation in response to situational demands (Berntson et al., 1994).

Research is less clear on what constitutes adaptive RSA reactivity to challenge: this question is complicated by mixed findings regarding the optimal direction (i.e., augmentation versus withdrawal) and degree of autonomic responding in different situations, regardless of the age of participants (Del Giudice et al., 2014). Withdrawal represents an RSA decrease in response to challenge and has been linked to better emotion regulation and child adjustment (Beauchaine, 2001; Graziano & Derefinko, 2013). Augmentation is an RSA increase to challenge and has often been theorized to represent social disengagement or avoidance (Beauchaine, 2001). However, some research has shown that RSA augmentation may serve as evidence of active coping in an effort to remain calm and engaged in challenging situations (Butler et al., 2006; Skowron et al., 2011). Additionally, other novel investigations have demonstrated that, in the presence of a supportive social partner, RSA augmentation may facilitate better social functioning (Hastings & Khale, 2019; Shahrestani et al., 2015). Autonomic reactivity data are also more complex than baseline due to the their susceptibility to change based on factors like developmental level and individual differences in coordination between the two branches (Alkon et al., 2003; Kupper et al., 2021). However, according to polyvagal theory, moderate RSA withdrawal is believed to be most adaptive (i.e., associated with better observed regulation in the moment and/or more adaptive distal outcomes) in situations involving mild challenge (Porges, 1995).

The specific factors that relate to individual differences in autonomic functioning at rest and in response to challenge are not yet clearly defined in the literature, particularly for young children. However, the first five years of life are believed to be particularly important for physiological emotion regulation development (Alkon et al., 2011). During this developmental period the sympathetic and parasympathetic nervous systems mature and begin to stabilize, coinciding with rapid changes in children's observable self-regulatory capabilities (Alkon et al., 2011; Porges & Furman, 2011). Variations in children's environments during these early years may influence the initial calibration and long-term functioning of these systems, contributing to the individual differences seen across autonomic functioning (Busuito & Moore, 2017).

In particular, individual differences in autonomic functioning may in part reflect differential exposure to stress during early childhood (Quigley & Moore, 2018). Specifically, both frequency and severity of exposure to childhood adversity may significantly impact an individual's ability to react physiologically to an external challenge and to recover from the challenging episode. Higher childhood adversity has been linked to lower parasympathetic activation at rest, which limits the capacity for physiological regulation through flexible withdrawal of RSA (Quigley & Moore, 2018). In contrast, responsive caregiving is believed to scaffold effective autonomic regulation (Armony & Vuilleumier, 2013). Taken together, this suggests that family-level risk factors may be especially important predictors of physiological regulation during emotional challenges in early childhood.

1.3 Family-level risks and emotion regulation development

The early development of behavioral emotion regulatory abilities and physiological regulatory functioning can be guided by a number of life circumstances and variations in the family environment. For example, early life adversities like exposure to violence and unsupportive parental emotional socialization have been linked to more parent-reported child emotion dysregulation and greater skin conductance response during a fear extinction period, indicating more physiological dysregulation (Milojevich et al., 2020). Another early life adversity, sociodemographic risk (defined as socioeconomic and demographic disadvantages that are generally long-term and exogenous to the child; Moore et al., 2006), may play a particularly important role in the development of emotion regulation. Experiencing poverty in childhood has been associated with emotional dysregulation, potentially as a function of experiencing many chronic stressors at a young age (Kim et al., 2013). Relatedly, familial financial difficulties early in life have been tied to difficulties with socioemotional functioning in children (McLoyd, 1990), perhaps because economic hardship may undermine parents' ability to be present and provide consistent caregiving. One relevant theory providing further insight to this relationship, the family stress model, suggests that economic hardship and pressure can lead to psychological distress among parents. This parental distress is expected to have downstream consequences for child adjustment by undermining coparenting relationships and parenting behavior (Masarik & Conger, 2017).

A previous study examining sociodemographic status and child emotion regulation found that higher scores on a familial risk index, created using maternal report of family income, marital status, household size, and parent education level, were associated with more parent-reported emotion dysregulation and lower adaptive emotion regulation in the child. These findings, which were mediated by unsupportive maternal reactions to children's negative emotions, highlight the importance of environmental context on vulnerability for disrupted regulatory development (Shaffer et al., 2012). Children in this study were ages four to 12 years, presenting a need for further examination of family-level regulatory influences during toddlerhood, a period of rapid emotion regulation development (Eisenberg et al., 2010). Additionally, several other risk factors may co-occur with the proposed pathway between sociodemographic risk and emotion dysregulation, providing further insight into this relationship.

One commonly co-occurring risk factor is parental substance use. Studies have found a positive relationship between substance use and sociodemographic risk (Swendsen et al., 2009). For example, living in a lower income neighborhood has been associated with increased tobacco use for men and increased tobacco and other drug use for women (Karriker-Jaffe, 2013). This is concerning given knowledge that children of substance-using parents are at increased risk for behavioral, social, and emotional problems as early as two years of age (Hussong et al., 2007: Solis et al., 2012;). Much of the research examining the relations between parental substance use and child emotion regulation thus far has focused on prenatal rather than early life substance exposure, finding that prenatal exposure confers risk for poor physiological and self-regulation from early infancy through the first year of life (Schuetze & Eiden, 2006; Schuetze et al., 2012).

Some studies examining links between prenatal substance exposure and early child emotion regulation have also included postnatal substance exposure. For example, Eiden and colleagues (2002) reported an indirect effect of prenatal cocaine exposure on child affect regulation at seven months through postnatal alcohol use, emphasizing the importance of considering environmental exposure to parental substance use in early childhood as an important predictor in its own right. One study exclusively examining the postnatal period found that higher maternal substance use predicted more non-supportive reactions to children’s emotional difficulties, which in turn predicted worse parent-reported emotion regulation in children aged three to eight years (Shadur & Hussong, 2020). Importantly, this prior study only examined parents' observations of emotion regulation in older children (i.e., how well children recovered behaviorally from emotional challenges in the previous six months) and could be further supported with behavioral and physiological levels of regulatory abilities in toddlers.

1.4. Limitations of existing literature

There are several relevant areas of study that, if examined, would help to bolster the current body of emotion regulation research. First, gaps in the literature call for an examination of physiological levels of regulation in young children during toddlerhood, as these are critical years for early emotion regulation development. Additionally, children in this age range may not have fully developed behavioral regulation strategies or the ability to communicate verbally about emotional experiences, highlighting the importance of supplementing behavioral data with a physiological measure of emotion regulation (Davidson, 2001). Additionally, valuable knowledge could be gained from clarifying the contributions of familial-level risk factors such as sociodemographic risk and parental substance use to both physiological and behavioral indicators of children's emotion regulation. Finally, mixed findings regarding adaptive patterns of autonomic regulation call for more research that include measures of autonomic regulation during challenge and link them with behavioral outcomes to illustrate their adaptive potential (Propper & Holochwost, 2013; Quigley and Moore, 2018).

1.5 The current study

The current study aimed to expand the emotion regulation literature by contributing to growing definitions of adaptive patterns of physiological regulation and examining associations linking both sociodemographic risk and parental substance use with toddler-age children's emotion regulation capabilities. Toddlerhood is of particular interest due to the rapid development of emotion regulation capabilities and the important role parents play in facilitating this development (Eisenberg et al., 2010; Hostinar et al., 2014). First, we aimed to examine the link between behavioral and physiological measures of emotion regulation with the goal of clarifying adaptive patterns of RSA activation in response to mild challenge. Given mixed findings in the literature, our first aim was to define adaptive RSA reactivity empirically through its association with observed behavioral regulation. Additionally, we aimed to clarify associations between two familial level risk factors, sociodemographic risk and parental substance use, and child autonomic and behavioral emotion regulation. We hypothesized that higher sociodemographic risk and more parental substance use would be related to less adaptive patterns of autonomic regulation, including lower baseline RSA and less adaptive RSA reactivity to challenge, as defined by the results of Aim 1. Additionally, we expected that more sociodemographic risk and parental substance use would be independently associated with less effective observed behavioral regulation, defined as how well children are able to manage the intensity of their emotions when facing challenge (Sheppes & Gross, 2012). We expected that bivariate associations would be robust controlling for candidate demographic covariates (i.e., child age, sex, and race/ethnicity).

Methods

2.1. Participants

A power analysis was completed in G-Power, yielding a minimum sample size of 107 for detecting a medium-sized effect (f^2=0.15) with 97% power in a multiple regression with two tested predictors and three total predictors (i.e., sociodemographic risk, substance use, and adjusted age; Faul et al., 2007). Participants were 117 parents (111 mothers, 6 fathers) and their 12- to 35-month-old toddlers. Families were recruited from southeastern Virginia by posting flyers in local parenting Facebook groups and daycare centers, as well as snowball sampling from previous participants. To ensure broad representation across a range of sociodemographic risk, participants were also recruited through state-sponsored programs serving low-income families (e.g., Early Head Start).

Parents ranged in age from 22 to 47 years (*M* = 33.3, *SD* = 5.0 years) and predominantly identified as White (75.2%). Participants' yearly income ranged from less than $10,000 to more than $400,000 per year (*M* = 6.6, *SD* = 2.5, on a scale from 1 to 12, corresponding to $75,000 - $100,000 per year). Toddlers were identified as White (75.2%), Multiracial (14.5%), or Black (10.3%) and 55 were identified as female (47.0%). Regarding parent relationship status, 84.6% were married or cohabitating, 5.1% were divorced or separated, and 10.3% were single and never married.

2.2. Procedures

The College of William and Mary Institutional Review Board approved all study procedures. Upon completing informed consent, heart rate sensors were placed on both the parent and the child to monitor their autonomic activity. Participants then completed a series of structured interaction tasks adapted from Kohlhoff and colleagues (2020), which were videorecorded for subsequent behavioral coding. First, parent-child dyads were asked to sit quietly while viewing a child-friendly video to acquire a baseline measure of autonomic physiology. They subsequently completed a series of 4-minute interaction tasks: 1) a picture book sharing activity, 2) an episode of free play, 3) a mildly frustrating wait task, 4) a second free-play episode, and 5) toy clean up. The current study focused on child regulation during the wait task, which involved a researcher removing all toys from the room and asking the parent to focus on completing a survey while the child did their best to wait for their attention. The researcher returned with a new set of toys after four minutes, or upon early termination of the task due to the child being extremely upset and unable to calm down for a period of 30 seconds. Autonomic data was collected throughout the duration of these activities.

Upon completion of the parent-child interaction tasks, researchers removed heart rate sensors and the parent and child completed individual assessments in adjacent rooms. During this portion, the child completed the Brigance Early Childhood Screens III, a brief screening measure of developmental milestones across language, motor, cognitive, and adaptive domains (Glascoe, 2002) and a second mildly frustrating task (attractive toy behind a transparent barrier, adapted from the Lab-TAB protocol; Goldsmith & Rothbart, 1996) while parents completed interviews and measures of cognitive functioning that are beyond the scope of the current study. Finally, the parent completed a survey battery that included measures to assess their sociodemographic status, history of early adversity, current and past stressors, health and wellbeing, and substance use, as well as their perspective on their child's development. Visits took around three hours to complete, and participants were compensated with $75 as well as a small toy for the child.

2.3. Measures

2.3.1. Behavioral regulation of emotion

Children's regulation of emotion at the behavioral level was rated during the wait task in the parent-child interaction series using a global emotion regulation scale that ranged from 0 (*Poorly Regulated*) to 4 (*Extremely Well-regulated*). In order to facilitate accurate and reliable coding, descriptions and behavior examples were attached to each scale point and half points were awarded for ambiguous cases. For example, the description for a score of 2 (*Moderately Regulated*) is:

> "Child is able to self-regulate at a moderate level. They may attempt a few regulatory strategies and may regulate effectively for up to half the task. Child shows moderate ability to control emotions, but some difficult regulating anger and/or distress as evidenced by both of the following:
>
> Multiple (3+) instances of clear but mild frustration, anger, or distress (e.g., slight frown, furrowed eyebrows, brief whine, slight sigh).
>
> One or two instances of moderate anger/distress (e.g., distinct frown or grimace, prolonged whine/deep sigh, tearful, voice clearly raised, angrily defies direct instruction)."

Two research assistants independently scored each video, and scores were averaged across each participant. Inter-rater reliability was excellent (intraclass correlation [*ICC*] = 0.95)

2.3.2. Child autonomic regulation

Toddler respiratory sinus arrhythmia (RSA) was measured using Mindware Technologies ambulatory electrocardiograph and three disposable Ag/AgCI electrodes placed on the children's lower right and left rib and right collar bone (MindWare Technologies Ltd., Columbus, Ohio, USA). ECG waves were transmitted through a wireless signal to a computer in an adjoining room throughout the parent-child interaction tasks. Data were cleaned and scored using Mindware Technologies HRV software (version 3.2.11) and exported in 60-second epochs for each task. Each epoch was inspected by trained research assistants and any mis specified R peaks were manually edited. Raw data underwent a fast Fourier Transformation, and RSA was defined as the natural log integral of the frequency 0.24 to 1.04 Hz power band, calculated in 60 second epochs. Two research assistants independently cleaned each epoch (*ICC* = 0.98) and discrepancies were resolved by consensus.

RSA values were averaged across epochs within the resting baseline and frustrating wait episodes, resulting in two task averages for each participant. Additionally, RSA response to challenge was calculated using standardized residualized change scores resulting from the regression of the frustration task average on the baseline task average (Krantz et al., 1996). Positive reactivity scores indicate RSA change that is greater than the predicted response from baseline to frustration whereas negative scores indicate RSA change less than the predicted response.

2.3.3. Sociodemographic status

During the final portion of the research visit, parents completed questionnaires that contained measures assessing income, marital status, use of income-based state-funded services, and education level. A sociodemographic risk score adapted from Moore and colleagues (2010) was created for each participant by summing the number of present risk factors: yearly income below the federal poverty level, single parent household, parent(s) without a high school diploma, currently unemployed parent(s), and currently receiving income-based services.

2.3.4. Parental substance use

Parents' recent substance use (past three months) was assessed with a modified version of the National Institute on Drug Abuse ASSIST Quick Screen Version 1 (NIDA, 2018). Participants were asked to indicate which of the following substances they had used in their lifetime: alcohol, tobacco, cannabis, cocaine, prescription stimulants, methamphetamines, inhalants, sedatives or sleeping pills, hallucinogens, street opioids, or prescription opioids. If the participant endorsed any lifetime use of the listed substances, follow-up questions were asked to assess whether they had ever been a regular user of the substance (3 or more times a week; yes or no), if the substance had ever caused a problem in their life (yes or no) and how frequently they had used the substance in the last three months. Frequency of recent use was scored on a 0 to 4 scale (0- never in the past three months, 1 - once or twice, 2 - monthly, 3 - weekly, and 4 - daily or almost daily). A substance use risk scored was created by summing the number and frequency of substances used in the past three months, resulting in a possible range of 0 to 44 where 0 indicates no substances used on any of the last 90 days and 44 indicates all substances used daily or almost daily.

2.3.5. Demographic Covariates

At the research visit parents reported on their child's sex assigned at birth, racial/ethnic identity, date of birth, and weeks premature if applicable. Chronological age was calculated by subtracting date of birth from date of assessment. Consistent with guidelines from developmental screening measures (Brigance & French, 2013; Squires & Bricker, 2009), weeks premature was used to calculate adjusted age for children less than two years old by chronological age who were born more than three weeks early.

2.4. Missing data

Percent missing data ranged from 0% (family demographics, parental substance use) to 12.8% (toddler autonomic activation data). Eight toddlers did not have autonomic data due to dyads choosing not to participate (e.g., parents requesting to skip child autonomic data due to toddler distress). One child was excluded from autonomic data analysis due to respiratory power consistently falling outside a physiologically plausible range. Three participants were missing behavioral codes due to technology failure resulting in video loss; because missingness was unrelated to participant characteristics, behavioral data was considered missing completely at random. Toddlers with versus without autonomic data did not differ on demographic covariates or behavioral regulation, and physiological data was thus assumed to be missing at random. Full-information maximum likelihood (FIML) was used to generate unbiased parameter estimates for multiple regression analyses.

2.5. Plan for analysis

Bivariate associations were calculated linking risk variables with observed regulatory abilities, RSA task averages for both baseline and frustration, and autonomic reactivity to challenge. Significant associations were followed up with multiple regressions controlling for relevant covariates to further understand predictive relationships. Child sex assigned at birth, adjusted age, and race (White versus non-White) were evaluated as potential covariates for all outcomes.

Analyses were completed in R (R Core Team, 2016). Linear regressions predicting continuous outcomes were modeled in the package ‘lavaan’ using maximum likelihood estimation with robust standard errors and FIML to account for missing data (Rosseel, 2012).

Results

3.1 Descriptive statistics

3.1.1 Behavioral Regulation

Global emotion regulation scores ranged from zero to four (*M* = 1.8, *SD* = 1.1). This corresponds to an average score of 2, indicating moderately successful regulation with intermittent expressions of mild to moderate frustration and/or distress.

3.1.2 Autonomic Regulation

Respiratory sinus arrythmia descriptive statistics are presented in Table 1. Baseline RSA scores ranged from 1.2 to 7.2 (*M* = 4.6, *SD* = 1.3), and frustration RSA values ranged from 1.1 to 6.5 (*M* = 4.0, *SD* = 1.0). The majority (73.8%) of toddlers experienced RSA withdrawal from baseline to frustration, whereas 5.8% of toddlers showed stable RSA and 20.4% experienced RSA augmentation or increases. RSA reactivity was represented using standardized residualized change scores, derived from regressing frustration RSA values on baseline RSA values, in order to model task-related changes in RSA activation while accounting for between-person differences in baseline RSA. These values ranged from -5.1 to 2.0.

3.1.3 Sociodemographic risk.

Parent and toddler demographics are presented in Tables 2 and 3. Mean household income for families in this study was $75,000 to $100,000 per year, with a modal yearly income of $100,001 - $150,000. About three-quarters (78.6%) of parents reported completing at least a two-year college degree and around one-quarter of participating families reported receiving income-based state services (supplemental nutrition through the Women, Infants and Children program, home-visiting and/or center-based childcare through Early Head Start, etc.). Sociodemographic risk scores ranged from zero to five (M = 0.63, SD = 1.1), suggesting generally low levels of poverty-related stress.

3.1.4 Parental Substance Use

About three-quarters of this sample (75.2%) reported at least some substance use in the last three months. Participants reported recent use of alcohol, tobacco, marijuana, and non-prescribed use of prescription stimulants, but not cocaine, methamphetamines, inhalants, sedatives or sleeping pills, hallucinogens, or prescription or street opioids. For a given substance, reported frequency of use in the past three months ranged from once or twice (alcohol, tobacco, marijuana) to daily or almost daily (alcohol, tobacco, marijuana, prescription stimulants not as prescribed). One-quarter of participants reported using alcohol at a frequency of weekly or greater, 4.2% reported using tobacco at least weekly, and 5.8% reported using marijuana at least weekly; only one participant reported using prescription stimulants not as prescribed at a frequency of daily or almost daily. Overall, parental substance use in this sample was low, with risk scores ranging from zero to nine (M = 2.0, SD = 1.9).

3.2 Bivariate Associations

Bivariate associations of focal variables and candidate covariates are presented in Table 4.

3.2.1 Focal analyses

Sociodemographic status and parental substance use were not significantly related to RSA averages, reactivity, behavioral regulation, or candidate covariates. However, RSA reactivity was significantly associated with behavioral emotion regulation

($r = .28$, $p < .01$), such that more positive RSA change (i.e., less withdrawal and/or more augmentation) from baseline to challenge predicted better observed emotion regulation.

3.2.2 Candidate covariates

Child sex was not significantly related to baseline or frustration RSA, RSA reactivity to challenge, or behavioral regulation during the frustration task. Adjusted age, however, was significantly correlated with both baseline RSA ($r = 0.43$, $p < 0.001$) and frustration RSA ($r = 0.33$, $p < 0.01$). Child race (White vs. non-White) was significantly related to baseline RSA ($r = -0.20$, $p < 0.05$), but not to frustration RSA or RSA reactivity to challenge. Because neither child sex nor child race were associated with RSA during the frustration episode, they were excluded from follow-up analyses.

3.3 Multiple Regressions

Given non-significant bivariate associations linking familial-level risk factors with child emotion regulation, no multiple regressions including sociodemographic risk or parental substance use were tested. However, in a follow-up linear regression testing the robustness of the link between behavioral and physiological emotion regulation, RSA reactivity to frustration continued to predict behavioral emotion regulation ($\beta = 0.31$, $p < .01$) controlling for adjusted age. These findings are presented in Table 5.

Discussion

This study examined how two relevant familial-level risk factors, sociodemographic status and parental substance use, related to behavioral and physiological aspects of toddler emotion regulation. Specifically, we examined how sociodemographic status and substance use risk scores related to toddlers' observed emotion regulation during a frustrating task, as well as their parasympathetic activation throughout task episodes (i.e., RSA during resting baseline and frustration episodes; RSA reactivity to frustration). We additionally considered important demographic covariates such as child adjusted age, race, and sex. We hypothesized that more sociodemographic risk and more parental substance use would be related to both worse behavioral and autonomic regulation. Hypotheses were not supported: neither sociodemographic risk nor parental substance risk were significantly related to behavioral or physiological regulation in the current sample.

An additional aim of the current study was to contribute to our growing understanding of adaptive RSA reactivity to challenge, believed to reflect physiological regulation in response to emotional experiences, as it relates to observed emotion regulation. We found that behavioral and autonomic regulation were significantly associated with each other, clarifying adaptive patterns of autonomic regulation to mild challenge in toddlerhood. In this sample, children who maintained higher RSA across the transition from resting baseline to frustration (i.e., withdrew less or augmented) showed better behavioral regulation than those who withdrew more. This aligns with previous findings which report that children who either maintained or increased in RSA values from baseline to challenge tended to display more adaptive behavioral regulation strategies during a task designed to elicit frustration (Perry et al., 2012).

In contrast to the current findings, one meta-analysis reported small effect sizes linking more RSA withdrawal to challenge with better adaptive functioning as demonstrated by internalizing, externalizing, and academic problems (Graziano & Derefinko, 2013). However, contextualizing the challenge task in the studies in the previous review may be important when considering what autonomic responding is theoretically most adaptive. For example, the most adaptive response to a task that involves perceived threat would likely involve RSA withdrawal; because RSA is inversely associated with heart rate, withdrawal is required to increase physiological arousal and mobilize resources to face a threat. In contrast, a milder challenge free of overt threat may not require such withdrawal (Hastings et al., 2008). Additionally, some have theorized that vagal augmentation is beneficial in situations requiring increased attention and emotional control (DiPietro et al., 1992). In the current sample, children may be successfully recruiting parasympathetic resources while engaged in active coping, facilitating better behavioral regulation. Relatedly, augmentation to challenge may reflect the presence of a caregiver who has historically demonstrated supportive emotion-related parenting. Previous research has shown that RSA augmentation may relate to social support from a significant other (in this case, a parent) buffering the effects of stress (Shahrestani et al., 2015; Zhang et al., 2020). Little research has examined the possible relationship between parental emotional support and child physiological augmentation as it relates to effective emotion regulation, particularly in toddlerhood.

While the current study found associations between behavioral and autonomic regulation, there were no significant associations linking sociodemographic risk or parental substance use with child emotion regulation. The null finding between sociodemographic risk and child emotion regulation is notable as several previous studies report that child emotion regulation, measured both behaviorally and physiologically, is undermined in the context of poverty, low parental education, and socioeconomic disadvantage (Blair et al., 2013; Evans & Kim, 2012; Hughes & Ensor, 2009). This relationship is thought to be in part a function of how the parent interacts with their children, as economic hardship can reduce parents' ability to be present and provide consistent caregiving (Carreras et al., 2019). In particular, the family stress model suggests that economic hardship and pressure can lead to psychological distress among parents, contributing to child maladjustment by undermining parenting (Masarik & Conger, 2017). Perhaps insight into the parenting behaviors of this sample could help elucidate the null findings. For example, Morris and colleagues (2017) have found that positive emotion-related parenting practices such as problem solving, providing comfort, and labeling emotions, particularly in toddlerhood, facilitates better child emotion regulation. If parents in the current sample were able to maintain high levels of support and adaptive emotion socialization regardless of socioeconomic status, resilient parenting may have buffered children's emotion regulation development from the potential negative effects of sociodemographic risk.

Of note, while about a quarter of the current sample reported receiving income-based state services, only 18.8% of participants had two or more risk factors present out of a total five. With an average sociodemographic risk score of 0.63, low amounts of risk and limited variability in the sample may also have contributed to null findings between sociodemographic risk and child emotion regulation.

In contrast to the extensive literature on effects of parental sociodemographic risk, research examining postnatal parental substance use as a predictor of children's emotion regulation is limited. However, previous studies report that in general children whose parents use substances tend to show increased emotional and behavioral problems as well as poorer academic functioning (Solis et al., 2012), and that these differences can become evident as early as two years of age (Hussong et al., 2007). This study diverges from previous findings, demonstrating no significant differences in emotion regulation at the behavioral and autonomic level for toddlers whose parents report higher amounts of recent substance use. While it is estimated that one in five children grow up in a home with substance misuse (Kulig, 2005), the current sample had somewhat limited amounts of substance use. Twenty-six parents reported weekly alcohol use, five daily tobacco use, three daily marijuana use, and one daily stimulant misuse. No additional substances were reported as used and all other participants reported using substances on a weekly or less basis. The relatively low frequency of regular substance use in the current sample may have reduced the power to find significant effects.

An important consideration is the role parent emotion socialization may play in mediating the relationship between parental substance use and child emotion regulation. Emotion socialization is the way parents talk to, instruct, and socialize children to the expression and experience of emotion (Eisenberg et al., 1998). This can be done directly, through explicit teaching about emotions and regulatory strategies, as well as indirectly through parental responses to children’s emotions and implicit modeling of their own emotional experience and expressions. Research has shown a direct link between parent emotion socialization practices and children’s emotion regulation capabilities (Brophy-Herb et al., 2010); however, this is rarely studied in the context of parental substance use. One study examining this found that the relationship between maternal substance use and parent reported child emotion regulation was in fact mediated by more non-supportive maternal responses to child negative emotions (Shadur et al., 2019). Consequently, if parents in the current sample supported regulatory development through adaptive emotion socialization practices despite recent substance use, their children may not demonstrate expected differences in emotion regulation outcomes.

Regarding demographic covariates, adjusted age was significantly related to RSA at baseline and during the frustration task. These findings were such that as children aged, they tended to have higher RSA values during both episodes, replicating previous evidence reporting increases in RSA across development (Dollar et al., 2020; Wagner et al., 2021). This is believed to reflect increasing dominance of the parasympathetic versus sympathetic nervous system and to correspond with developmental increases in regulatory skill across early childhood (Quigley & Moore, 2018).

Additionally, results showed that non-White toddlers tended to have significantly higher baseline RSA values than their White peers. Other studies have reported similar race-related differences in early childhood RSA, with longitudinal data demonstrating that these differences typically disappear by middle childhood (Dollar et al., 2020; Hinnant et al., 2011; Saloman, 2005). Further research is needed to clarify the functional significance of this difference in developmental trajectory.

4.1 Limitations and future directions

While this study contributes to the important and growing body of emotion regulation literature, there are some limitations to note. First, while adequately powered for medium effects, the current sample was underpowered to detect small effect sizes (25% power for f^2=0.02). Additionally, relatively low levels of parental substance use and sociodemographic risk limit power to find hypothesized associations. Future studies should aim to examine similar questions in larger samples recruited specifically for sociodemographic disadvantage and postnatal substance use, while also controlling for prenatal exposure (Schuetze & Eiden, 2006;

Schuetze et al., 2012). Also relevant to note, this study used an adapted version of the NIDA ASSIST (NIDA, 2018), a tool mainly used for screening of problematic substance use in primary care settings. Methods could be strengthened by the incorporation of a more comprehensive substance use measure, such as the Timeline Follow back Interview, that has been validated against biomarkers of substance use and can provide more nuanced information (Brown et al., 1998; Schuetze et al., 2008).

Behavioral assessment of emotion regulation in toddlers using a summary measure, such as the one used in this study, is a historically popular method of assessment that is prominent throughout the literature (Diener & Mangelsdorf, 1999; Morelen et al., 2016). However, creating distinctions between emotional regulation and reactivity may be particularly difficult when using a global measure due to limited information available on nuanced aspects of emotional functioning such as intensity and duration of expressions (Cole & Deater-Deckard, 2009; Sheeber et al., 2009). Researchers have begun to address this limitation through examinations linking in-the-moment physiological responding and specific regulatory behaviors and emotional expressions, coded micro-socially rather than globally (Kahle et al., 2018). To date this research has been conducted mainly in higher SES and low racial/ethnic diversity samples, leading to calls for further examination of similar constructs in samples at risk for child dysregulation due to poverty and family stress.

These gaps in the literature highlight an important area of future direction for the current study, particularly given the opportunity to link these specific outcomes with in-the-moment autonomic functioning. For example, Kahle and colleagues (2018) found that behavioral emotion regulation was more strongly associated with autonomic outcomes than emotional expression. Specifically, verbal strategies were linked with more sympathetic activity and recovery, whereas attention diversion was linked with blunted sympathetic reactivity. However, the described study was low in racial, ethnic, and sociodemographic diversity, and confidence in findings could be strengthened from similar examinations in more diverse samples.

Kahle and colleagues (2018) highlight an additional area of future direction for the current study: inclusion of sympathetic nervous system data. The autonomic nervous system has been theorized as a two-part system, the sympathetic and parasympathetic branches, that reveals biological levels of control of physiological arousal (Berntson et al, 1994). The current study only addresses half of that system, limiting understanding of the sympathetic nervous system's role in toddler emotion regulation and preventing investigations of co-activation between the two branches. Future studies including racially, ethnically, and socioeconomically diverse samples should aim to examine both sympathetic and parasympathetic levels of arousal during challenge and frustration.

4.2 Conclusion

In conclusion, we found that sociodemographic risk and low levels of recent parental substance use were not linked to toddlers' parasympathetic or behavioral emotion regulation capabilities. However, this study did replicate previous evidence demonstrating that RSA tends to increase over age and that White toddlers tended to have lower RSA scores at baseline and frustration task than their non-White peers (Dollar et al., 2020; Wagner et al., 2021). Additionally, this study aligned with previous research reporting a significant relationship between autonomic and behavioral emotion regulation such that children with better emotion regulation also tended to augment or remain stable in their RSA scores from baseline to frustration or challenge (Perry et al., 2012).

This study has many strengths. First, physiological assessment of regulation captures biological correlates of emotional experiences, which can serve to supplement behavioral indicators of regulation that may not be fully developed in toddlerhood (Davidson, 2001). Additionally, the current sample is quite diverse in terms of household income, with 25.8% of participants qualifying for income-based state services. This increases confidence in the generalizability of results beyond a higher sociodemographic sample (Kahle et al., 2018). Finally, the current investigation holds clinical relevance in helping to highlight populations most at risk for disrupted emotion regulation and inform the development of future interventions aimed at enhancing adaptive emotion regulation in early childhood and beyond.

Although risk variables were not linked with emotion regulation outcomes, the current study brings to light a number of relevant future directions that can help continue to diversify and supplement the emotion regulation literature. The inclusion of specific regulatory behaviors, emotions, and sympathetic nervous system activation data will allow for a more thorough understanding of the relationship between sociodemographic risk, parental substance use, and child emotion regulation. Continuing to examine the factors that contribute to physiological and behavioral indicators of emotion regulation is of the upmost importance given the known associations of emotion regulation with social competence, adjustment and resilience across the lifespan (Denham et al., 2003; Eisenberg et al., 2002). Investigations such as these will allow us to best serve at-risk communities by improving our understanding of predictors of emotion regulation, guiding intervention efforts to target malleable aspects of family functioning to facilitate healthy regulatory development.

Tables and Figures

Table 1. Descriptive statistics for respiratory sinus arrythmia and differences by race.

Variable	RSA at baseline task	RSA during frustration task
Mean	4.56 ± 1.27	3.96 ± 0.98
Minimum	1.18	1.09
Maximum	7.16	6.53
White	$4.40 \pm 1.24^{*}$	$3.09 \pm 0.93^{*}$
Non-white	$4.95 \pm 1.27^{*}$	$4.08 \pm 1.08^{*}$

Note. RSA differences by race in toddlers. $p < .05$, *. Total N = 106 baseline, 104 frustration task. White N = 72 baseline, 72 frustration task. Non-White N = 33 baseline, 32 frustration task.

Table 2

Parent demographics.

Participant Demographics	*n*	%
Parent Demographics		
Gender		
Female	111	94.1
Male	6	5.1
Did not report	1	0.8
Race/Ethnicity		
Black/African American	12	10.2
White	95	80.5
Multiracial	8	6.8
Other	3	2.5
Marital status		
Single	12	10.2
Married/partnered	99	83.9
Divorced/separated	6	5.1
Education		
Less than high school	2	1.7
High school degree or equivalent	7	5.9
Some college	16	13.6
Associate degree	11	9.3
Bachelor’s Degree	37	31.4
Master’s degree	34	28.8
Doctoral or professional degree	10	8.5
Household Income		
Less than $10,000	5	4.3
$10,001-$20,000	6	5.0
$20,001-$30,000	6	5.0
$30,001-$40,000	8	6.7
$40,001-$50,000	6	5.0
$50,001-$75,000	17	14.2
$75,001-$100,000	17	14.2
$100,001-$150,000	30	25.0
$150,001-$200,000	12	10.0
$200,001-$300,000	5	4.2
$300,001-$400,000	2	1.7
More than $400,001	2	1.7

Note. Parent age (*M* = 33.3 years, *SD* = 5.0).

Table 3

Toddler demographics.

Participant Demographics	*n*	%
Toddler Demographics		
Gender		
Female	61	51.7
Male	56	47.5
Did not report	1	0.8
Race/Ethnicity		
Black/African American	12	10.2
White	84	71.2
Multiracial	20	16.9
Other	1	0.9

Note. Toddler age (*M* = 23.0 months, *SD* = 6.7 months).

Table 4. *Bivariate associations among sociodemographic risk, parental substance use, child autonomic and behavioral emotion regulation, child adjusted age, and sociodemographic covariates.*

	1	2	3	4	5	6	7
1. Sociodemographic risk	--						
2. Parental substance use	.04	--					
3. Baseline RSA	.07	-.02	--				
4. Frustration RSA	.06	.05	.69***	--			
5. RSA reactivity	.03	-.01	.00	.74***	--		
6. Emotion regulation	-.09	.07	.07	.24**	.28**	--	
7. Adjusted age (months)	.11	-.12	.43***	.33***	.06	.18	--
8. Child sex (Male)	.02	-.07	-.13	-.10	.01	.04	-.11

Note. RSA reactivity represented as standardized residual change scores from regressing frustration task RSA average on baseline task RSA average.

Table 5.

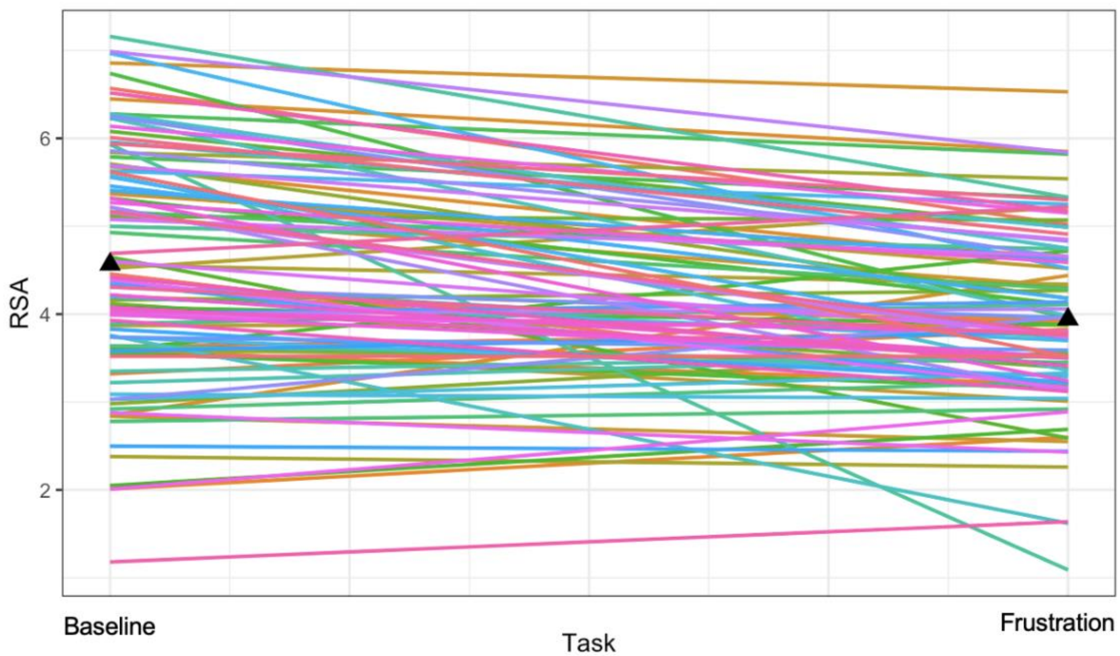
Results from regression predicting global emotion regulation and baseline RSA from autonomic reactivity and adjusted age.

Variable	*β*	*SE*	*p*
Global Emotion Regulation			
RSA Reactivity	**0.31**	0.10	**0.00**
Adjusted Age	0.03	0.02	0.06

Note. N = 118 using full-information maximum likelihood. RSA reactivity represented as standardized residual change scores from regressing frustration task RSA average on baseline task RSA average.

Figure 1.

Spaghetti plot demonstrating task RSA changes from baseline to frustration for each participant.



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