PSYCHOPHYSIOLOGY

Psychophysiology, 00 (2017), 00–00. Wiley Periodicals, Inc. Printed in the USA.

DOI: 10.1111/psyp.12838

Emotion dysregulation and autonomic responses to film, rumination, and body awareness: Extending psychophysiological research to a naturalistic clinical setting and a chemically dependent female sample

SHEILA E. CROWELL,[a] CYNTHIA J. PRICE,[b] MEGAN E. PUZIA,[a] MONA YAPTANGCO,[a] AND SUNNY CHIEH CHENG[c]

[a]Department of Psychology, University of Utah, Salt Lake City, Utah, USA
[b]Biobehavioral Nursing and Health Systems, University of Washington School of Nursing, Seattle, Washington, USA
[c]Psychosocial and Community Health Department, University of Washington School of Nursing, Seattle, Washington, USA

Abstract

Substance use is a complex clinical problem characterized by emotion dysregulation and daily challenges that can interfere with laboratory research. Thus, few psychophysiological studies examine autonomic and self-report measures of emotion dysregulation with multidiagnostic, chemically dependent samples or extend this work into naturalistic settings. In this study, we used a within-subject design to examine changes in respiratory sinus arrhythmia (RSA), electrodermal activity (EDA), and self-reported affect across three tasks designed to elicit distinct psychophysiological and emotional response patterns. We also examined emotion dysregulation as a moderator of psychophysiological responses. Participants include 116 women with multiple comorbid mental health conditions enrolled in substance use treatment, many of whom also reported high emotion dysregulation. Participants were assessed in the treatment setting and completed three tasks: watching a sad movie clip, rumination on a stressful event, and a mindful interoceptive awareness meditation. Multilevel models were used to examine changes from resting baselines to the tasks. During the film, results indicate a significant decrease in RSA and an increase in EDA. For the rumination task, participants showed a decrease in RSA but no EDA response. For the body awareness task, there was an increase in RSA and a decrease in EDA. Emotion dysregulation was associated with differences in baseline RSA but not with EDA or with the slope of response patterns across tasks. Self-reported affect was largely consistent with autonomic patterns. Findings add to the literature on emotion dysregulation, substance use, and the translation of psychophysiological measurements into clinical settings with complex samples.

Descriptors: Respiratory sinus arrhythmia, Electrodermal, Substance use, Ecological validity, Disadvantaged participant groups, Emotion dysregulation

Traditionally, psychophysiological research has been conducted with healthy adult participants in carefully controlled laboratory settings (Zisner & Beauchaine, 2015). This work has a long history and has established important autonomic nervous system (ANS) correlates of many psychological and physical health conditions (e.g., Dienstbier, 1989). Furthermore, because ANS measures are a fruitful means of assessing dynamic responses to complex stimuli, physiological methods have been widely used to study emotional processes (Kreibig, 2010), social interactions (Mendes, 2009), and brain-body-behavior associations (Taylor, Goehler, Galper, Innes, & Bourguignon, 2010). Over the past several decades, psychophysiological measurement tools have become less costly, smaller, and it is now possible to collect high-quality data with fewer electrode contact points. These technological advances have led many researchers to design studies with a wider range of samples and in settings that offer greater ecological validity.

Psychophysiological research with clinical samples can provide key insights into the biological and emotional response patterns of vulnerable individuals. However, such participants typically face countless challenges that can interfere with participation in laboratory research (e.g., transportation, childcare, discomfort or unfamiliarity with university settings). In addition, many psychophysiological studies with clinical populations have been conducted with participants who have fewer diagnostic comorbidities (e.g., Byrne et al., 2010; Dichter, Tomarken, Shelton, & Sutton., 2004; Woodward

The researchers would like to acknowledge the study participants and the research coordinators who diligently collected this psychophysiological data within the clinical environments: Margaret O'Malley, Sara Parent, and Danielle Shandera.

Address correspondence to: Sheila E. Crowell, Ph.D., Department of Psychology, University of Utah, 380 South 1530 East, Room 502, Salt Lake City, UT 84112, USA. E-mail: sheila.crowell@psych.utah.edu

et al., 2015). This has occurred, in part, due to the belief that different diagnoses would show unique constellations of biological deficits as well as funding agencies that encouraged diagnosis-specific research. Thus, there are relatively fewer studies that have gone into clinical treatment settings to conduct transdiagnostic biological research with participants who are socioeconomically, emotionally, and/or physically disadvantaged, and who often have multiple comorbid conditions.

Emotion dysregulation is a transdiagnostic vulnerability that may contribute to the emergence and maintenance of substance dependence among those who initiate use (e.g., Berking & Wupperman, 2012; Price & Crowell, 2016). Indeed, emotion regulation deficits are common in clinical samples, such as those with internalizing, externalizing, or co-occurring internalizing/externalizing forms of psychopathology (Gross & Munoz, 1995; Vasilev, Crowell, Beauchaine, Mead, & Gatzke-Kopp, 2009). Studies with chemically dependent samples show self-reported differences in emotion dysregulation using measures such as the Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004). For example, difficulties with emotion regulation differentiate those in substance use disorder treatment from community controls (Fox, Axelrod, Paliwal, Sleeper, & Sinha, 2007; Fox, Hong, & Sinha, 2008). More importantly, emotion regulation difficulties predict posttreatment relapse (Berking et al., 2012), and treatment studies find associations between improved DERS scores and reduced substance use (Berking et al., 2012; Price, Donovan, Wells, & Rue, 2012). Thus, emotion dysregulation is a relevant construct for research on psychopathology, substance use, and treatment outcomes for chemically dependent populations (Sinha, 2008).

ANS responses are also of interest given that they appear to index individual differences in emotional reactivity and regulation. Electrodermal responding (EDR), a measure of eccrine sweat gland secretion, is a reliable marker of sympathetic nervous system (SNS) arousal (Shields, MacDowell, Fairchild, & Campbell, 1987; Wallin, 1981). Phasic increases in EDR typically follow from stressors, increased attending, or emotional arousal, and this measure is used commonly in studies of emotion and psychopathology (Beauchaine, 2012; Dawson, Schell, & Filion, 2007). For example, several studies find that emotionally dysregulated externalizing samples have lower resting EDR, consistent with underarousal models of psychopathology (e.g., Beauchaine et al., 2015; Crowell et al., 2012). Studies examining EDR find that those who engage in substance use also show lower electrodermal responding and quicker electrodermal habituation to laboratory tasks (Isen, Iacono, & Malone, 2013). Links between EDR and emotion dysregulation are consistent with this picture, finding that well-regulated individuals show a strong sympathetic response to stress but also more flexibility and a more rapid return to baseline, whereas dysregulated participants show a blunted and less flexible profile (e.g., Mennin, Turk, Heimberg, & Carmin, 2004).

Similarly, respiratory sinus arrhythmia (RSA) is a measure of parasympathetic (PNS) control over heart rate that appears to be useful as a transdiagnostic biomarker of emotion dysregulation and psychopathology (Beauchaine & Thayer, 2015). RSA is a peripheral index of vagal regulation over cardiovascular output (Beauchaine, 2001; Porges, 2007). During inhalation, inhibitory influences of the vagus (i.e., 10^{th} cranial) nerve are partially withdrawn, which generally produces concomitant increases in heart rate. During exhalation, the vagus nerve reengages its inhibitory influence and heart rate slows. Psychophysiologists theorize that higher resting state RSA (i.e., greater heart rate variability across the respiratory cycle) marks better conservation of bodily resources, the ability to adapt flexibly to stressors, and higher self-regulatory capacity (Porges, 2007). When stimulus demands increase (e.g., during stress), RSA typically decreases from baseline levels, allowing an organism to respond adaptively to environmental challenges. Although results are conflicting, lower baseline RSA and more pronounced RSA withdrawal under stress are characteristic of many clinical populations and may be associated with emotion regulation difficulties (Beauchaine, 2001; Crowell et al., 2005).

It is important to extend psychophysiological research into settings where there is greater access to emotionally dysregulated substance-using participants. However, there are many challenges inherent in this work. Given time constraints and daily pressures, when research is conducted with clinical samples, there is pressure to keep protocols brief and standardized. Thus, researchers are often compelled to choose only one or two short tasks that each assess a limited number of emotions or constructs. There are also pros and cons for each of the types of tasks that have been validated in prior studies, which can make it challenging to choose a single task that is relevant for each hypothesis.

For example, film clips are widely used and are typically selected to elicit a discrete, easily identifiable emotion (Gross & Levenson, 1995). However, it can be difficult for participants to immerse themselves in the emotional content of a brief film clip, even if they report experiencing the target emotion. It is also possible that complex clinical samples, such as those who are emotionally dysregulated or who have experienced multiple traumatic stressors, may find film clips to be far less stressful than daily life, leading the clip to be less effective for some participants. Other studies have used unstandardized tasks, such as rumination on a negative life event (Ottaviani, Shapiro, Davydov, Goldstein, & Mills, 2009). The advantages of such a task include relevance to the participant and the potential to elicit much stronger emotions. However, there is no way to perfectly standardize the intensity of the experience across participants. Moreover, life events rarely involve single discrete emotions.

In addition to time constraints, researchers typically select tasks designed to elicit negative emotions. Indeed, responses to negative emotions have important implications for psychopathology and health, and there may be conceptual reasons to elicit emotions that are diagnosis relevant. However, tasks that induce mindful awareness are also gaining traction in psychophysiological research in order to better understand potential mechanisms underlying mindfulness and to test whether mindfulness elicits positive affect (e.g., Dickenson, Berkman, Arch, & Lieberman, 2013; Eddy, Brunyé, Tower-Richardi, Mahoney, & Taylor, 2015; Zbozinek, Holmes, & Craske, 2015). It is also likely a result of the inclusion of conceptual models of emotion regulation in psychopathology (e.g., Aldao, Nolen-Hoeksema, & Schweizer, 2010), particularly given the burgeoning research on mindfulness interventions for individuals with severe symptoms or diagnosed psychiatric and medical conditions (e.g., Garland, Gaylord, Boettinger, & Howard, 2010). However, no studies have looked at whether a brief guided interoceptive (i.e., bodily) awareness task can induce positive affect and physiological changes in the moment, even without prior training. This is interesting given that mindfulness and interoceptive awareness are theorized to be a primary means of enhancing positive and reducing negative affect among substance users, and psychophysiological changes are a potential mechanism underlying such outcomes (Bowen et al., 2014; Price & Crowell, 2016).

In this study, we examine EDA and RSA responses across three distinct tasks with a multidiagnostic clinical sample of adult

women. Moreover, we examined emotion dysregulation as a moderator of psychophysiological response patterns, given theoretical ties to substance use, psychopathology, and both sympathetic and parasympathetic profiles. Data were collected within the facility where patients were newly sober and beginning treatment for chemical dependence. The objective of this study was to extend research on psychophysiological correlates of emotion dysregulation to a disadvantaged and dysregulated population of women and to further evaluate the effectiveness of different manipulations, each with distinct task demands, on psychophysiological responses using an ecologically valid design and setting. Given the pros and cons of each task alone, we selected three distinct manipulations, including negative mood induction with a validated film clip (Gross & Levenson, 1995), rumination on a recent and unresolved negative event (Ottaviani et al., 2009), and a guided interoceptive awareness task developed for our study.

We hypothesized that EDA would increase to the first two negative mood induction tasks whereas RSA would decrease. We theorized the opposite psychophysiological pattern for the interoceptive awareness task, producing decreases in EDA and increases in RSA. We used the Positive and Negative Affect Scales (PANAS) at the beginning of the study visit and after each task to examine participant experience of each task and to provide convergent evidence regarding the expected associated positive or negative affect. We further hypothesized that greater emotion dysregulation as measured by the DERS would be associated with lower resting EDA and more EDA reactivity as well as lower resting RSA and greater RSA withdrawal.

Method

Sample Characteristics

The current study was based on analysis of pretreatment data from participants enrolled in an intervention study for women in intensive outpatient treatment for alcohol and drug use disorders (i.e., substance use disorder, SUD). This sample was comprised of 116 participants enrolled to date in the larger treatment study, which recruits women from three community-based nonprofit treatment facilities in the Pacific Northwest. Participants ranged in age from 20–61 years old (median age 35), and most (81%) were high school graduates. Primary substances used at enrollment were alcohol (40.5%) and stimulants (43.1%). A minority of participants (16.4%) reported primary use of narcotics, marijuana, nonnarcotic opioids, sedatives, or multiple substances (e.g., stimulants plus narcotics, alcohol, or marijuana). The sample was largely Caucasian (85%), although 5% were African American, 4% Native American, 1% Asian, and 5% reported mixed race. Thirteen percent of the sample identified as Hispanic. Participants were mostly very low socioeconomic status (SES; only 9% reported a monthly income at or above $1,000), 90% received Medicaid/Medicare, 45% were unemployed, and 66% were mothers with underage children. The majority of the sample reported comorbid mental health problems such as elevated symptoms of depression, posttraumatic stress disorder (PTSD), and eating disorder on self-report measures. As would be expected, given the high-risk nature of the sample, a large percentage of the women reported taking prescription medications: 76% were taking antidepressants, 46% were taking sleep aids, and 24% were taking mood stabilizers. Additional demographic, mental health status, and medication-related sample characteristics are presented in Table 1 and 2.

Table 1. *Demographic Characteristics of the Sample*

Age, median (range)	34 (20–59)
Race	
White/European American	84.5% (N = 98)
Black/African American	4.3% (N = 5)
Native American	3.4% (N = 4)
Asian American	0.9% (N = 1)
Native Hawaiian	0.9% (N = 1)
Mixed race	0.9% (N = 1)
Other	5.2% (N = 6)
Hispanic ethnicity	12.7% (N = 14)
Committed relationship (e.g., married, domestic partnership)	14.6% (N = 17)
Education	
$\leq 11^{th}$ grade	19.1% (N = 22)
High school or GED	44.3% (N = 51)
Two-year college/technical school	28.7% (N = 33)
College degree (e.g., BA, BS)	6.8% (N = 8)
$\geq$ Master's degree	0.9% (N = 1)
Employment status	
Full time ($\geq$ 35 hours/week)	18.3% (N = 21)
Part time, regular hours	9.6% (N = 11)
Part time, irregular hours	7.8% (N = 9)
Student	5.2% (N = 6)
Unemployed	46.1% (N = 53)
Retired or receiving disability	12.2% (N = 14)
In controlled setting	0.9% (N = 1)
Monthly income	
< $400	72.8% (N = 83)
$400–$799	14.0% (N = 16)
$\geq$ $800	13.1% (N = 15)

$N = 117$.

Enrollment and Data Collection Procedures

All study procedures were approved by the University of Washington Institutional Review Board, and participants provided written informed consent prior to being enrolled in the study and undergoing study procedures. Participants were recruited through flyers describing the project, which were distributed to women during their group SUD treatment along with a verbal explanation of the study provided by the research coordinator. Interested individuals who were eligible for participation were asked to fill out a form with their contact information for follow-up screening and consent. Inclusion criteria were enrolled in intensive outpatient treatment for SUD at one of the three treatment facilities, fluent in English, willing to forego manual (e.g., massage) or mind-body therapies for the first 3 months of the study, and willing to provide permission to collect treatment attendance and urinalysis data from facility electronic medical records. Exclusion criteria included untreated psychotic disorder diagnosis or symptoms, cognitive impairment, currently pregnant, or unable to remain in the study for a 1-year duration.

Once enrolled, participants were scheduled for an initial pretreatment assessment that involved completion of a set of self-report questionnaires for collection of demographic data, reported substance use, difficulties with emotion regulation, mental health symptoms (see below), and related health outcomes. This was followed by the administration of three tasks during the collection of psychophysiological data. To reduce variability associated with nonpsychological influences on physiology, participants were instructed to prepare by eating a meal or snack before the appointment. Those who smoked or drank caffeine were asked to consume no more or less than their usual level of intake. In addition, the assessment began with 1 h of self-report measures to ensure that all

Table 2. *Psychiatric, Health, and Substance Use Characteristics of the Sample*

Self-reported chronic physical health problems	42.6% ($N = 49$)
Chronic pain	20.7% ($N = 24$)
Obesity	4.3% ($N = 5$)
Hepatitis	4.3% ($N = 5$)
Diabetes	2.6% ($N = 3$)
Cancer	1.7% ($N = 2$)
Heart disease	0.9% ($N = 1$)
Medications	
Psychiatric medications	44.0% ($N = 51$)
Selective serotonin reuptake inhibitor	19.8% ($N = 23$)
Selective serotonin/norepinephrine reuptake inhibitor	8.6% ($N = 10$)
Tricyclic/atypical antidepressant	15.5% ($N = 18$)
Benzodiazepine	1.7% ($N = 2$)
Atypical antipsychotic	12.9% ($N = 15$)
Anticonvulsant/mood stabilizer	9.5% ($N = 11$)
Other psychiatric medication	4.3% ($N = 5$)
Antihistamine	12.9% ($N = 15$)
Beta blocker	6.9% ($N = 8$)
Analgesic/pain management medications	9.5% ($N = 11$)
Narcotic analgesic	4.3% ($N = 5$)
Opioid analgesic	6.0% ($N = 7$)
Gabapentin	7.8% ($N = 9$)
Other medications	16.4% ($N = 19$)

Mental Health Symptom Scores	Mean (*SD*)	Range	% above cutoff
BDI	15.9(10.2)	0–53	12.0% ($N = 14$)
EDE-Q	2.1 (1.3)	0–4.9	47.4% ($N = 55$)
PSS-SR	20.5(13.1)	0–51	68.1% ($N = 79$)
DERS	68.9 (29.5)	23–151	–

Note. $N = 116$. BDI-II = Beck Depression Inventory II (cutoff for moderate to severe symptoms = 29); DERS = Difficulties in Emotion Regulation Scale; EDE-Q = Eating Disorder Examination Questionnaire (cutoff for clinical elevated symptoms = 2.3); PSS-SR = PTSD Symptom Scale-Self Report (cutoff for clinically elevated symptoms = 13).

participants had not smoked or had anything to eat or drink for a standardized period of time (Hawkley, Burleson, Berntson, & Cacioppo, 2003). All data collection procedures were administered by a trained research coordinator at the facility in which the participants attend SUD treatment.

Psychophysiological Protocol

Film. To examine reactivity to a standardized emotional stressor, a 5.5-min clip from the movie *Steel Magnolias* (Stark & Ross, 1989) was used. This clip of the funeral scene has been validated among racially and ethnically diverse samples (Gross & Levenson, 1995) and has been shown to elicit sadness (Fredrickson & Levenson, 1998; Hastings et al., 2009).

Rumination. To examine response to a personal life stressor, we used a previously tested rumination procedure (Ottaviani et al., 2009). Participants were asked to recall an upsetting and unresolved stressful event that occurred within the past 2 weeks. The participant was then asked to rate her current level of distress on a scale of 1–5, with 1 = *least upset* and 5 = *most upset*. She was then asked to rate the current level to which the event could be considered resolved on a scale of 1–5, with 1 = *totally resolved* and 5 = *not at all resolved*. If responses to both scales were not within the 3–5 range, the participant was asked to think of an alternate event with the goal of identifying a sufficiently upsetting and unresolved situation. In order to ensure that all participants had some event to consider, participants were allowed to move back in time if necessary. They were then asked to think about the upsetting/unresolved nature of the event for 2 min. Participants were told when this period was complete.

Interoceptive awareness. To examine response to an interoceptive awareness task, we used an audio recording of a guided mindful body awareness process. This 5-min task was developed by one of the authors (CP) and involved 2.5 min of guided instruction focused on attention to breath and inner body awareness, followed by 2.5 min of silence with instruction to maintain awareness of breath and inner body sensations until instructed to stop.

Tasks were completed in the same order for all participants and not counterbalanced (film, rumination, body awareness). This design was selected for several reasons. First, we expected wider variability in responses to the rumination task relative to the movie task. Thus, we theorized that participants who engaged in the rumination task first would experience the movie very differently than those who had not, possibly inferring more personalized meaning or experiencing a greater range of emotions than those who watched the movie first. Second, given the clinical nature of the sample, we chose to place the mindful body awareness last. This was done so that all participants could end the study on a more positive note. As described below, for each task, we used the baseline immediately prior to that task for comparisons. This was done to account for lingering changes induced by the prior task.

Emotion Dysregulation and Mental Health Measures

Mental health questionnaires were used to characterize the sample. The PTSD Symptom Scale-Self Report (PSS-SR), a 17-item questionnaire, was used to assess symptoms of PTSD. Scores with rating 0 (*not at all*) to 3 (*almost always*) for evaluating PTSD symptom frequency according to DSM-IV-TR criteria (American Psychiatric Association [APA], 2000; Foa, Riggs, Dancu, & Rothbaum, 1993); a score above 14 is used as the screening indicator of

PTSD (Coffey, Gudmundsdottir, Beck, Palyo, & Miller, 2006). In our study, the internal consistency coefficient α value was excellent (Cronbach's $\alpha = .82$).

Participants also completed the Beck Depression Inventory-II (BDI-II), a 21-item questionnaire used to measure severity of depressive symptoms (Beck, Steer, Ball, & Ranieri, 1996). Scores on the BDI-II have excellent psychometric properties, and have demonstrated high test-retest reliability (.93; Dozios, Dobson, & Ahnberg, 1998). Scores can range from 0–63; scores above 29 are in the moderate to severe range for depression. Internal reliability within the current sample was excellent (Cronbach's $\alpha = .92$).

The Eating Disorder Examination Questionnaire (EDE-Q; Fairburn & Beglin, 1994), a 33- item scale, was used to assess disordered eating. Scores on the EDE-Q have excellent psychometric properties (Mond, Hay, Rodgers, Owen, & Beumont, 2004) (sensitivity = .92, specificity = .86, positive predictive value = .30, criterion validity $r = .17$), and higher scores are indicative of eating disorder psychopathology. Based on the DSM-IV diagnostic criteria (APA, 2000), it includes a cutoff point of 2.3 for diagnostic screening (Mond, Hay, Rodgers, & Owen, 2006). Cronbach's alpha for this sample was .78.

The DERS (Gratz & Roemer, 2004) is a widely used self-report measure indexing broad difficulties in emotion regulation. The DERS consists of 36 items with responses along a 5-point (1 = *almost never* to 5 = *almost always*) Likert-style scale. Total scores can range from 36 to 180, with higher scores corresponding to greater dysregulation. Scores on the DERS have high internal consistency, good test-retest reliability, and adequate construct and predictive validity in both clinical and nonclinical populations. Additionally, DERS scores show correspondence with resting-state physiology (Williams et al., 2015) and physiological reactivity to emotionally evocative stimuli (Vasilev et al., 2009).

The PANAS (Watson, Clark, & Tellegan, 1988) is a 20-item scale measuring positive (8 items) and negative (12 items) emotions. We used a slightly modified version of this scale to include emotional items most relevant to the tasks. Using a scale from 1 (*very slightly or not at all*) to 5 (*extremely*), participants rated the extent to which they felt each particular emotion at that moment. The PANAS was administered four times (baseline, postfilm, postrumination, and postbody awareness) as a manipulation check. Total positive affect (PA) and negative affect (NA) scores were computed by summing the ratings for positive and negative emotions, respectively. Changes in PANAS-PA and PANAS-NA scores were used to facilitate the interpretability of psychophysiological measures.

Psychophysiological Assessment, Cleaning, and Scoring

RSA and EDA data were collected during an initial 5-min resting baseline, the entirety of each of the three tasks, and during a 2.5-min recovery period after each task, which also served as the baseline recordings for the subsequent task. Psychophysiological data were recorded using a Biopac MP150 system (Biopac Systems Inc., Goleta, CA) with Acqknowledge software and sampled at 1 kHz. To obtain electrocardiograph (ECG) signals for RSA measurements, electrodes were placed on participants using a standard spot electrode configuration (Qu, Zhang, Webster, & Tompkins, 1986) with one electrode placed on the right shoulder and the other on the left abdomen near the bottom of the rib cage. EDA was recorded with two 0.8-cm^2 Ag-AgCl electrodes attached to the thenar eminence of the participant's nondominant hand using a .05 molar NaCl solution. All data were collected in a quiet room away from other clinical activities. During data collection, a trained research coordinator was separated from the participant by a standing screen to reduce distraction. The research coordinator was able to monitor and record patient movements or noises through visual access points in the screen and auditory cues.

Following data collection, RSA and EDA data were converted from Acqknowledge and calculated using MindWare software (MindWare Technologies Ltd., Gahanna, OH). RSA data were cleaned by trained research assistants using MindWare heart rate variability software to identify missing/extra heartbeats. Then, RSA was scored in MindWare by calculating the high frequency component (> .15 Hz) of the R-R time series extracted from the ECG signal (e.g., Rottenberg, Clift, Bolden, & Salomon, 2007). EDA data were cleaned in MindWare GSR software by research assistants who were trained to identify true responses from movement artifacts. EDA responses were counted as the number of nonspecific fluctuations greater than or equal to 0.05 microsiemens (Dawson et al., 2007). RSA and EDA data were scored in 30-s epochs. In addition to collecting clean data, multiple steps were taken to ensure that data were useable and scored appropriately. All scorers had a minimum of 6 months supervised training, any noisy files were reviewed by a graduate assistant with a minimum of 2 years of training, and outliers were examined at multiple points in the process. Those files in which some or all epochs were outliers were reviewed by the faculty mentor. Nonetheless, some EDA data were unscorable or unusable (film, $N = 9$; rumination, $N = 10$; interoceptive awareness, $N = 5$). These reasons include participant characteristics (e.g., dehydration), a temperature control failure in the data collection room, poor adherence of the electrodes to participants' skin, and research coordinator error. Missing data for RSA were due primarily to movement artifacts and/or electrodes becoming detached (film, $N = 5$; rumination, $N = 2$; interoceptive awareness, $N = 1$). Data were analyzed through a series of multilevel models examining slopes of raw scores from the baseline immediately preceding the task of interest to the task. Across all three tasks, DERS scores were examined as a moderator.[1]

Analytic Approach

Multilevel modeling was used to assess changes in psychophysiology to the three tasks (i.e., sad movie, rumination on a stressful event, and guided mindful body awareness meditation) and in self-reported emotions. Multilevel models are appropriate given the hierarchical structure of the data (i.e., measurements nested within individuals) and that data were unbalanced due to some missing physiological data. Models were estimated using hierarchical linear and nonlinear modeling (HLM7; Raudenbush, Bryk, & Congdon, 2013) using restricted maximum likelihood estimation procedures and a homogeneous error structure. HLM's default criteria for convergence were retained (Raudenbush, Bryk, Cheong, & Congdon,

1. After careful consideration, we decided that substance use history was neither an appropriate covariate nor moderator of psychophysiological responses. All participants had used different substances for different durations, had been sober for differing lengths of time since they were in treatment requiring abstinence, and several participants had used a combination of substances that likely had different effects on biological systems. These women are representative of those seeking treatment for chemical dependence, and thus the variability in substance use history is a strength of the study. More importantly, we used a within-subject statistical approach to look at changes from baseline to the task. Therefore, much of the variability in participants is accounted for by our statistical design.

Table 3. *Model Construction and Changes in Model Fit Indices*

	RSA					EDA				
Model	−2LL	Δ-2LL	p value$_{LRT}$	AIC	ΔAIC	−2LL	Δ-2LL	p value$_{LRT}$	AIC	ΔAIC
Film task										
Null model	5366.49	–	–	5370.49	–	6633.15	–	–	6637.15	–
Unconditional change	5229.70	−136.79	<.001	5237.70	−132.79	6360.93	−272.23	<.001	6368.93	−268.23
DERS-moderated change	5244.69	14.99	–	5275.77	14.99	6377.08	16.15	–	6385.08	16.16
Rumination task										
Null model	2666.85	–	–	2680.71	–	3243.23	–	–	3256.71	–
Unconditional change	2611.40	−55.45	<.001	2639.12	−51.45	3131.30	−111.93	<.001	3158.27	−98.44
DERS-moderated change	2626.02	14.62	–	2653.74	14.62	3146.79	15.49	–	3173.76	15.49
Body awareness task										
Null model	2055.99	–	–	2059.99	–	2013.66	–	–	2017.66	–
Unconditional change	2007.29	−48.70	<.001	2015.29	−44.70	1997.45	−16.21	<.001	2005.45	−12.21
DERS-moderated change	2021.18	13.89	–	2029.18	13.88	2012.16	14.71	–	2020.16	14.71
			PANAS-PA					PANAS-NA		
All tasks										
Null model	2958.87	–	–	2962.87	–	3282.32	–	–	3286.32	–
Unconditional change	2652.08	−306.79	–	2656.08	−306.79	2981.73	−300.59	–	2985.73	−300.59

Note. Δ-2LL and ΔAIC refer to change relative to the preceding model. −2LL = −2 log likelihood (i.e., deviance); AIC = Akaike information criterion; EDA = electrodermal activity; LRT = likelihood ratio test; PANAS-NA = Positive and Negative Affect Schedule, negative affect; PANAS-PA = Positive and Negative Affect Schedule, positive affect; RSA = respiratory sinus arrhythmia.

2000). Simple slopes were computed using the online utility developed by Preacher, Curran, and Bauer (2006).

Multilevel models were used to assess changes in PANAS scores for PA and NA. For PANAS scores, null models with no predictors were compared to a model that included three predictors, reflecting the start of each task.

$$\begin{aligned}\text{PANAS\_POSITIVE}_{ij} &= \gamma_{00} + \gamma_{10}\text{FIL}M_{ij} \\ &+ \gamma_{20}\text{RUMINAT}E_{ij} + \gamma_{30}\text{BODYAWARE}_{ij} + u_{0j} + r_{ij}\end{aligned}$$

Predictors were dummy coded (0 = pretask; 1 = posttask) such that the intercept γ_{00} represents baseline PANAS scores obtained prior to all tasks, and the slopes of each predictor reflect chronological changes over time. Given this, a significant predictor reflects changes in PANAS scores relative to the most recently preceding scores. We expected that the film and the rumination task would elicit negative emotions and decrease positive emotions, and that the opposite pattern would emerge in response to the body awareness task.

Physiological reactivity was treated as continuous during but not between tasks, given a brief interruption between tasks to complete the PANAS. Therefore, we assessed changes separately for each task. Using a repeated measures design, we compared multilevel models accounting for the time relative to the task period (i.e., pretask, task) to null models.

$$\text{RSA}_{ij} = \gamma_{00} + \gamma_{10}\text{FIL}M_{ij} + u_{0j} + u_{1j}\text{FIL}M_{ij} + r_{ij}$$

In this model of RSA reactivity during the film task, *i* represents RSA, averaged across 30-s epochs, for individual *j*. *FILM* is a dichotomous predictor, dummy coded to reflect prefilm baseline = 0 or the film task = 1. Significance of the slope for *FILM* (γ_{10}) indicates a significant difference in RSA during the film compared to the prefilm baseline. We predicted that, in response to the film task and the rumination task, participants would show increased EDA and RSA withdrawal, whereas we expected EDA to decrease and RSA to increase during body awareness.

Unconditional change models were then additionally compared to models in which reactivity was moderated by emotion dysregulation, as measured by total scores on the DERS.

$$\begin{aligned}\text{RSA}_{ij} &= \gamma_{00} + \gamma_{01}\text{DERS}_j + \gamma_{10}\text{FIL}M_{ij} \\ &+ \gamma_{11}(\text{DERS} * \text{FILM})_{ij} + u_{0j} + u_{1j}\text{FIL}M_{ij} + r_{ij}\end{aligned}$$

In this example model of RSA reactivity during the film task, grand-mean centered DERS scores (*DERS*) were entered at Level 1 and Level 2. As noted above, we hypothesized that DERS scores would statistically predict the intercept (γ_{01}), such that those higher on emotion dysregulation would have lower RSA and lower EDA at baseline. We predicted that the cross-level interaction between DERS scores and the baseline/task predictor slope (γ_{11}) would also

Table 4. *Changes in Self-Reported Positive and Negative Affect Across Tasks*

	PANAS-positive affect				PANAS-negative affect			
	γ (*SE*)	*t*	*df*	*p*	γ (*SE*)	*t*	*df*	*p*
Fixed effects								
Intercept	23.10 (0.64)	35.63	114		28.02 (0.91)	30.94	114	
Postfilm	−9.04 (0.62)	−14.62	2434	<.001	−7.53 (0.98)	−7.69	2434	<.001
Postrumination	−2.89 (0.41)	−6.99	2434	<.001	14.12 (0.98)	14.46	2434	<.001
Postbody awareness	8.88 (0.65)	13.57	2434	<.001	−20.06 (1.03)	−19.35	2434	<.001
Random effects	Variance	χ^2	*df*	*p*	Variance	χ^2	*df*	*p*
Intercept	11.23	362.05	114	<.001	18.88	273.83	114	<.001

Note. Reported using robust standard errors. PANAS = Positive and Negative Affect Schedule; γ (*SE*) = unstandardized coefficient and standard error.

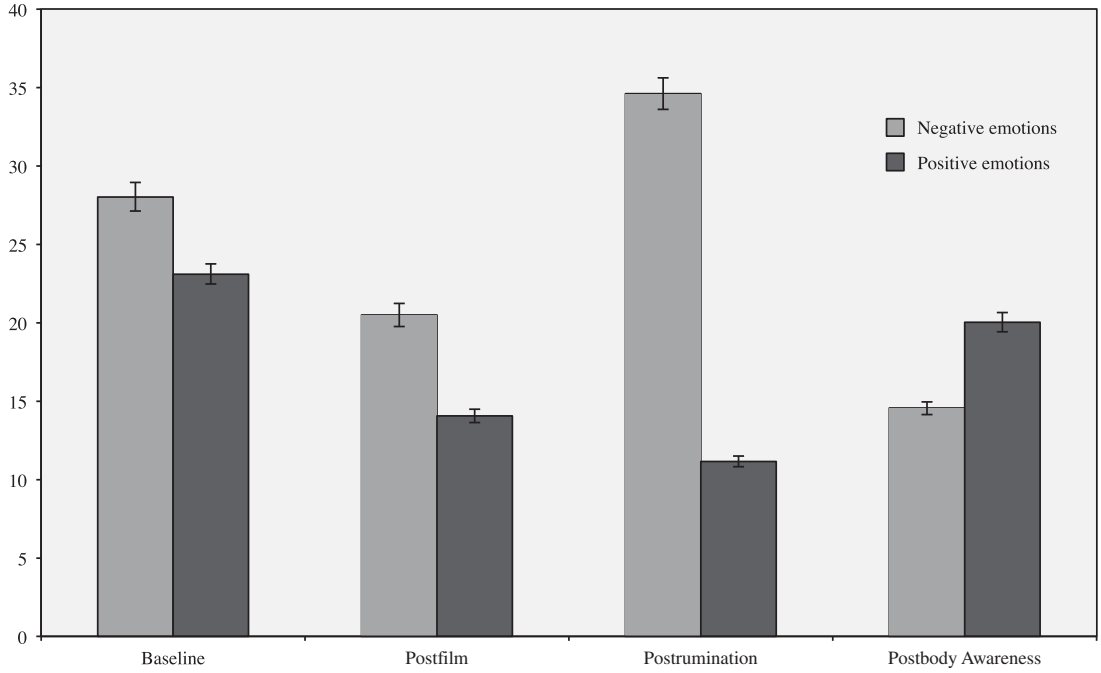

Figure 1. PANAS scores of self-reported emotional response patterns to three distinct tasks.

be significant, indicating that individuals who were high on emotion dysregulation would respond more strongly to the tasks than less dysregulated participants. In addition to evaluating the significance of the individual predictors, differences in overall model fit were assessed using likelihood ratio tests and by comparing the Akaike information criterion (AIC) values.

Results

Model Fit Statistics

Results of the model construction process are presented in Table 3. For all variables, accounting for changes from baseline to task resulted in improvements in model fit. Additionally, AIC values for models of change were between 12.21 and 268.22 points lower than null models; given that differences greater than 2 indicate a meaningful decrease in misfit (McCoach & Black, 2008), we can conclude that the change models provide superior fit. However, including DERS scores in the models of psychophysiological reactivity did not result in significant improvements in fit compared to the unconditional change models. This suggests that the study tasks operate similarly across individuals, regardless of their level of emotion dysregulation. As an explicit test of this, we present results of the DERS-moderated models, noting that model fit did not improve with DERS included in the model.

Self-Report of Emotions

Changes in self-reported emotions were largely consistent with expected responses to each of the tasks (see Table 4, Figure 1). PANAS scores for positive emotions decreased in response to the film task ($p < .001$) and the rumination task ($p < .001$). The body awareness task was associated with increases in positive emotions ($p < .001$). For self-reported negative emotions, however, participants had lower PANAS-NA scores following the film task relative to baseline ($p < .001$). The rumination task produced significant increases in negative emotion ($p < .001$), and participants reported decreased negative emotions following body awareness ($p < .001$).

Psychophysiological Changes to Tasks

Film. Psychophysiological changes are reported in Table 5 (see also Figure 2). In examining changes from prefilm baseline to the film task, results indicate there was a significant decrease in RSA ($p < .001$) and an increase in EDA responses ($p < .001$). Participants with higher emotion dysregulation had significantly lower RSA at baseline ($p = .023$), but emotion dysregulation did not interact with RSA reactivity ($p = .579$). Simple slopes indicated that participants who were high (+1 *SD*) and low (−1 *SD*) both demonstrated significant and similar decreases in RSA in response to the film (low dysregulation: slope = −0.16(0.06), $p = .003$; high dysregulation: slope = −0.21(0.07), $p = .013$). Emotion dysregulation was not related to EDA at baseline ($p = .085$) or to EDA reactivity during the film ($p = .899$).

Rumination. RSA also decreased during the rumination task ($p < .001$), but there were no significant changes in EDA responding ($p = .232$).[2] As with the film task, higher emotion dysregulation was associated with lower RSA during the prerumination baseline ($p = .044$), but emotion dysregulation and RSA reactivity did not interact ($p = .481$). Simple slopes indicated the rumination task elicited significant RSA withdrawal in both high- (slope = −0.29(0.09), $p = .003$) and low-dysregulation participants (slope = −0.19(0.09), $p = .039$).

2. Across all three manipulations, EDA during rumination was the only psychophysiological measure that did not show a significant main effect of task. Thus, we conducted a post hoc test to examine whether this could possibly be due to a lack of full EDA recovery following the film task. The analysis was consistent with this possibility. The EDA scores did not show significant change from the end of the film task to the beginning of the rumination task (slope = 0.02, *SE* = 0.10, $p = .86$).

Table 5. *Changes in EDA and RSA During Task Periods, Moderated by Emotion Dysregulation*

	RSA				EDA			
	γ (*SE*)	*t*	*df*	*p*	γ (*SE*)	*t*	*df*	*p*
Film								
Fixed effects								
Intercept	5.77 (0.12)	47.77	113	<.001	0.90 (0.11)	7.91	95	<.001
Period	−0.18 (0.04)	−3.91	113	<.001	0.62 (0.11)	5.92	95	<.001
DERS	−0.01 (0.00)	−2.31	113	.02	−0.01 (0.00)	−1.74	95	.09
DERS × Period	0.001 (0.00)	0.57	113	.57	0.00 (0.00)	0.13	95	.90
Random effects	Variance	χ^2	*df*	*p*	Variance	χ^2	*df*	*p*
Intercept	1.66	4526.88	113	<.001	1.14	868.37	91	<.001
Period	0.17	353.33	113	<.001	0.81	393.57	91	<.001
Rumination								
Fixed effects								
Intercept	5.77 (0.11)	51.19	114	<.001	1.59 (0.16)	10.06	99	<.001
Period	−0.24 (0.06)	−2.04	114	<.001	0.21 (0.17)	1.20	99	.23
DERS	−0.01 (0.00)	−3.77	114	.04	−0.01 (0.01)	−1.29	99	.20
DERS × Period	0.00 (0.00)	−0.71	114	.48	0.00 (0.01)	0.55	99	.59
Random effects	Variance	χ^2	*df*	*p*	Variance	χ^2	*df*	*p*
Intercept	1.40	1682.83	110	<.001	2.13	683.81	88	<.001
Period	0.25	237.59	110	<.001	2.18	354.65	88	<.001
Body awareness								
Fixed effects								
Intercept	5.62 (0.13)	43.54	114	<.001	1.48 (0.16)	9.02	99	<.001
Period	0.46 (0.08)	5.96	114	<.001	−0.38 (0.11)	−3.30	99	.001
DERS	−0.01 (0.00)	−2.30	114	.02	−0.01 (0.00)	−1.69	99	.09
DERS × Period	0.00 (0.00)	0.83	114	.41	−0.01 (0.00)	−0.16	99	.88
Random effects	Variance	χ^2	*df*	*p*	Variance	χ^2	*df*	*p*
Intercept	1.63	667.46	113	<.001	2.11	430.35	93	<.001
Period	0.20	161.44	113	.002	0.40	134.84	93	.003

Note. Reported using robust standard errors. DERS = Difficulties in Emotion Regulation Scale; EDA = electrodermal activity; RSA = respiratory sinus arrhythmia; β = standardized coefficient; γ (*SE*) = unstandardized coefficient and standard error.

Body awareness. There was an opposite pattern of physiological reactivity during the body awareness task. Body awareness was associated with an increase in RSA ($p < .001$), and a decrease in EDA responses ($p = .001$). Higher emotion dysregulation was associated with lower pretask RSA ($p = .023$), but not with changes in RSA during the task ($p = .407$), such that RSA increased significantly for participants who were high (slope = 0.53(0.12), $p < .001$) and low (slope = 0.39(0.10), $p < .001$) on emotion dysregulation. Similar to the other tasks, emotion dysregulation was not associated with EDA as baseline ($p = .093$) or with changes in EDA during the body awareness task ($p = .876$).

Discussion

In this study, we sought to better understand and characterize emotion dysregulation and psychophysiological response patterns in a complex sample of women who were engaged in outpatient SUD treatment and recently sober. There is a growing body of evidence to suggest that emotion dysregulation is a transdiagnostic vulnerability for psychiatric disorders, such as SUD (Gross & Munoz, 1995). Furthermore, substance users are a heterogeneous population, which makes it especially important to understand SUD outside of traditional diagnostic categories. There is also evidence that emotion dysregulation is related to psychophysiological profiles including lower RSA and EDA as well as greater RSA and EDA reactivity to stressors (Beauchaine & Thayer, 2015; Crowell et al., 2012).

An additional aim of this study was to examine autonomic response patterns to three different tasks within this complex sample. This study aligns with other basic psychophysiological methods studies conducted in laboratory settings and extends that work to underprivileged, emotionally dysregulated women assessed in an ecologically valid clinical context. We included measures of both sympathetic (EDA) and parasympathetic (RSA) responding to a standardized film task, a rumination task, and a novel interoceptive awareness task. Across all three tasks, SNS and PNS responses were opposite to one another, consistent with a reciprocal physiological pattern (Berntson, Cacioppo, & Quigley, 1993). In addition, psychophysiological responses to negative emotion induction were relatively similar for both the film and the rumination, with parasympathetic withdrawal to both tasks and EDA increases to the film but not the rumination. In contrast, the interoceptive awareness task resulted in RSA increases and EDA decreases from pretask baseline.

These psychophysiological findings are interpreted in the context of self-reported PA and NA on the PANAS. During both the film and the rumination task, participants reported decreased positive affect relative to baseline. NA increased significantly during rumination but was lower than baseline during the movie. This was likely due to high baseline levels of NA in a distressed sample and to the nature of the film task. This film was originally validated for the purposes of evoking a single discrete emotion (sadness; Gross & Levenson, 1995), and therefore overall levels of NA likely did not capture the specific response to the film task. Nevertheless, self-reported NA was still relatively high following the film (e.g., relative to body awareness). Thus, psychophysiological and self-report measures suggest that the film and rumination tasks were upsetting and effective in this sample and setting, although future research should continue to examine whether this film is sufficiently upsetting for highly distressed samples. Self-reports of PA and NA during the body awareness task were also consistent with hypotheses (PA increased and NA decreased). When

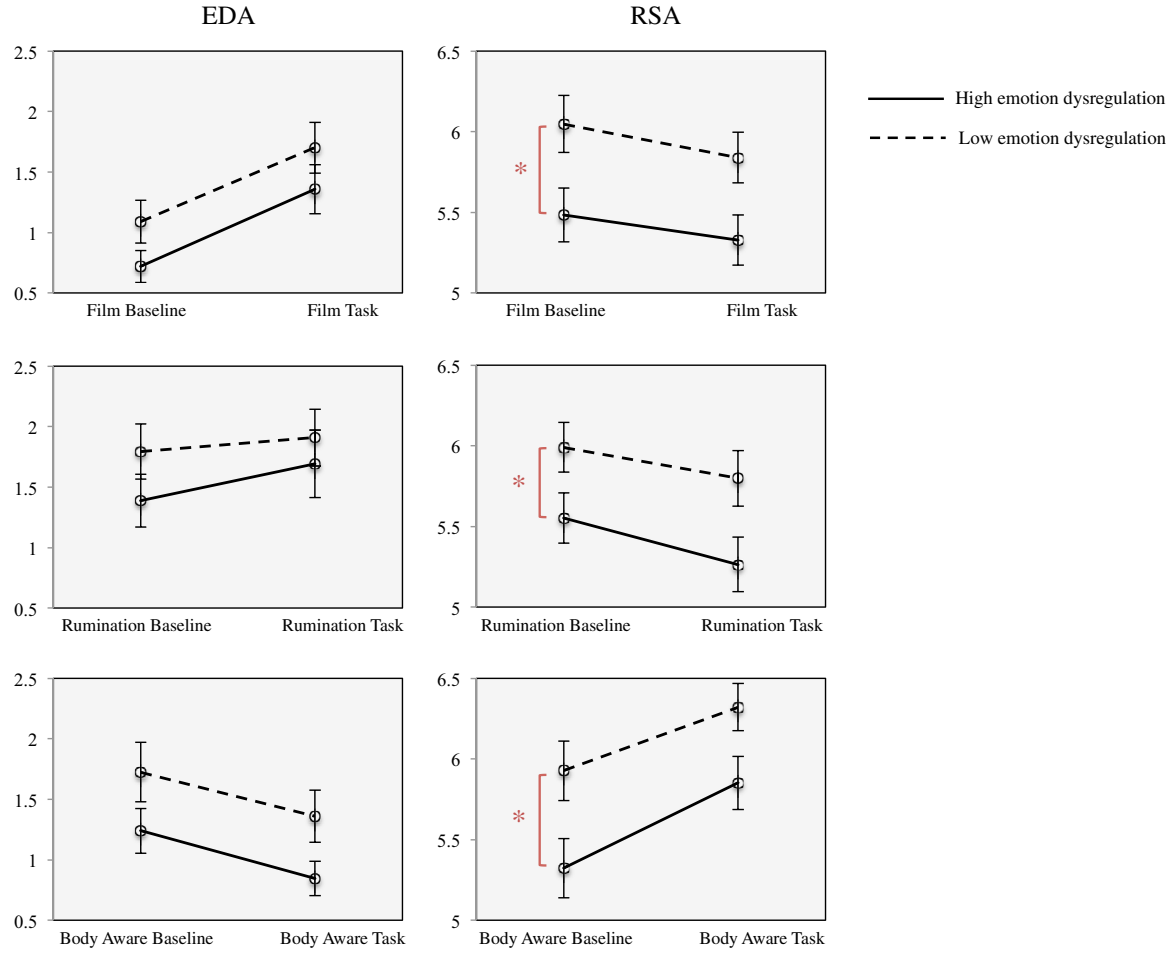

Figure 2. Autonomic response patterns to three distinct tasks. EDA = electrodermal activity, measured in number of nonspecific responses/30-s epoch; RSA = high frequency respiratory sinus arrhythmia, measured in log(beats/min^2/Hz).

psychophysiological results are interpreted in relation to PANAS data, they suggest that participants experienced improved physiological regulation and reduced arousal during the body awareness task. Participants were untrained in mindfulness and interoceptive awareness. Thus, even brief interoceptive tasks appear to have potential to affect physiological response patterns and mood. Over the course of treatment, it is possible that mindful interoceptive training could contribute to better emotion regulation and health.

Consistent with the theoretical and empirical literature guiding this study, we also examined difficulties with emotion regulation on the DERS as a moderator of psychophysiological response patterns. For this complex, chemically dependent sample, we selected the DERS given both theoretical and empirical evidence that emotion dysregulation is a transdiagnostic marker of risk for psychopathology and because it has been studied in relation to both sympathetic and parasympathetic response patterns (e.g., Beauchaine, Gatzke-Kopp, & Mead, 2007; Niedtfeld et al., 2016; Vasilev et al., 2009). As hypothesized, DERS scores were associated with baseline differences in RSA before all three tasks. This is consistent with several studies and the theory that resting RSA is a valid biomarker of emotion dysregulation (Beauchaine, 2001; Crowell et al., 2005). In contrast, DERS scores were not associated with resting EDA or with RSA/EDA reactivity, although resting EDA findings trended in the expected direction. Taken together, these findings suggest that there is a main effect of DERS on RSA, but all participants reacted similarly to the three tasks. Thus, future researchers can expect that heterogeneous, emotionally dysregulated clinical samples may respond similarly to these specific laboratory paradigms.

In addition to the challenges associated with the sample and setting, we made several study design choices that are limitations of this study and may have affected our findings, such as the decision not to counterbalance tasks. For example, it appears that participants had not achieved full EDA recovery from the film task prior to initiating the rumination tasks. This appears to have led to higher baseline EDA and less of a change to the task, which may account for the lack of EDA findings to the film. However, participants did return to baseline on RSA measures following the film, suggesting parasympathetic recovery may have occurred. In addition, placing the interoceptive awareness task last could have led to similar underestimates of the potency of this manipulation. We also had slightly more missing data than a typical laboratory study. Given the distressed nature of the sample, RAs were instructed to minimize the amount of time spent placing and replacing electrodes, which may have affected results. Finally, we did not collect SNS cardiovascular measures such as cardiac preejection period. This would have allowed for a more sophisticated understanding of SNS-PNS interactions but would have required more time and placed a greater burden on participants.

A primary strength of this study is the low-SES clinical sample with multiple comorbid diagnoses. Indeed, these participants

experienced many problems that would result in exclusion from most psychophysiological methods studies—a recent history of substance use, multiple medications, comorbid health conditions, and other challenges (e.g., transportation, childcare, money) that would likely preclude travel to a university setting. Furthermore, the clinical setting lacked many of the amenities common to university-based psychophysiological laboratories, such as complete sound attenuation, perfect temperature control, and audio/video monitoring from a separate control room. Scholars interested in researching underserved samples may be deterred by these factors, yet our results suggest that psychophysiological measures are reasonably robust to the issues that may have precluded real-world clinical research.

Future research should continue to work with underserved populations at high risk for negative health outcomes. Substance use in particular takes a tremendous toll on physical and emotional health—two pathways by which physiological systems may be affected. Among substance-using women, negative or stressful emotional events (Abulseoud et al., 2013) and comorbid conditions (Greenfield, Back, Lawson, & Brady, 2010) are factors associated with relapse following treatment. Thus, it is possible that interventions targeting the capacity to cope with these problems through interoceptive awareness may improve psychophysiological reactivity and emotion regulation, leading to improved treatment outcomes. By bringing psychophysiological measurements into clinical settings, we may enrich clinical research and improve understanding of treatment mechanisms.

References

Abulseoud, O. A., Karpyak, V. M., Schneekloth, T., Hall-Flavin, D. K., Loukianova, L. L., Geske, J. R., … Frye, M. A. (2013). A retrospective study of gender differences in depressive symptoms and risk of relapse in patients with alcohol dependence. *American Journal on Addictions*, *22*, 437–442. doi: 10.1111/j.1521-0391.2013.12021.x

Aldao, A., Nolen-Hoeksema, S., & Schweizer, S. (2010). Emotion-regulation strategies across psychopathology: A meta-analytic review. *Clinical Psychology Review*, *30*, 217–237. doi: 10.1016/j.cpr.2009.11.004

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., Rev.). Washington, DC: Author.

Beauchaine, T. P. (2001). Vagal tone, development, and Gray's motivational theory: Toward an integrated model of autonomic nervous system functioning in psychopathology. *Development and Psychopathology*, *13*, 183–214. doi: 10.1017/s0954579401002012

Beauchaine, T. P. (2012). Physiological markers of emotion and behavior dysregulation in externalizing psychopathology. *Monographs of the Society for Research in Child Development*, *77*, 79–86. doi: 10.1111/j.1540-5834.2011.00665.x

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

Beauchaine, T. P., Neuhaus, E., Gatzke-Kopp, L. M., Reid, M. J., Chipman, J., Brekke, A., … Webster-Stratton, C. (2015). Electrodermal responding predicts responses to, and may be altered by, preschool intervention for ADHD. *Journal of Consulting and Clinical Psychology*, *83*, 293–304. doi: 10.1037/a0038405

Beauchaine, T. P., & Thayer, J. F. (2015). Heart rate variability as a transdiagnostic biomarker of psychopathology. *International Journal of Psychophysiology*, *98*, 338–350. doi: 10.1016/j.ijpsycho.2015.08.004

Beck, A. T., Steer, R. A., Ball, R., & Ranieri, W. F. (1996). Comparison of Beck Depression Inventories-IA and -II in psychiatric outpatients. *Journal of Personality Assessment*, *67*, 588–597. doi: 10.1207/s15327752jpa6703_13

Berking, M., Poppe, C., Luhmann, M., Wupperman, P., Jaggi, V., Seifritz, E. (2012). Is the association between various emotion-regulation skills and mental health mediated by the ability to modify emotions? Results from two cross-sectional studies. *Journal of Behavior Therapy and Experimental Psychiatry*, *43*, 931–937. doi: 10.1016/j.jbtep.2011.09.009

Berking, M., & Wupperman, P. (2012). Emotion regulation and mental health: Recent findings, current challenges, and future directions. *Current Opinion in Psychiatry*, *25*, 128–134. doi: 10.1097/YCO.0b013e3283503669

Berntson, G. G., Cacioppo, J. T., & Quigley, K. S. (1993). Cardiac psychophysiology and autonomic space in humans: Empirical perspectives and conceptual implications. *Psychological Bulletin*, *114*, 296–322. doi: 10.1037//0033-2909.114.2.296

Bowen, S., Witkiewitz, K., Clifasefi, S. L., Grow, J., Chawla, N., Hsu, S. H., … Larimer, M. E. (2014). Relative efficacy of mindfulness-based relapse prevention, standard relapse prevention, and treatment as usual for substance use disorders: A randomized clinical trial. *JAMA Psychiatry*, *71*, 547–56. doi: 10.1001/jamapsychiatry.2013.4546

Byrne, M. L., Sheeber, L., Simmons, J. G., Davis, B., Shortt, J. W., Katz, L. F., & Allen, N. B. (2010). Autonomic cardiac control in depressed adolescents. *Depression and Anxiety*, *27*, 1050–1056. doi: 10.1002/da.20717

Coffey, S. F., Gudmundsdottir, B., Beck, J. G., Palyo, S. A., & Miller, L. (2006). Screening for PTSD in motor vehicle accident survivors using the PSS-SR and IES. *Journal of Traumatic Stress*, *19*, 119–128. doi: 10.1002/jts.20106

Crowell, S. E., Beauchaine, T. P., Hsiao, R. C., Vasilev, C. A., Yaptangco, M., Linehan, M. M., & McCauley, E. (2012). Differentiating adolescent self-injury from adolescent depression: Possible implications for borderline personality development. *Journal of Abnormal Child Psychology*, *40*, 45–57. doi: 10.1007/s10802-011-9578-3

Crowell, S. E., Beauchaine, T. P., McCauley, E., Smith, C. J., Stevens, A. L., & Sylvers, P. (2005). Psychological, autonomic, and serotonergic correlates of parasuicide among adolescent girls. *Development and Psychopathology*, *17*, 1105–1127. doi: 10.10170S0954579405050522

Dawson, M. E., Schell, A. M., & Filion, D. L. (2007). The electrodermal system. In J. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.) *Handbook of psychophysiology*, 159–181. New York, NY: Cambridge University Press.

Dichter, G. S., Tomarken, A. J., Shelton, R. C., & Sutton, S. K. (2004). Early- and late-onset startle modulation in unipolar depression. *Psychophysiology*, *41*, 433–440. doi: 10.1111/j.1469-8986.00162.x

Dickenson, J., Berkman, E. T., Arch, J., & Lieberman, M. D. (2013). Neural correlates of focused attention during a brief mindfulness induction. *Social Cognitive and Affective Neuroscience*, *8*, 40–47. doi: 10.1093/scan/nss030

Dienstbier, R. A. (1989). Arousal and physiological toughness: Implications for mental and physical health. *Psychological Review*, *96*, 84–100. doi: 10.1037//0033-295x.96.1.84

Dozois, D. J., Dobson, K. S., & Ahnberg, J. L. (1998). A psychometric evaluation of the Beck Depression Inventory–II. *Psychological Assessment*, *10*, 83–89. doi: 10.1037/1040-3590.10.2.83

Eddy, M. D., Brunyé, T. T., Tower-Richardi, S., Mahoney, C. R., & Taylor, H. A. (2015). The effect of a brief mindfulness induction on processing of emotional images: An ERP study. *Frontiers in Psychology*, *6*, 1391. doi: 10.3389/fpsyg.2015.01391

Fairburn, C. G., & Beglin, S. J. (1994). Assessment of eating disorders: Interview or self-report questionnaire? *International Journal of Eating Disorders*, *16*, 363–370. doi: 10.1002/1098-108X(199412)16:4 < 363::AID-EAT2260160405 > 3.0.CO;2-#

Foa, E. B., Riggs, D. S., Dancu, C. V., & Rothbaum, B. O. (1993). Reliability and validity of a brief instrument for assessing post-traumatic stress disorder. *Journal of Traumatic Stress*, *6*, 459–473. doi: 10.1002/jts.2490060405

Fox, H. C., Axelrod, S. R., Paliwal, P., Sleeper, J., & Sinha, R. (2007). Difficulties in emotion regulation and impulse control during cocaine abstinence. *Drug Alcohol Dependence*, *89*, 298–301. doi: 10.1016/j.drugalcdep.2006.12.026

Fox H. C., Hong, K. A., Sinha, R., (2008). Difficulties in emotion regulation and impulse control in recently abstinent alcoholics compared with social drinkers. *Addictive Behavior*, *33*, 388–394. doi: 10.1016/j.addbeh.2007.10.002

Fredrickson, B. L., & Levenson, R. W. (1998). Positive emotions speed recovery from the cardiovascular sequelae of negative emotions. *Cognition & Emotion*, *12*, 191–220. doi: 10.1080/026999398379718

Garland, E. L., Gaylord, S. A., Boettiger, C. A., & Howard, M. O. (2010). Mindfulness training modifies cognitive, affective, and physiological mechanisms implicated in alcohol dependence: Results of a randomized

controlled pilot trial. *Journal of Psychoactive Drugs*, *42*, 177–192. doi: 10.1080/02791072.2010.10400690

Gratz, K. L., & Roemer, L. (2004). Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure, and initial validation of the difficulties in emotion regulation scale. *Journal of Psychopathology and Behavioral Assessment*, *26*, 41–54. doi: 10.1023/b:joba.0000007455.08539.94

Greenfield, S. F., Back, S. E., Lawson, K., & Brady, K. T. (2010). Substance abuse in women. *Psychiatric Clinics of North America*, *33*, 339–355. doi: 10.1016/j.psc.2010.01.004

Gross, J. J., & Levenson, R. W. (1995). Emotion elicitation using films. *Cognition & Emotion*, *9*, 87–108. doi: 10.1080/02699939508408966

Gross, J. J., & Muñoz, R. F. (1995). Emotion regulation and mental health. *Clinical Psychology: Science and Practice*, *2*, 151–164. doi: 10.1111/j.1468-2850.1995.tb00036.x

Hastings, P. D., Nuselovici, J. N., Klimes-Dougan, B., Kendziora, K. T., Usher, B. A., Ho, M. H. R., & Zahn-Waxler, C. (2009). Dysregulated coherence of subjective and cardiac emotional activation in adolescents with internalizing and externalizing problems. *Journal of Child Psychology and Psychiatry*, *50*, 1348–1356. doi: 10.1111/j.1469-7610.2009.02159.x

Hawkley, L. C., Burleson, M. H., Berntson, G. G., & Cacioppo, J. T. (2003). Loneliness in everyday life: Cardiovascular activity, psychosocial context, and health behaviors. *Journal of Personality and Social Psychology*, *85*, 105–120. doi: 10.1037/0022-3514.85.1.105

Isen, J. D., Iacono, W. G., & Malone, S. M. (2013). Characterizing electrodermal response habituation: A latent class approach with application to psychopathology. *Psychophysiology*, *50*, 954–962. doi: 10.1111/psyp.12080

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

McCoach, D. B., & Black, A. C. (2008). Evaluation of model fit and adequacy. In A. A. O'Connell & D. B. McCoach (Eds.) *Multilevel modeling of educational data* (pp. 245–272). Charlotte, NC: Information Age Publishing Inc.

Mendes, W. B. (2009). Assessing the autonomic nervous system. In E. Harmon-Jones & J. S. Beer (Eds.) *Methods in social neuroscience* (pp. 119–148). New York, NY: Guilford Press.

Mennin, D. S., Turk, C. L., Heimberg, R. G., & Carmin, C. N. (2004). Regulation of emotion in generalized anxiety disorder. In M. A. Reinecke & D. A. Clark (Eds.) *Cognitive therapy across the lifespan: Evidence and practice* (pp. 60–89). Cambridge, UK: Cambridge University Press.

Mond, J. M., Hay, P. J., Rodgers, B., & Owen, C. (2006). Eating Disorder Examination Questionnaire (EDE-Q): Norms for young adult women. *Behaviour Research and Therapy*, *44*, 53–62. doi: 10.1016/j.brat.2004.12.003

Mond, J. M., Hay, P. J., Rodgers, B., Owen, C., & Beumont, P. J. V. (2004). Validity of the Eating Disorder Examination Questionnaire (EDE-Q) in screening for eating disorders in community samples. *Behaviour Research and Therapy*, *42*, 551–567. doi: 10.1016/s0005-7967(03)00161-x

Niedtfeld, I., Defiebre, N., Regenbogen, C., Mier, D., Fenske, S., Kirsch, P., . . . Schmahl, C. (2016). Facing the problem: Impaired emotion recognition during multimodal social information processing in borderline personality disorder. *Journal of Personality Disorders*, *30*, 248–264. doi: 10.1521/pedi_2016_30_248

Ottaviani, C., Shapiro, D., Davydov, D. M., Goldstein, I. B., & Mills, P. J. (2009). The autonomic phenotype of rumination. *International Journal of Psychophysiology*, *72*, 267–275. doi: 10.1016/j.ijpsycho.2008.12.014

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

Preacher, K. J., Curran, P. J., & Bauer, D. J. (2006). Computational tools for probing interaction effects in multiple linear regression, multilevel modeling, and latent curve analysis. *Journal of Educational and Behavioral Statistics*, *31*, 437–448. doi: 10.3102/10769986031004437

Price, C. J., & Crowell, S. E. (2016). Respiratory sinus arrhythmia as a potential measure in substance use treatment-outcome studies. *Addiction*, *11*, 615–625. doi: 10.1111/add.13232

Price, C. J., Donovan, D., Wells, E., & Rue, T. (2012). Mindful awareness in body-oriented therapy as an adjunct to women's substance use disorder treatment: A pilot feasibility study. *Journal of Substance Abuse Treatment;* 94, 94–107. doi: 10.1016/j.jsat.2011.09.016

Qu, M., Zhang, Y., Webster, J. G., & Tompkins, W. J. (1986). Motion artifact from spot and band electrodes during impedance cardiography. *IEEE Transactions on Biomedical Engineering*, *33*, 1029–1036. doi: 10.1109/tbme.1986.325869

Raudenbush, S. W., Bryk, A. S., Cheong, Y. F., & Congdon, R. T., Jr. (2000). *HLM 5: Hierarchical linear and nonlinear modeling*. Skokie, IL: Scientific Software International.

Raudenbush, S. W., Bryk, A. S, & Congdon, R. (2013). HLM 7.01 for Windows [Computer software]. Skokie, IL: Scientific Software International, Inc.

Rottenberg, J., Clift, A., Bolden, S., & Salomon, K. (2007). RSA fluctuation in major depressive disorder. *Psychophysiology*, *44*, 450–458. doi: 10.1111/j.1469-8986.2007.00509.x

Shields, S. A., MacDowell, K. A., Fairchild, S. B., & Campbell, M. L. (1987). Is mediation of sweating cholinergic, adrenergic, or both? A comment on the literature. *Psychophysiology*, *24*, 312–319. doi: 10.1111/j.1469-8986.1987.tb00301.x

Sinha, R. (2008). Chronic stress, drug use, and vulnerability to addiction. *Annals of the New York Academy of Sciences*, *1141*, 105–130. doi: 10.1196/annals.1441.030

Stark, R. (Producer) & Ross, H. (Director). (1989). *Steel magnolias* [Motion picture]. United States: TriStar Pictures.

Taylor, A. G., Goehler, L. E., Galper, D. I., Innes, K. E., & Bourguignon, C. (2010). Top-down and bottom-up mechanisms in mind-body medicine: Development of an integrative framework for psychophysiological research. *Explore: The Journal of Science and Healing*, *6*, 29–41. doi: 10.1016/j.explore.2009.10.004

Vasilev, C. A., Crowell, S. E., Beauchaine, T. P., Mead, H. K., & Gatzke-Kopp, L. M. (2009). Correspondence between physiological and self-report measures of emotion dysregulation: A longitudinal investigation of youth with and without psychopathology. *Journal of Child Psychology and Psychiatry*, *50*, 1357–1364. doi: 10.1111/j.1469-7610.2009.02172.x

Wallin, B. G. (1981). Sympathetic nerve activity underlying electrodermal and cardiovascular reactions in man. *Psychophysiology*, *18*, 470–476. doi: 10.1111/j.1469-8986.1981.tb02483.x

Watson, D., Clark, L. A., & Tellegan, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*, 1063–1070. doi: 10.1037//0022-3514.54.6.1063

Williams, D. P., Cash, C., Rankin, C., Bernardi, A., Koenig, J., & Thayer, J. F. (2015). Resting heart rate variability predicts self-reported difficulties in emotion regulation: A focus on different facets of emotion regulation. *Frontiers in Psychology*, *6*, 261. doi: 10.3389/fpsyg.2015.00261

Woodward, S. H., Shurick, A. A., Alvarez, J., Kuo, J., Nonyieva, Y., Blechert, J., . . . Gross, J. J. (2015). A psychophysiological investigation of emotion regulation in chronic severe posttraumatic stress disorder. *Psychophysiology*, *52*, 667–678. doi: 10.1111/psyp.12392

Zbozinek, T. D., Holmes, E. A., & Craske, M. G. (2015). The effect of positive mood induction on reducing reinstatement fear: Relevance for long term outcomes of exposure therapy. *Behaviour Research and Therapy*, *71*, 65–75. doi: 10.1016/j.brat.2015.05.016

Zisner, A. R., & Beauchaine, T. P. (2015). Psychophysiology (peripheral). *The Encyclopedia of Clinical Psychology*. 1–5. doi: 10.1002/9781118625392.wbecp306

(Received January 7, 2016; Accepted December 18, 2016)