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BRIEF REPORT

Emotion dysregulation and reward responsiveness as predictors of autonomic reactivity to an infant cry task among substance-using pregnant and postpartum women

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Abstract

Maternal substance use may interfere with optimal parenting, lowering maternal responsiveness during interactions with their children. Previous work has identified maternal autonomic nervous system (ANS) reactivity to parenting-relevant stressors as a promising indicator of real-world parenting behaviors. However, less is known about the extent to which individual differences in emotion dysregulation and reward processing, two mechanisms of substance use, relate to maternal ANS reactivity in substance-using populations. The current study examined associations among emotion dysregulation, reward responsiveness, and ANS reactivity to an infant cry task among 77 low-income and substance-using women who were either pregnant ($n = 63$) or postpartum ($n = 14$). Two indicators of ANS functioning were collected during a 9 min computerized infant cry task (Crybaby task): respiratory sinus arrhythmia (RSA) and pre-ejection period. Mothers also completed self-reported measures of emotion dysregulation and reward responsiveness. Analyses revealed that trait emotion regulation was associated with RSA reactivity to the Crybaby task, such that greater emotion dysregulation was associated with greater RSA reduction during the infant cry task than lower emotion dysregulation. Reward responsiveness was not significantly associated with either indicator of ANS reactivity to the task. Findings revealed distinct patterns of associations linking emotion dysregulation with ANS reactivity during a parenting-related computerized task, suggesting that emotion regulation may be a key intervention target for substance-using mothers.

KEYWORDS
parenting, pre-ejection period, prenatal, respiratory sinus arrhythmia, vagal regulation

1 | INTRODUCTION

Maternal substance use may interfere with optimal parenting, lowering maternal sensitivity during interactions with their children, particularly among women experiencing high levels of financial and life stress (Johnson et al., 2002; Lefmann et al., 2017; Mayes & Sean, 2002; Molitor & Mayes, 2010; Scheyer & Urizar, 2016). Emerging research has highlighted the impact of stress- and reward-based processing implicated in substance use behaviors as key predictors of both parenting and child outcomes (Landi et al., 2011; Rutherford et al., 2011). However, relatively little research has investigated the extent to which individual differences in emotional and reward-based processes may relate to maternal physiological reactivity to infant cues among substance-using pregnant women. The goal of the current study was to investigate associations between emotion regulation and reward responsiveness—two emotion-based constructs implicated in parenting and substance use—and autonomic nervous system (ANS) reactivity to a novel infant cry task among substance-using pregnant and postpartum women.

1.1 | Impact of maternal emotion dysregulation and reward responsiveness: implications for substance-using mothers

Extant research has implicated both emotion- and reward-based processing in parenting behaviors across levels of analysis (for reviews, see Pechtel et al., 2013; Rutherford et al., 2015). Behavioral measures of maternal emotion regulation—or mothers' abilities to successfully identify, regulate, and cope with negative emotions—have consistently been linked to parenting practices and child outcomes across developmental periods (e.g., Binion & Zalewski, 2018; Carreras et al., 2019; Langevin et al., 2023; Leerkes et al., 2017; Morelen et al., 2016). Further, research has shown that maternal emotion dysregulation during pregnancy is associated with child outcomes (Van den Bergh et al., 2020). In addition to mothers' ability to manage negative emotions, research has also linked maternal reward processing to parenting practices, including maternal sensitivity (e.g., Kim et al., 2011). In fact, it has been posited that parenting at its core may be fundamentally rewarding, with research showing increased neural activity in reward-related regions in response to new mothers' infant cues (Kim, 2016; Strathearn et al., 2008). However, relatively few studies have examined how self-reported emotion dysregulation and reward functioning relate to mothers' physiological reactivity to parenting-sensitive tasks. One exception is a recent study by Leerkes et al. (2020) that found among mothers of infants, elevated self-reported emotion dysregulation was associated with greater physiological reactivity (i.e., respiratory sinus arrhythmia [RSA]) during stressful parenting tasks, lower maternal sensitivity, and greater incidence of infant attachment disorganization.

Understanding maternal emotional functioning across valence systems may be particularly important for elucidating maternal sensitivity among substance-using mothers, given the overlap between emotion and reward-based systems involved in parenting and substance use behaviors (Landi et al., 2011; Rutherford et al., 2011). Specifically, emotion dysregulation and alterations to reward circuitry have been linked to the initiation and maintenance of substance use across samples (Bounoua et al., 2021; Cheetham et al., 2010; Garland et al., 2020). Further, substance use-related alterations to these systems may go on to impact physiological responses to infant cues, leading to a continuous cycle of emotion dysregulation, disrupted reward responsiveness, and increased drug cravings among substance-using mothers (see Rutherford et al., 2011). Landi et al. (2011) found that, when compared to non-substance using mothers, substance-using mothers (across substance types) evidenced reduced neural activity to infant cries in brain regions associated with reward, motivation, and cognitive control. These findings suggest that emotion- and reward-based processes may impact mothers' internal responses to infant cues. However, the extent to which these systems relate to substance-using mothers' physiological reactivity to infant cues has been relatively understudied.

1.2 | Maternal autonomic nervous system regulation and parenting

ANS regulation has long been established as a robust physiological indicator of self-regulation at baseline and in response to various environmental demands (e.g., Beauchaine, 2015; Davis et al., 2020; Porges, 2011). The ANS contains two branches: the sympathetic nervous system, which can be measured using pre-ejection period (PEP), and the parasympathetic nervous system, typically measured using RSA. ANS resting activity has been conceptualized as a marker of regulatory capacity, with the majority of research implicating low resting RSA in particular as a marker of poor self-regulation and risk for psychopathology (Beauchaine, 2015; Beauchaine & Thayer, 2015; Chalmers et al., 2014). Consistent with polyvagal theory (Porges, 2007, 2011), it is believed that RSA and PEP are correlated with distinct emotion- and reward-based processes. Specifically, blunted or excessive RSA reactivity (withdrawal) to stressors has been linked to psychopathology, perhaps reflecting a mismatch between physiological regulation and environmental demands (Beauchaine et al., 2019). On the other hand, PEP reactivity has been shown to be associated with reward-based processes in particular. Reward responsivity refers to the degree to which an individual experiences positive response to reward and has been conceptualized as a distinct trait-like tendency to experience reward that is part of the larger behavioral approach system (Carver & White, 1994). For example, empirical evidence has shown associations between PEP reactivity to a myriad of reward-related processes, including behavioral approach toward incentives (Ahles et al., 2017; Beauchaine et al., 2001; Brenner et al., 2005), and self-reported trait reward responsiveness (Franzen et al., 2019). It is posited that these associations may be driven at least in part given PEP as a peripheral marker of mesolimbic dopamine reactivity to reward processing and reinforcement (Beauchaine & Gatzke-Kopp, 2012; Berridge, 2007; Forbes & Dahl, 2012). Given these associations, it is unsurprising that studies have also found that blunted PEP reactivity has been linked to the initiation and maintenance of substance use (e.g., Brenner & Beauchaine, 2011; Derefinko et al., 2016).

ANS reactivity may be particularly relevant to understanding parenting behaviors in the moment, in that excessive or blunted reactivity may be barriers to responding effectively to infant cues. Indeed, recent work has linked RSA activity during parenting tasks to parenting quality and behaviors among low-income mothers of preschool-aged children (Molina et al., 2022; Skowron et al., 2013). In one study of pregnant women, Lin et al. (2019) found that emotion dysregulation corresponded to blunted RSA reactivity to an infant cry task in a sample of pregnant women (26–40 weeks gestation). These findings provide preliminary evidence that ANS reactivity to parenting cues may be a marker for emotional processing among pregnant women.

1.3 | Current study

To date, there is limited research on RSA and PEP reactivity to infant cues among substance-using pregnant and postpartum women. This is despite extant research pointing to alterations in emotion- and reward-based processes as mechanisms involved in both parenting practices and the development of substance use behaviors (e.g., Rutherford et al., 2011). Further elucidating how these processes relate to physiological response to parenting-relevant tasks, such as reactivity to infant cues, may be a useful avenue toward the development of effective interventions for these at-risk families. To address this gap, the current study aimed to examine associations between trait emotion regulation and reward responsiveness and ANS reactivity to a novel infant cry task among substance-using pregnant and postpartum women. Based on previous work (e.g., Lin et al., 2019), we expected that emotion dysregulation would be associated with RSA reactivity (withdrawal) to the Crybaby task. Alternatively, given research linking PEP activity to reward-based processes, we expected trait reward responsivity to be associated with PEP-reactivity to the Crybaby task. Given the limited research in this population, hypotheses about the directionality of effects were exploratory.

2 | METHODS

2.1 | Participants

Participants were 77 substance-using women ($M/SD_{age} =$ 29.16/4.47 years) who were either pregnant (n = 63) or postpartum (n = 14) at the time of assessment. Participants were oversampled for opioid use via recruitment from opioid treatment programs; approximately 80.3% of the sample was currently receiving pharmacological treatment for opioid use disorder. The most endorsed substances used during pregnancy included methamphetamines (59.2%), heroin (40.8%), marijuana (43.4%), alcohol (36.8%), and cocaine (27.6%). The majority of mothers (92.1%) reported current combustible cigarette use. This sample is drawn from a larger randomized clinical trial of a parenting intervention for mothers with opioid use disorder (trial was registered on ClinicalTrials.gov—NCT03891628). All data reported in the present study were collected at baseline prior to randomization to clinical intervention.

Women were predominantly White (66.2%), with 24.7% of women identifying as Black or African-American, 7.8% as multiracial, and 1.3% as American Indian or Alaska Native. Six participants (7.8%) identified as Latina. Over half (64.8%) of the sample reported an annual income below $20,000, with 28.2% reporting income between $20,000 and $50,000, and 7% reporting an income above $50,000. Approximately 27.3% of participants completed less than a high school diploma, followed by 42.9% attaining a high school diploma or equivalent (e.g., GED), 8.2% participating in some college but no degree, 6.5% attaining a certificate from technical school, and 5.2% attaining some advanced degree (e.g., associate and bachelors).

2.2 | Procedures

All study procedures were approved by the University Institutional Review Board. When women were pregnant or within 1 month postpartum, they were invited to complete a laboratory assessment. Women completed several tasks, whereas their ANS data were continuously recorded. First, women completed a task in which they were instructed to care for a distressed infant simulator; the analysis of reactivity to this task is beyond the scope of the present study. Next, women completed a 3-min resting period, during which they sat in a comfortable chair while viewing a nature image and listening to nature sounds. ANS activity during this period served as the "resting period" in the present analysis. Finally, women completed a novel 9 min "Crybaby" computerized task (described below), which is the focus of the present study.

2.3 | Measures

2.3.1 | Crybaby task

Women completed a novel, 9 min computerized task designed to assess maternal distress tolerance to infant cries and reward pursuit (Crybaby task). First, mothers were asked to select infant characteristics that they believed would best match their own infants, specifically infant sex and race/ethnicity. This option was used to increase external validity of the task to women's "real world" experience of their own children. Next, participants were given the following instructions: *Now you will complete a computer game. The baby is hungry. To keep the baby from crying, you need to give them their bottle. Your job is to feed the crying baby by clicking on their picture with your mouse. If you don't move quickly enough, the baby will cry. You can quit the task at any time. However, the longer you last in the task, the more money you will make for this appointment*. The goal of the task was to test mothers' ability to tolerate their distress upon hearing infant cries, while persisting in the task to earn a bigger monetary reward. Given this task design, we conceptualize the Crybaby task as an active parenting-relevant task that elicits

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both negative emotional processes (i.e., emotional reactivity to infant cries; distress tolerance) and reward responsiveness (i.e., approach motivation and responsivity to monetary incentive). Examination of the behavioral data from the task provides insight into potential motivational processes relevant to the study. For example, we found that the majority of participants (97.4%) persisted in the task for the entire 9 min (i.e., did not quit early), indicating that mothers were engaged and motivated to complete the task (i.e., earn greater monetary incentive). Second, we assessed the amount of task time that mothers were exposed to infant cries (using a number of "missed feedings" as an indicator of infant cry). On average, mothers were exposed to 39.92 cries per minute (SD = 8.51, min/max = 8.14–57.14), suggesting that there was variability in success in meeting stimulant exposure to infant cries). As preliminary analyses, we will also examine how the proportion of infant cry exposure relates to study variables (see Section 3).

2.3.2 | Autonomic nervous system activity

Women's ANS data were collected with MindWare hardware (mobile impedance cardiograph) and software (BioLab Acquisition Software 3.1). Electrocardiogram (ECG) data were collected with three disposable electrodes in a bipolar configuration, and cardiac impedance data were collected with four disposable electrodes on the chest and back. Data were divided into 1 min segments for cleaning.

ECG data were first cleaned using heart rate variability analysis software (HRV; version 3.2). Artifacts were manually removed, and data were estimated as needed. Segments that required estimation of greater than 10% of total beats or which had less than 30 s of usable data were excluded from analyses. RSA was calculated in each minute as the natural log of the individual's high-frequency HRV. RSA was averaged across the 3 min resting period to create a baseline RSA value, and RSA was averaged across the Crybaby task to create a Crybaby RSA value.

Next, ECG and impedance data were cleaned in impedance cardiography analysis software (IMP; version 3.2). Segments were visually inspected and estimated beats and artifacts were removed. Segments that had less than 30 s of usable data were excluded from analyses. Impedance ensembles were also visually inspected, and critical morphological components were adjusted as needed. PEP in each segment was calculated as the time interval between the Q point of the average ECG cycle and the B point of the average dZ/dt cycle. PEP was averaged across the resting period and the Crybaby task as described above for RSA. See Figure 1 for individual RSA and PEP levels across time.

2.3.3 | Trait emotion dysregulation

Emotion dysregulation was assessed using the difficulties in emotion regulation—short form (DERS-SF; Kaufman et al., 2015). The DERS-SF is an 18-item self-report measure of emotion regulation problems, with higher scores indicating more problems than lower scores. Reliability for this scale was good in this sample (**α** = .85).

2.3.4 | Trait reward responsiveness

Reward responsiveness was assessed using the reward responsiveness scale (RRS; Van den Berg et al., 2010). The RRS is an eight-item self-report measure of reward responsiveness, with higher scores indicating greater reward responsiveness. Reliability for this scale was good in this sample (**α** = .75).

2.4 | Data analytic plan

Bivariate correlations were conducted between PEP and RSA and key study variables. ANS reactivity to the task was modeled separately for RSA and PEP as residualized change from rest to the Crybaby task using Mplus 8.0 (Muthén & Muthén, 2017). Next, trait ER and RS were simultaneously included as predictors of RSA and PEP reactivity. Pregnancy status (0 = postpartum; 1 = pregnant) was included as a covariate of interest in all analyses. In order to include all participants with at least partial data, missing data were accommodated using maximum likelihood estimation with robust standard errors. Standardized results are reported below.

3 | RESULTS

3.1 | Preliminary analyses

Descriptive statistics and bivariate correlations among key study variables can be found in Table 1. As expected, baseline RSA correlated with RSA during the Crybaby task, as did baseline PEP activity with PEP during Crybaby task. Difficulties with emotion dysregulation were negatively associated with RSA activity at baseline and during the Crybaby task, such that greater emotion dysregulation was associated with lower RSA levels. Emotion dysregulation, however, was not significantly associated with baseline PEP or PEP during the Crybaby task. Reward responsiveness was not significantly associated with any indicator of ANS activity at the bivariate level. Pregnancy status was negatively associated with PEP scores at baseline and PEP and RSA levels during the Crybaby task. The proportion of infant cry exposure was not significantly related to trait emotion dysregulation, trait reward responsiveness, and ANS reactivity to the Crybaby task.

3.2 | RSA model

As expected, baseline RSA was associated with RSA during the Crybaby task ($B = .82$, $p < .001$). A significant negative effect of emotion dysregulation was found on RSA reactivity ($B = -.15$, $p = .027$), indicating that greater emotion dysregulation was associated with greater RSA reactivity (more RSA withdrawal) to infant cues than less emotion dysregulation. Conversely, no significant effect of reward responsiveness on RSA reactivity was observed ($B = -.11$, $p = .162$). Similarly,

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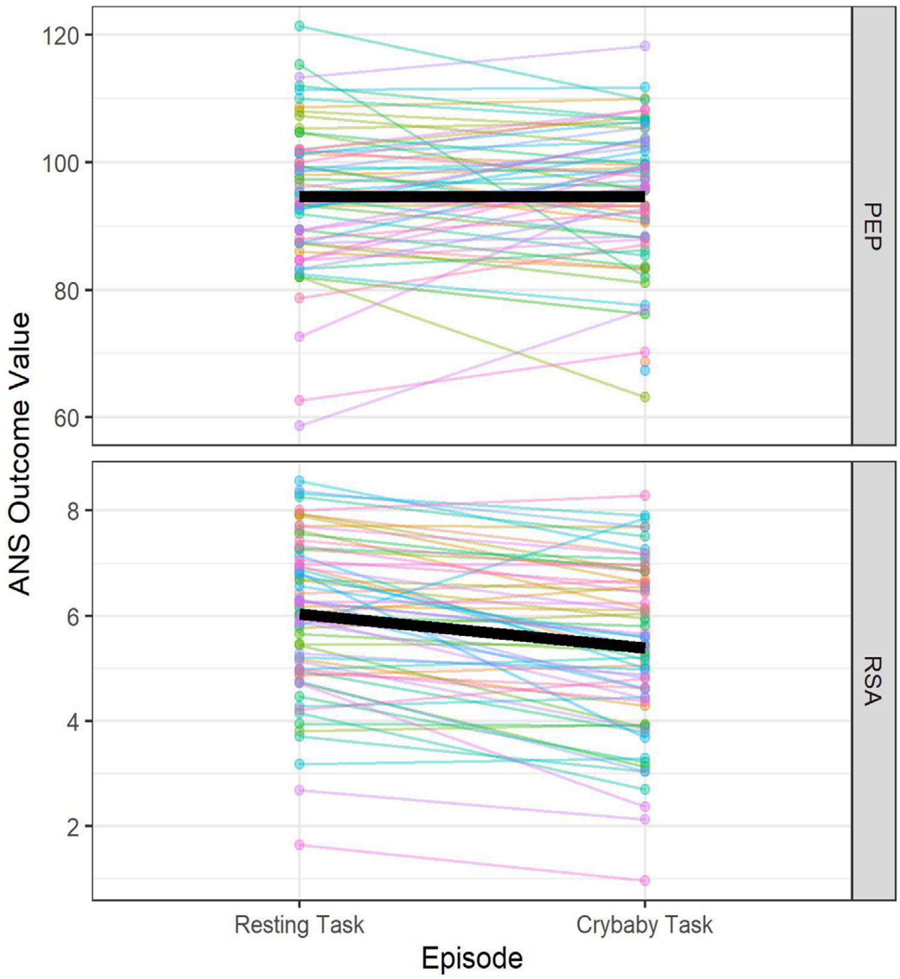

FIGURE 1 Spaghetti plots of pre-ejection period (PEP) and respiratory sinus arrhythmia (RSA) reactivity to Crybaby task.

TABLE 1 Descriptive statistics and bivariate correlations of primary study variables.

	M/SD	1	2	3	4	5	6	7	8
1. Pregnancy status	.82/.39	1	–	–	–	–	–	–	–
2. DERS	36.33/10.56	.02	1	–	–	–	–	–	–
3. RRS	27.39/3.38	.22	.02	1	–	–	–	–	–
4. Baseline RSA	6.04/1.46	−.28*	−.25*	.12	1	–	–	–	–
5. Average RSA during Crybaby task	5.39/1.57	−.32*	−.35*	−.02	.86*	1	–	–	–
6. Baseline PEP	94.67/11.41	−.34*	−.08	−.23	.02	.08	1	–	–
7. Average PEP during Crybaby task	94.64/11.39	−.39*	.07	−.19	.12	.08	.70*	1	–
8. Average exposure to infant cries during task[a]	39.92/8.51	.03	−.15	.18	−.07	−.002	.10	.03	1

Note: Pregnancy status is coded as 0 = peripartum, 1 = pregnant.
Abbreviation: DERS, difficulties in emotion regulation scale; PEP, pre-ejection period; RRS, reward responsiveness scale; RSA, respiratory sinus arrhythmia.
[a]Exposure to infant cries was calculated by dividing total number of missed opportunities to feed the baby (resulting in infant cry) by total task time (in minutes).
*$p < .05$.

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there was no significant effect of pregnancy status on RSA reactivity ($B = -.06$, $p = .365$). In total, the model explained 77.8% of the variance in RSA activity during the Crybaby task ($p < .001$).

3.3 | PEP model

As expected, baseline PEP was associated with PEP during the Crybaby task ($B = .65$, $p < .001$). There was no significant association between trait emotion dysregulation ($B = .11$, $p = .299$) or reward responsiveness ($B = -.01$, $p = .931$) on PEP reactivity to the Crybaby task. Interestingly, pregnancy status was associated with PEP reactivity to the Crybaby task ($B = -.18$, $p = .010$), such that pregnancy was associated with enhanced PEP reactivity. In total, the model explained 54.7% of the variance in PEP activity during the Crybaby task ($p < .001$).

3.4 | Supplementary analyses

Given the observed associations between pregnancy status and ANS functioning, and the possibility of differences in reactivity to the Crybaby task among pregnant women versus postpartum women, we conducted the above analyses in a subset of the sample only including pregnant women ($N = 63$). Findings from these analyses revealed the same pattern of effects (significant effects remained significant and no new significant effects emerged). We also conducted supplementary analyses to test whether the interaction between emotion dysregulation and reward responsiveness was associated with ANS reactivity to the Crybaby task. Results revealed no significant interaction effect on RSA reactivity ($B = -.56$, $p = .387$) or PEP reactivity ($B = -.49$, $p = .552$) to the Crybaby task. It should be noted, however, that the study may have been underpowered to test for these interactions.

4 | DISCUSSION

Extant research highlights disruptions in emotion- and reward-based processing as sustaining mechanisms of substance use and parenting difficulties. The current study sought to examine the degree to which trait emotion dysregulation and reward responsiveness relate to two dimensions of ANS reactivity to infant cues among substance-using pregnant and postpartum women. Distinct patterns of associations emerged between emotion dysregulation and reward responsiveness and RSA and PEP activity during a novel computerized infant cry task. Specifically, mothers with greater emotion dysregulation evidenced enhanced RSA reactivity, potentially indicating a greater need for vagal regulation in response to the infant cry task, than mothers who reported higher emotion regulation. This finding was specific to RSA reactivity to the Crybaby task, as we found no significant effect of emotion dysregulation on PEP reactivity. Contrary to expectations, reward responsiveness was not associated with RSA or PEP reactivity to the task. Interestingly, results also revealed that pregnant women showed greater PEP reactivity to the Crybaby task than postpartum women, which raises important questions about the role of pregnancy physiology on ANS reactivity to parenting-related stress. However, given the relatively small number of postpartum women in the current sample, pregnancy effects should be interpreted with caution. Taken together, findings highlight the role of emotion regulation on substance-using mothers' vagal reactivity to infant cues using a novel Crybaby task and suggest that emotion regulation may be a candidate mechanism that may drive less sensitive parenting among substance-using mothers.

4.1 | RSA findings

We found that emotion dysregulation was associated with reduced average RSA at rest and during the Crybaby task, which is consistent with research linking poor emotion regulation capabilities to low resting RSA and greater RSA reactivity to a stressor (Beauchaine, 2015). Second, DERS predicted RSA reactivity during the Crybaby task, suggesting that mothers who endorsed greater emotion regulation problems also demonstrated greater RSA reactivity. This is in contrast to previous findings by Lin et al. (2019) who found that emotion dysregulation was associated with blunted RSA reactivity to an infant cry task in a sample of pregnant women. One reason for discrepant findings may be task differences—the present study included an active computer task requiring behavioral responses, whereas the task in Lin et al. (2019) involved passively viewing film clips. Indeed, psychophysiological research underscores the sensitivity of RSA to context and task demands, and thus, it is not surprising that patterns of findings may differ depending on task designs. For the present study, the Crybaby task was intentionally designed to pull for different motivational processes relevant to substance use and parenting that are not present in other task designs, particularly passive viewing tasks. Specifically, women were required to both regulate their own emotional reactions to infant distress (i.e., emotion regulation) and actively participate in the computer task by engaging in parenting-relevant behavior (i.e., feed the simulated baby) to earn more money (i.e., reward pursuit). Because most participants persisted throughout the entire task and the number of cries heard per minute was not associated with ANS reactivity during the task, our findings may specifically reflect physiological response to persisting in an incentivized parenting-relevant task despite potential distress resulting from infant cries. Taking our findings and Lin et al. (2019)'s findings together, we see that for mothers with emotion dysregulation, patterns of vagal reactivity may depend both on the stimuli (i.e., infant cry sounds) and task demands. The properties of our Crybaby task design may have particular relevance for substance-using mothers, who are often faced with similar motivational considerations. For example, substance-using mothers may need to balance urges to engage in substance use (i.e., reward pursuit), particularly when facing emotional distress (i.e., parenting-related stress).

Our findings showed that mothers with emotion regulation difficulties showed greater RSA reactivity (i.e., withdrawal) during the Crybaby task, which may index a maladaptive excessive response. Polyvagal theory conceptualizes RSA withdrawal as a physiological response that facilitates the mobilization of resources in "fight or flight"

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scenarios (Porges, 2007, 2011). Viewed through this lens, one potential interpretation of our results may be that mothers with higher degrees of emotion dysregulation viewed the Crybaby task as more challenging (e.g., more threatening), and thus, the observed RSA withdrawal to the task may be indicative of increasing readiness to manage the task. Moreover, the observed RSA reactivity may also be reflective of the physiological state these mothers experience when they are trying to regulate emotions while trying to attend to their own infant's cries. Another possible interpretation is that well-regulated mothers evidenced smaller RSA decreases to the Crybaby task, which may be an indicator of social engagement in nonthreatening contexts (e.g., Hastings et al., 2014; Porges, 2007, 2011) and readiness to engage in a simulated parenting task (Augustine & Leerkes, 2019). Although the present study is a preliminary examination of ANS functioning during a novel Crybaby task, our findings indicate that trait emotion dysregulation relates to RSA reactivity during an active, simulated parenting task among substance-using mothers. Insofar as substance-using mothers with emotional dysregulation difficulties experience infant cues as more taxing than mothers who are more regulated, these findings may ultimately translate to greater parenting difficulties, including less responsiveness to their own infants. Future research will be needed to replicate and extend the presenting findings to continue to delineate the role of ANS functioning among substance-using mothers in predicting real-world parenting behaviors.

It should be noted that trait reward responsiveness was not significantly associated with RSA reactivity to the Crybaby task, suggesting that RSA reactivity to the Crybaby task may be impacted by individual differences in the regulation of negative, but not positive, emotions. Interestingly, we also found that pregnant women evidenced lower RSA activity at rest and across the Crybaby task compared to postpartum women. This is in line with previous work showing lower resting RSA during pregnancy, particularly among stress-exposed mothers (DiPietro et al., 2005; Kaliush et al., 2021). Future research will be needed to test the effect of self-reported emotion dysregulation on ANS activity to laboratory-based infant cue tasks and examine how these indicators correspond to real-world parenting practices.

4.2 | PEP findings

We found that neither trait emotion dysregulation nor reward responsiveness was significantly associated with PEP reactivity to the Crybaby task. This finding was somewhat surprising given research linking alterations in reward-based systems to substance use behaviors (Baskin-Sommers & Foti, 2015; Joyner et al., 2019), and thus, we expected that PEP activity might be altered in a sample of substance-using mothers completing an infant cue task tied to earning a monetary reward. Indeed, previous research has linked indicators of PEP to reward-based processes specifically, such as anhedonia and approach motivations (Ahles et al., 2017; Brenner et al., 2005). One potential explanation for this finding may be that despite the inclusion of a monetary reward for persistence, the Crybaby task was designed to elicit a stressful parenting context rather than a solely rewarding context, and so the task may not have sufficiently activated the reward system. Further, research on reward processing has established the multidimensional and complex nature of reward functioning over time, particularly among substance-using individuals (Baskin-Sommers & Foti, 2015; Joyner et al., 2019). For the current study, we focused on only one measure of reward processing (i.e., reward responsiveness), and it is possible that other facets of reward processing implicated in substance use, such as reward anticipation or approach motivational systems, may better converge with ANS reactivity to a parenting-relevant task in a sample of substance-using mothers. Accordingly, it would be useful for future research to extend on the previous study by examining the extent to which other facets of reward processing correlate with ANS reactivity to other parenting-relevant tasks, particularly among substance-using mothers.

Interestingly, we found that pregnancy status was associated with PEP reactivity, but not RSA reactivity, to the Crybaby task. Specifically, we found that pregnant women showed greater reductions in PEP during the Crybaby task than postpartum women. Although not the primary focus of the current study, this finding raises potentially important questions about the influence of pregnancy on PEP activity to infant cry stimuli. Indeed, previous work has documented changes to ANS activity, including shorter PEP, over the course of pregnancy (e.g., DiPetro et al., 2005). It may also be the case that, compared to postpartum women who are caring for infants, pregnant women experience the infant cues as more distressing, leading to greater sympathetic arousal. More research is needed to further disentangle the specificity of ANS functioning to infant cues among mothers across the prenatal to postnatal timeline, and examining other individual predictors, such as prenatal anxiety, which may contribute to enhanced PEP reactivity among pregnant women. Finally, future research should examine patterns of reactivity between both indicators of ANS together (i.e., coactivation, coinhibition, and reciprocal activation) to further understand how these processes interact during parenting-relevant tasks. For example, although supplementary analyses in our sample revealed no significant interaction effect between emotion dysregulation and reward responsiveness on RSA- and PEP-reactivity to the Crybaby task examined individually, these variables may interact in predicting co-activation patterns across both branches of the ANS system.

4.3 | Strengths and limitations

The current study has several methodological strengths, such as the inclusion of an at-risk and underrepresented sample of pregnant and postpartum women and the examination of both branches of the ANS at rest and in response to an infant-cue task. However, there are also study limitations that need to be considered. First, as discussed above, the infant cry task may not have adequately activated reward-based processes, which may have limited our ability to test for associations between reward responsiveness and ANS reactivity to a parenting-relevant task. Second, given the relatively small sample size, we were underpowered to examine additional individual difference factors that may relate to ANS reactivity to the Crybaby task. For example, we

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were unable to test for differences based on pregnancy status or usage of different drugs of choice. Future research should seek to address these gaps using different methodologies and in different populations, including other high-risk groups.

5 | CONCLUSION

The goal of the present study was to examine associations between maternal emotion dysregulation and reward responsiveness and ANS reactivity to a novel infant cry task. Findings pointed to greater vagal reactivity in response to infant cries among mothers who struggle with emotion regulation. Findings support the utility of a novel tool to measure vagal reactivity to infant cues and suggest that emotion dysregulation may be a key intervention target for substance-using mothers. Future research should continue in this line of research to further explicate regulatory deficits during and post-pregnancy among substance-using mothers that may ultimately expand understanding on multilevel factors that may explain parenting difficulties in this at-risk population.

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None.

CONFLICT OF INTEREST STATEMENT

None.

DATA AVAILABILITY STATEMENT

Deidentified participant data and a data dictionary will be made available to qualified external researchers whose proposed use of the data has been approved by their Institutional Review Board for a specific research purpose upon approval of a proposal and with a signed data access agreement.

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