A MULTI-METHOD APPROACH TO EXAMINING EMOTION REGULATION PROFILES IN WOMEN WITH AND WITHOUT BORDERLINE PERSONALITY DISORDER

by

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DISSERTATION ABSTRACT

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Title: A Multi-Method Approach to Examining Emotion Regulation Profiles in Women with and without Borderline Personality Disorder

Emotion regulation is an important transdiagnostic symptom of psychopathology and a key treatment target for intervention. It has been extensively researched in psychology using multiple measurement methods. Despite the diverse methodological approaches used to measure emotion regulation, little research has examined the correspondence of those measures. This multi-study dissertation investigated how different measures of emotion regulation correspond in women with and without Borderline Personality Disorder (BPD) to generate preliminary ideas of how the relationships among these measures may be used to better understand mental disorders and improve treatment.

The first study examined correspondence among self-report, behavioral, and physiological measures of emotion regulation and emotion dysregulation in 50 women with BPD and 55 non-disordered controls. Latent profile analyses were used to identify unique profiles of emotion regulation and dysregulation. Results showed that few measures of emotion regulation correlated with each other and that differences between groups were primarily found only in self-report measures. Three latent profiles of

emotion regulation and four latent profiles of emotion dysregulation were identified in the full sample, demonstrating unique patterns among the relationships of these measures.

The second study expanded on the neuroimaging literature of emotion reactivity and regulation in women with BPD, as well as, examined the relationships of neural findings with other measures of emotion reactivity and regulation. A sample of 32 women, 17 with BPD and 15 non-disordered controls viewed negative and neutral images while undergoing functional magnetic resonance imaging and were instructed to either view, suppress, or reappraise. Results did not show hypothesized group differences in limbic hyperreactivity or prefrontal control regions. Activation unique to suppressing negative images was related to several measures, including self-report of increased anger and of dysfunctional coping skills.

Findings of these two studies demonstrate that multi-method approaches are important in the study of emotion regulation as different measurement methods do not always correspond with each other and therefore a single measurement does not provide an accurate picture of the emotion regulation system as a whole. This research has important clinical implications in the understanding of assessment and treatment of individuals who experience difficulties in emotion regulation.

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CHAPTER I

GENERAL INTRODUCTION

Difficulties in emotion regulation has been identified as a prominent transdiagnostic symptom of psychopathology (Aldao, Nolen-Hoeksema, & Schweizer, 2010; Sloan et al., 2017) and is estimated to occur in over 85% of mental disorders (Kring & Sloan, 2010). It has further been established as a mechanism of change and predictor of treatment outcome (Forster, Berthollier, & Rawlinson, 2014; Neacsiu, Eberle, Kramer, Wiesmann; & Linehan, 2014). As such a wide occurring and high-impact phenomenon, researchers and clinicians must have a thorough understanding of the systems that can be disrupted by emotion regulation and a clear understanding of the ways it can be assessed. This dissertation takes steps towards addressing this goal through implementation of a multi-method approach in two studies examining clinical populations experiencing severe disruptions in emotion regulation and comparing them to non-disordered controls.

As the research field has come to understand emotion regulation as a complex construct composed of multiple domains, many measurement methods have arisen to capture these different systems (Davidson, Goldsmith, & Scherer, 2009). Subjective experience, behaviors, physiological changes, and neural activity have all been considered important facets of emotion regulation (Gross, 2015). For a thorough understanding of emotion regulation, all of these facets need to be examined, which requires a set of multiple measures. Beyond understanding each of these facets, the associations among them should be examined to understand how different processes interact or differentially relate to other phenomena such as physical or mental health.

Little research, however, has implemented multiple methods in the study of emotion regulation and fewer have directly tested the association between the measures creating a key gap in the literature.

This dissertation will contribute significantly to this gap through examining the transdiagnostic factor of emotion regulation across three measures commonly used in the field—self-report, behavior and physiology—and directly testing the associations among these measures. This research will provide additional knowledge to the general understanding of emotion regulation as a multi-dimensional system and yield new understanding of the use of multi-method approaches to assess functioning and disruptions of emotion regulation. This has important clinical implications related to the understanding of the development and maintenance of psychological disorders, as well as, implications for intervention and improving treatment effectiveness. Two studies were conducted and are discussed in this dissertation. A brief review of each is provided below.

The Present Studies

The present studies were designed to address the gap in the emotion regulation literature by using multi-method approaches and comparing a highly dysregulated sample to non-disordered controls. Each study uses a combination of self-report, behavioral, and physiological measures of emotion regulation and directly compares the correspondence among them.

Women with Borderline Personality Disorder (BPD) were recruited as the clinical sample of interest. Difficulties with emotion regulation has been identified as one of the core features of BPD, making it an excellent group to examine emotion

regulation disruptions (Linehan, 1993). An extensive literature on emotion regulation in BPD across different measures already exists, which provides a foundation to inform hypotheses and compare results to the literature. Further, BPD is highly comorbid with other disorders providing some generalizability of the results to emotion regulations disruptions related to other mental health symptoms (Shah & Zanarini, 2018). Each study is framed towards the understanding of emotion regulation disturbances in BPD, and measures in were chosen based on their relevance to the BPD literature.

Study 1

Study 1 (Chapter II) examined emotion regulation and emotion dysregulation in a sample of 105 women, 50 with BPD symptoms, and 55 non-disordered controls. Measures of self-report, behavior, and physiology were collected and were then compared across groups and examined for correspondence using correlations. Latent Profile analyses were then used to examine how these measures may relate to each other differently in identifiable and meaningful patterns. Person-centered approaches such as these provide another way of examining the relationships of emotion regulation measures and capture more individual differences than traditional approaches.

Study 1 aims

The aims of study 1 are: (1a) Compare women with BPD to non-disordered controls on all measures of emotion regulation and dysregulation; (1b) Examine the correspondence across self-report, behavioral, and physiological measures of emotion regulation and emotion dysregulation in the entire sample and then compare associations in BPD women versus non-disordered controls; (2) Identify profiles of emotion regulation and emotion dysregulation using latent profile analyses with the entire sample

and then within group; (3) Examine the relation between profiles of emotion regulation and emotion dysregulation with mental health symptoms.

Study 1 hypotheses

Hypotheses for study 1 are: (1a) There will be significant differences between groups on self-report measures of emotion regulation and dysregulation; however, there will not be differences in physiological or behavioral measures; (1b) There will be small to moderate correlations among self-report measures of emotion regulation and dysregulation and among physiological measures. Self-report, physiological, and behavioral measures will not correlate across methods. Further, correlations within the BPD group will show the same relationships among variables as the full sample; (2a) Three profiles of emotion regulation will be identified across the whole sample – a profile in which persons generally score high on each measure, a profile in which persons generally score low on each measure and a profile in which persons generally score in the middle of each measure; (2b) Three profiles of emotion dysregulation will be identified across the whole sample – a profile in which persons generally score high on each measure, a profile in which persons generally score low on each measure, and a profile in which persons generally score in the middle of each measure; (2c) By examining the BPD group separately, additional profiles of emotion regulation and dysregulation than the three hypothesized above will be identified.

Study 2

Study 2 (Chapter III) is written in a journal article format and uses functional magnetic resonance imaging (fMRI) to examine putative neural correlates of emotion reactivity and regulation in 32 women, 17 with BPD and 15 non-disordered controls. It

then examines the associations of neural findings and other measures of emotion regulation.

Study 2 aims

The aims of study 2 are: (1) Examine functional changes in neural networks associated with emotion reactivity and emotion regulation in women with and without BPD during a visual emotion task; (2) Examine the correlations between neural activity associated with reactivity (e.g. amygdala) and neural activity associated with regulatory processes (e.g. prefrontal cortex) and other measures of emotion regulation including self-report, behavioral, and physiology across the whole sample.

Study 2 hypotheses

Hypotheses for study 2 are: (1) BPD individuals, as compared to non-disordered controls, are hypothesized to show patterns of hyperreactivity, such as increased activation of regions associated with emotion reactivity (i.e., amygdala, posterior cingulate cortex), when viewing negatively valenced images, and demonstrate blunted activation in regions associated with inhibitory control (i.e., dorsolateral prefrontal cortex) when attempting to use regulation strategies in response to negative stimuli; (2) Based on the putative construct tested by the measures, increased activity in regions associated with reactivity are hypothesized to correlate with other measures that capture reactivity, and inhibited activity in regions associated with measures that capture difficulties or impairment with regulation.

CHAPTER II

STUDY 1: EMOTION REGULATION AND EMOTION DYSREGULATION PROFILES IN WOMEN WITH AND WITHOUT BORDERLINE PERSONALITY DISORDER

Difficulties in emotion regulation, referred to as emotion dysregulation, is a core transdiagnostic feature of many types of mental disorders and is considered the hallmark feature of borderline personality disorder (BPD) (Linehan, 1993; Sloan et al., 2017). The evidence for emotion regulation's role in psychopathology as well as its potential as a mediator of treatment effectiveness is so well established, that it has been proposed as a sixth domain of the Research Domain Criteria (RDoC; Fernandez; Jazaieri, & Gross, 2016). In order to understand it as a construct, the field has examined emotion regulation through an extensive range of methodologies including – genes, neurotransmitters, neural circuits and functioning, cardiophysiology, behavioral, and self-report. While there are a range of methodologies employed to study emotion regulation, the majority of evidence documenting the role that emotion regulation difficulties play in mental health disorders and when it is being measured as a treatment outcome, has been examined predominantly through self-report measurements, and to a lesser extent, behavioral, physiological and neuroimaging measurement approaches. Even fewer studies have employed multi-method approaches, and furthermore, there is a particular dearth of literature examining the relationships between or among these various emotion regulation measures. The lack of findings published on multi-method emotion regulation approaches broadly and in clinical samples specifically may at least partly stem from the complexity of emotion regulation as a construct. Multifaceted and composed of dynamic systems, measurement

of emotion regulation is complicated. The relationships between and among these systems have not been well established, and the lack of consistently observed correspondence has further challenged researchers' ability to synthesize these findings into meaningful relationships or patterns. As such, researchers have begun to advocate for multilevel and multi-method approaches as a more meaningful and interpretable approach to understanding these divergent patterns of correspondence between various emotion regulation measures, known as emotion regulation profiles (Eid & Diener, 2006).

A primary goal of this dissertation and the explicit focus of this study is to identify emotion regulation and emotion dysregulation profiles that permit various patterns of associations among self-report, behavioral, and physiological measures in women with elevated BPD symptoms versus women with no mental health disorders. To accomplish this, person-oriented approaches are used to preliminarily identify emotion regulation and dysregulation profiles in both groups and then within the BPD group alone. Emotion regulation and dysregulation profiles are then compared with women's mental health symptoms.

The introduction of this study is organized by the following topics: I) Define emotion regulation and discuss the way it is measured, II) Review the evidence of emotion regulation as a transdiagnostic feature of psychopathology and target of intervention, III) Detail the evidence of emotion regulation deficits as related to BPD through self-report, behavioral, and physiological measures, and IV) Review multi-method approaches to studying emotion regulation and dysregulation and how they may

advance our understanding of emotion-related deficits in individuals with BPD and potential variations in treatment response.

Defining and Measuring Emotion Regulation and the Need for Multi-Measure Approaches

Consensus on a single definition of emotion regulation has not been achieved within the field, even though it is generally agreed that emotion regulation is multifaceted and involves the recruitment and coordination of multiple psychological domains, including emotion recognition, emotional reactivity, effortful cognitive modulation, and the transactional correspondence between these (Bridges et al., 2004). Major differences between definitions include the degree to which context is taken into consideration (Gratz & Roemer, 2004) or whether emotion is even dissociable from emotion regulation (Gross & Barett, 2011; Kappas, 2011). Different definitions of emotion regulation vary by the theories underlying them. One prevailing theory used in the field is the process-oriented model (Gross, 1998), which defines emotion regulation as:

> "…processes by which individuals influence which emotions they have when they have them, and how they experience and express these emotions." (p. 275)

Another popular theory is the competency-focused model developed by Gratz and Roemer (2004):

> "Emotion regulation may be conceptualized as involving the (a) awareness and understanding of emotions, (b) acceptance of emotions, (c) ability to control impulsive behaviors and behave in accordance with desired goals when experiencing negative emotions, and (d) ability to use situationally appropriate

regulation strategies flexibly to modulate emotional responses as desired in order to meet individual goals and situational demands." (p.42-43)

These are two prevalent theories in the field, but more exist as well. Within this dissertation, emotion regulation is approached from the competency-focused model as this model is commonly used in the literature on BPD and is more person-oriented.

In addition to the several definitions of emotion regulation, there are also many proposed indicators of emotion regulation. Emotion regulation involves the coordination of behavioral, biological, and psychological processes, necessitating a wide variety of approaches to measure putative emotion regulation functioning (i.e., subjective report, heart rate, brain network activation, etc.). Research has examined many of these indices independently, leading to a plethora of information on emotion regulation using different approaches, but less research has examined emotion regulation *across* measures. The processes involved in emotion regulation do not operate in isolation from each other, but rather, interact transactionally or in parallel with one another. Therefore, examining emotion regulation from a single approach may oversimply a far more complex process. Individual indicators of emotion regulation may be deficient while others indicators experience no disruptions, which may be why a lack of observed correspondence between measures has sometimes been found. A multi-method approach offers a way to understand how these processes may relate to one another and how differential function or dysfunction in one or more processes may contribute to overall emotion regulation ability, or an individual's unique emotion regulation profile.

Another aspect of emotion regulation that varies in research is whether the study approach is examining emotion regulation or emotion *dysregulation.* Emotion

dysregulation, more prominently examined in the clinical literature, may be described as patterns of emotional experiences or behaviors that interfere with an individual's adaptive functioning or goals (Beauchaine & Gatzke-Kopp, 2012). This may be experienced as one or more negative emotions occurring at a higher intensity and/or longer duration than is tolerable or effective for that individual (Beauchaine, 2015). While it may seem like emotion dysregulation is merely the inverse of emotion regulation, it is possible for an individual to experience emotion dysregulation in some capacities but be regulated in others and therefore it can be useful to consider these as separate dimensions.

Finally, another variation in methodological approaches that may contribute to the lack of correspondence across measures of emotion regulation is whether the construct is being examined at a baseline level (i.e., self-reported regulation capabilities) or during a reactivity/regulatory task (i.e., emotion regulation capabilities in response to an emotion-inducing task). This is an important distinction as some deficits may only be observable within a given context. For example, Kuo, Fitzpatrick, Metcalfe, & McMain (2016) found that dysfunctions in baseline measures of emotion regulation rather than reactivity measures were observed in their sample of individuals with BPD and proposed it may be that baseline emotion dysregulation is core to the pathology of BPD. Further, even within a regulatory task, studies may vary in whether they use generally reactive stimuli or tasks or personally relevant material. Individuals may vary in how they experience emotion regulation or dysregulation such that these deficits may only be observable under certain conditions and contexts. A multi-method approach offers more opportunities for those variations to occur and be observed.

In sum, emotion regulation is defined, measured, and approached in a multitude of ways. A single measure of emotion regulation may provide insight into one aspect of emotion regulation, and while useful, it does not capture it as a more dynamic and complex system, such that it may simplify the extent of an individual's difficulties or capabilities with emotion regulation and/or strengths. Through a multi-method approach, unique patterns, or emotion regulation and emotion dysregulation profiles, may emerge among the various processes, providing unique information about an individual's functioning. This study examines the relationships among emotion regulation and dysregulation measures using measures that capture behavioral, biological, and psychological processes, both at baseline and during reactivity. This study then examines how these measures may vary in their relationships such that they form unique profiles of emotion regulation and dysregulation.

A Transdiagnostic Symptom of Psychopathology and Intervention Target

Difficulties in emotion regulation has been identified in as many as 85% of psychiatric disorders including Major Depressive Disorder (Gortner, Rude, & Pennebaker, 2006), Bipolar Disorder (Van Rheenen, Murray, & Rossell, 2015), Generalized Anxiety Disorder (Barlow, Allen, & Choate, 2004; Brown, 2007; Foa & Kozak, 1986), Post-Traumatic Stress Disorder (Powers, Cross, Fani, & Bradley, 2015) such that emotion regulation his commonly referred to as a transdiagnostic marker of psychopathology. In addition to being a transdiagnostic feature, the presence of emotion dysregulation has been shown to exacerbate both internalizing (i.e. depression, anxiety, dissociation) and externalizing (i.e. aggression, impulsivity, substance abuse) symptoms such that these symptoms are experienced more often and more severely (Leahy, Tirch,

& Napolitano, 2011). Emotion regulation difficulties have also been shown to *lead* to the development of depression and anxiety in times of extended stress (Mennin, Holaway, Fresco, Moore, & Heimberg, 2007). Conversely, the *ability* to regulate emotions is routinely associated with higher levels of functioning and well-being (Haga, Kraft, & Corby, 2009) and is identified as a protective factor for risk of mental health disorders. This evidence cumulatively shows that emotion regulation is an important aspect of psychological health and a highly relevant target of psychological treatment interventions.

Emotion regulation has been examined as a significant mediator of psychological interventions, including cognitive-behavioral and acceptance-based therapies (Bloch, Moran, & Kring, 2010; Gratz & Tull, 2010). Cross-sectional work has reported mediating effects of emotion regulation on the development of symptoms of psychopathology (Hopfinger, Berking, Bockting, & Ebert, 2016), as well as its' effectiveness as a mechanism of change for symptom reduction, demonstrating that on average, if individuals do not experience improvements in emotion regulation, their symptoms are less likely to remit (Gratz, Bardeen, Levy, Dixon-Gordon, & Tull, 2015; Kramer et al., 2016; Slee, Spinhoven, Garnefski, & Arensman, 2008). Treatments that directly target emotion regulation, such as Dialectical Behavioral Therapy (DBT), Emotion Regulation group therapy, and the Unified Protocol have demonstrated effectiveness at reducing the frequency and severity of other symptoms including depression, anxiety, substance use, disordered eating behaviors, and self-harm behaviors (Chambers, Gullone, & Allen, 2009; Linehan et al., 2015; Mennin et al., 2007; Neacsiu, Lungu, Harned, Rizvi, & Linehan, 2014; Sauer-Zavala et al., 2012; Treanor, Erisman, Salters-Pedneault, Roemer,

& Orsillo, 2011), further highlighting emotion regulation's importance as an intervention target and providing increasing support for emotion regulation as the *mechanism* through which changes may occur.

Overall, the clinical trial literature shows strong evidence that 1) emotion regulation can be improved through psychological intervention, and 2) the degree to which emotion regulation improves is highly related to symptom reduction. However, many intervention studies examine the effects of emotion regulation from self-reports exclusively, and to a lesser extent include an additional measure of behavioral, physiological, or neural measures. A multi-method approach may provide a better understanding of what processes of emotion regulation or dysregulation are changing with intervention and/or if there are particular patterns of emotion regulation or dysregulation that are more strongly associated with specific symptoms. This may lead to further treatment improvement, mainly through identifying individual capabilities and difficulties of emotion regulation. Further, nearly 30% of individuals who receive evidence-based treatment, regardless of treatment type, do not improve or only achieve partial remission (Reuter et al., 2016; Westen & Bradley, 2005). Using a multi-method approach to study emotion regulation in clinical groups may help identify if there are profiles of emotion regulation or dysregulation that tend to respond poorly to treatment, and through identifying these, may help identify particular areas to target to increase treatment effectiveness.

Overall multi-method approaches offer the opportunity to advance our understanding of transdiagnostic symptoms and may lead to improvements in treatment approaches and treatment response. This dissertation takes the first steps towards a long-

termer goal of identifying the relationships among emotion regulation processes and measures, examining whether unique emotion regulation or dysregulation profiles emerge, and determining how/if those profiles may be meaningful in their relationships to clinical symptoms.

Borderline Personality Disorder and Emotion Regulation

A particular diagnosis in which emotion dysregulation is a core symptom is Borderline Personality Disorder (BPD; Linehan, 1993). BPD is described as a mental disorder in which persons experience pervasive disturbances in affect lability, impulsivity, identity, and attachment (American Psychiatric Association, 2013). Furthermore, BPD is often comorbid with a multitude of other mental disorders known to be associated with emotion regulation difficulties, such as Major Depressive Disorder, Post-Traumatic Stress Disorder, Bipolar Disorder, and Substance Abuse (McGlashan et al., 2000; Zanarini et al., 1998a.; Zanarini et al., 1998b). Because BPD is a diagnosis for which emotion dysregulation is so severe, it is especially suitable for discerning variations across measures of emotion regulation and emotion dysregulation and determining if those differences in emotion regulation profiles are meaningful. By selecting to focus on a mental disorder that is highly comorbid with other disorders and is known to be associated with severe difficulties in emotion regulation, we will be able to optimally examine the transdiagnostic aspect of emotion regulation and capture variation in the way in which these difficulties may manifest in an individual and the relationship they may have with other mental health symptoms. This dissertation recruited a sample of women with elevated BPD symptomatology, many meeting full diagnostic criteria, to examine emotion regulation and emotion dysregulation profiles as they compare to

women with no mental health disorders. I now introduce each method of measurement employed in this study (self-report, behavioral, and physiological) and briefly summarize the strengths and limitations as a measure of emotion regulation, and finally, review the evidence of emotion regulation dysfunction in BPD within each method in order to understand the expected pattern of results within a BPD sample and as compared to healthy controls.

Self-Report

Self-report measures are the most widely used measure of emotion regulation or any other mental health symptom. They are easy to administer and relatively inexpensive. Further, they can be administered and scored quickly, providing information about emotion or symptoms almost instantly. Self-report measures hold the particular advantage of providing insight into an individual's perception of their own emotions, something no other measure can capture. There exist many self-report questionnaires of emotion regulation, and they vary widely in what they measure; some may capture aspects of emotional awareness, while others measure reactivity or emotion strategies. Further, some may assess emotion regulation while others dysregulation.

While subjective reports on emotion regulation provide an initial understanding of a person's potential abilities with emotion regulation, they are subject to the limitations that all self-report measures face, including potential response bias – an individual feeling prompted to respond a certain way either because they are sensitive to experimental demands or social response bias (Van de Mortel, 2008). Furthermore, self-report measures often rely on retrospective reporting of emotions and behaviors, something several studies have documented as sometimes unreliable (Fahrenberg, Myrtek, Pawlik,

& Perrez, 2007; Shiffman, Stone, & Hufford, 2008). They further require that a person understands and interpret each item the same way and has the ability to be aware and identify their own emotions as they arise and change over time, something that many individuals with difficulties in emotion regulation struggle with, and therefore may not be able to accurately report (Lukowitsky & Pincus, 2013). Despite this, an individual's self-reported perspective of their emotion regulation abilities provides a unique insight of how the individual experiences their own emotions, which may be meaningful in understanding an individual's emotion regulation profile and is, therefore, an essential aspect to understanding and measuring emotion regulation. Because they are the most widely used measure in clinical studies, it is particularly important to understand how they may correspond with other measures of emotion regulation.

The Difficulties in Emotion Regulation Scale (DERS) is one of the most commonly used instruments in the study of emotion dysregulation in clinical populations, including BPD (Gratz & Roemer, 2004) and has been cited in nearly 3000 papers to date (Hallion, Steinman, Tolin, & Diefenbach, 2018). Because of its centrality to the emotion regulation in BPD literature, it is reviewed in-depth here. DERS was created under a clinically-minded framework and proposes to be a multidimensional conceptualization of emotion regulation that taps into (a) awareness and understanding of emotions, (b) acceptance of emotions, (c) access to emotion strategies, and (d) control over impulsive and emotion urge behaviors in the context of individual goals and situation appropriateness. The measure is composed of 36-items, which can be broken down into 6 subscales and is generally found to have internal consistency and test-retest reliability (Gratz & Roemer, 2004). Using a 5-point Likert scale respondents rate how often a

statement applied to them (1=Almost never (0-10%), 5=Almost Always (91-100%)); higher scores are indicative of higher levels of emotion dysregulation. Example questions include statements like, "I am clear about my feelings," or "When I'm upset, I feel out of control." Clinical populations consistently score higher on the DERS as compared with the normative population (*M*=77.18(22.37); means taken from Ritschel, Tone, Schoemann, & Lim, 2015), and BPD populations typically score more than 2 standard deviations above the normative mean (*M*=118(18.47) – Axelrod, Perepletchikova, Holtzman, & Sinha, 2011; *M*=128(22) – Silvers et al., 2016; *M*=127 (22) -Wilks, Korslund, Harned, & Linehan, 2016). The DERS has also been used as a measure of treatment effectiveness in studies that examine emotion regulation as a mediator of treatment outcomes and has been shown to change in response to treatment. For example, Wilks et al., (2016) showed that DERS scores changed significantly in individuals with BPD undergoing treatment across two years, (Baseline DERS=127.04(21.14); DERS at 24 months=87.25(27.87)). Similar findings were reported in a pre-post treatment investigation of women with BPD and comorbid substance abuse undergoing a 20-week DBT treatment program, (Baseline DERS=118(18.47); DERS Post-Treatment=94.8(17.89); (Axelrod et al., 2011). The large standard deviations in DERS however, highlight that the range in DERS for both baseline and of DERS recovery varies widely across individuals, and while a common and useful measure, the DERS also has some limitations, including its focus on the regulation of negative emotions and absence of questions regarding the regulation of positive emotions (Gratz & Roemer, 2004).

While the DERS is not the only self-report measure of emotion regulation or dysregulation, it is used most frequently in BPD research and therefore will be used in this study along with two other self-report measures commonly used with BPD populations, the Acceptance and Action Questionnaire (AAQ; Bond et al., 2011) and the DBT Ways of Coping Checklist (DWCL; Neacsiu, Rizvi, Vitaliano, Lynch, & Linehan, 2010), which are described in the methods. The DWCL measures an individual's use of both adaptive and maladaptive coping skills, thus measuring both emotion regulation and dysregulation, respectively. The AAQ measures a person's psychological flexibility and acceptance of negative emotions, thus representing a measure of emotion regulation. By including multiple self-reports of both emotion regulation and dysregulation, we will be able to examine correspondence among self-report measures in addition to their correspondence with other measurement methods.

Behavioral

Behavioral measures of emotion regulation can be examined in many ways – facial expressions (emotional expression), the effect of emotion stimuli on behavior (emotion reactivity), or the ability to inhibit emotion responses (inhibitory control). It has also been common in the field to measure behavioral aspects of cognition or perception as an indirect measure of emotion regulation as cognitive processes such as inhibitory control, facial recognition, and attention have been associated with emotion regulation functioning. Behavioral performance, which can be observed in several ways, is the typical output of a behavioral measure. This includes accuracy, response time, or response inhibition. Behavioral measures have an advantage over self-reports in that they may provide a less subjective measure of emotion regulation abilities. While less

subjective than self-report measures, behavioral measures also have limitations. One limitation is that because many behavioral measures of emotion regulation examine aspects of executive function, they are not measuring emotion regulation directly, but rather variables associated with emotion regulation. Furthermore, because executive functioning is a cognitive ability that can be measured outside the context of emotional experiences, these tasks are almost always conducted in laboratory settings that rarely measure behavior in the presence of extreme emotions; therefore, it may fail to capture how executive functioning may be altered in response to extreme emotions.

Deficits in inhibitory control, one core aspect of executive function (Diamond, 2013), has been posited as one way emotion dysregulation may manifest and higher inhibitory control is commonly used as a behavioral indication of emotion regulation (Domes et al., 2006). Inhibitory control has often been researched in individuals with severe emotion dysregulation, including individuals with BPD (Berlin, Rolls, & Iversen, 2005; Domes et al., 2006; Fertuck, Lenzenweger, Clarkin, Hoermann, & Stanley, 2006), and therefore, will be reviewed in-depth here. In this domain, individuals with BPD are hypothesized to score poorly on measures of executive function and inhibition as this may contribute to difficulties in regulating emotions; however, the evidence supporting this has been mixed (Arntz et al., 2000; Minzenberg et al., 2008; Wingenfeld et al., 2009a, Wingenfeld et al., 2009b). Furthermore, it is unclear if these deficits are expected to occur as a global deficit which manifests across all contexts or if the inhibitory control deficits occur mainly in the presence of intense emotions.

The Stroop task is a widely used measure of interference and inhibitory control (Scarpina & Tagini, 2017; Stroop, 1935). Within BPD populations, the Stroop has been

used as a measure of general inhibitory control, and while it is not a measure of emotion regulation, poor inhibitory control has been associated with difficulties in regulationg emotions. For the Stroop, participants see words presented on either a screen or a piece of paper and are instructed to respond with the color the word appears in, therefore requiring conscious control of attention and action. Some empirical studies have shown increased interference effects in persons with BPD (Besteiro-González, Lemos-Giráldez, & Muñiz, 2004; Jacob, 2010), while there are also many studies that *fail* to find a difference in Stroop performance in individuals with BPD as compared to healthy controls (Lampe et al., 2007; LeGris et al., 2012; Völker et al., 2008). Correlations between poor executive functioning and BPD have been found; however, there have been inconsistent findings in a BPD sample on Stroop performance, a highly used measure of inhibition. This suggests that some but not all individuals with BPD may experience this particular deficit associated with emotion regulation, and demonstrates another way in which an individual's emotion profile may differ. Including this measure in the present study will allow us to examine the correspondence of inhibitory control with aspects of emotion regulation and see if it differentially contributes to some emotion regulation profiles but not others.

Physiological (HR/HRV)

The autonomic nervous system (ANS) of the human body regulates physiological responses to events in the environment and coordinates both the activation of systems that are responsible for reaction and for regulation of systems returning to baseline following action, and as such plays an integral role in emotions and emotion regulation processes (Thayer et al., 2012). Both heart rate (HR) and heart rate variability (HRV) are

two commonly measured physiological processes of ANS activity believed to be indicators of stress, arousal, and emotion reactivity. HR, which refers to the rate of heartbeats, is associated primarily with sympathetic nervous system activity, such that increased HR is indicative of increased reactivity to stimuli (Gordon, Gwathmey, & Xie, 2015). HRV is regulated by both branches of the ANS, the parasympathetic and sympathetic nervous systems, and therefore may indicate both reactive and regulatory behavior. High-frequency HRV in particular, which is associated with respiratory sinus arrhythmia (RSA), is almost exclusively a measure of parasympathetic activity and therefore is more indicative of an individual's ability to regulate physiological responses and return to baseline (Berntson, Cacioppo, & Quigley, 1993). Researchers have examined HR and HRV both at baseline, an individual at rest or engaged in normal activities, and in reactivity, their HR or HRV patterns during stress or emotion-inducing condition or task. Higher resting HR and HR in response to stressors have been associated with increased levels of arousal and hyperreactivity and has been observed in mental health disorders particularly associated with anxiety symptoms (Aikins & Craske, 2010). Higher HRV is indicative of a more flexibly responsive ANS, thus increasing the ability of the individual's physiological systems to meet the demands of the dynamic environment (Fabes & Eiseinberg, 1997; Porges, 2007). Low HRV and RSA, alternatively is indicative of more difficulties in emotion regulation (Beauchaine, 2001; Appelhans & Lueken, 2006) and has been associated with a number of mental health disorders (Chalmers et al., 2014; Kemp et al., 2012; Montaquila et al., 2015; Sammito, Thielmann, Zimmermann, Böckelmann, 2015).

Physiological measures of emotion regulation have the advantage over self-report measures in that they are resistant to many types of response biases. Additionally, unlike some other measures, they can provide real-time temporal information on changes in arousal and reactivity. This type of measurement is also useful when an individual may lack emotional awareness, which is needed to be able to report on subjective experiences. A limitation to HR and HRV measures is that they lack precision around discrete emotions such that they may be a better indicator of emotional arousal in general, such that they are unable to differentiate anger versus sadness, for example. Furthermore, physiological measurements alone do not provide information on if or how those physiological states affect an individual's perception of their own emotions.

The empirical evidence on the relationship between HR and HRV in individuals with BPD is mixed. In accordance to the Biosocial Theory (Linehan, 1993) which posits higher emotional sensitivity and reactivity in individuals with BPD, higher observations of basal HR are often hypothesized and has been observed in several studies (Kuo, Fitzpatrick, Metcalfe, & McMain, 2016). In contrast to this theory, a portion of the literature has actually found *lower* baseline HR in BPD individuals as compared to healthy controls (Austin, Riniolo, & Porges, 2007; Kuo & Linehan, 2009; Lobbestael et al., 2009; Weinberg, Klonsky, & Hajcak, 2019; Schmahl et al., 2004). In studies of reactivity, including exposure to emotional or stressful stimuli, BPD individuals have been found to have significantly increased HR as compared to healthy controls, but only for negative valenced stimuli (Herpertz, Kunert, Schwenger, & Sass, 1999). This effect failed to replicate in similar studies, however (Herpertz et al., 2000; Kuo et al., 2016; Sauer et al., 2016).

Further, due to BPD's association with severe difficulties in emotion regulation, BPD individuals are also hypothesized to show inadequate parasympathetic responses and therefore, lower HRV and basal RSA. Several studies have found evidence to support this hypothesis (Kuo & Linehan, 2009; Weinberg et al., 2009; Kuo et al., 2016), but there are also a number that have failed to find differences in basal HRV or RSA in individuals with BPD (Ebner-Priemer et al., 2015; Meyer et al., 2016). There has also been evidence to suggest that meaningful HRV differences may only be present in the context of situations that require regulation, such as being presented with emotional clips. Several studies have demonstrated increased HRV reactivity in response to emotional stimuli in BPD samples (Austin et al., 2007; Kuo et al., 2016; Fitzpatrick & Kuo, 2015). However, studies have also found no evidence of reactivity differences (Kuo & Linehan, 2009; Kuo et al., 2016; Daros et al., 2018). Dixon-Gordon, Turner, Rosenthal, & Chapman (2017) found that HRV decreased in BPD participants when they used suppression regulation strategies, but increased when they used acceptance-based strategies, implying physiology may differ with how one engages with the stimuli. In the treatment literature, there are also mixed results. Very minimal research has been done on how physiological measures change in persons with BPD following treatment; however, a pilot study using several forms of modified DBT intervention showed that individuals with BPD had decreases in their baseline HRV following treatment, counter to their hypothesis (Dixon-Gordon, Chapman, & Turner, 2015). However, improvements in baseline HRV have been seen to occur following treatment in other mental disorders associated with difficulties in emotion regulation (Aubert-Khalfa, Roques, & Blin, 2008;

Blanchard et al., 2002; Cyranowski, Swartz, Hofkens, & Frank, 2009; Steffen, Fidalgo, Schmuck, Tsui, & Brown, 2014).

Physiological measurements provide objective indicators of emotion regulation, both in reactivity and regulatory processes; however, they do not capture the subjective experience of the individual and are incapable of differentiating one emotion from another. Therefore, the information they provide is limited to states of arousal and recovery, which may or may not correspond with subjective levels of reactivity, distress, or access to regulatory skills. Furthermore, the mixed results in the literature imply that single measures of emotion regulation in BPD individuals may not be capable of capturing dysfunction in every individual, and therefore to capture those unique disruptions in emotion regulation difficulties, an examination of emotion profiles using multiple measures is required.

Use of Multi-Method Approaches to Emotion Regulation

Despite the recognition that emotion regulation involves a full system response, most studies rely on a single measurement approach when studying emotion regulation, which as discussed earlier, does not always correspond with other measurement indicators of emotion regulation. While the use of multi-method approaches is increasing, there remain few studies that have directly compared the correspondence of methodologically different measures of emotion regulation even when multiple measurements are used. Additionally, while the main focus of this dissertation is on BPD, there is little research that has examined and directly compared multiple measures of emotion regulation in BPD samples, and therefore, the literature reviewed here includes studies that focused on normative samples and other diagnostic categories other

than BPD when relevant. Further, while the studies reviewed here use multiple methods, many do not explicitly examine the degree of correspondence among the emotion regulation measures, and therefore correspondence is inferred based on whether the measures show the same effects. In this next section, empirical findings that have examined the relationship between two or more methodologically different measures of emotion regulation are reviewed.

Self-Report and behavior measures

Comparing the correspondence of behavioral and self-report measures can demonstrate whether an individual's subjective experiences of their own emotions and experiences have observable effects on behavior and activity; however, the evidence on this is mixed. Several studies have examined the correspondence between self-report measures and behavioral measures in individuals with BPD. Gratz, Rosenthal, Tull, Lejuez, & Gunderson (2006) found that self-reported DERS and AAQ were correlated with behavior on a distress tolerance task, such that higher emotion dysregulation and lower acceptance of distressing emotions resulted in faster task termination times, demonstrating correspondence between self-report and behavior. However, these results were not replicated in a different study using the same task and measures (Iverson, Follette, Pistorello, & Fruzzetti, 2012). Sauer et al., (2016) reported that while BPD participants self-reported using more maladaptive emotion regulation strategies, their actual use of the effective vs. maladaptive strategies in a behavior experiment did not differ from healthy controls, potentially demonstrating lack of correspondence between self-report and behavior. A recent empirical article examined the relationships between self-report and behavioral measures of self-regulatory processes in a normative sample

using an extensive battery of standard behavioral and self-report measures of self-regulation in over 500 participants (Eisenberg et al., 2019). Results demonstrated that the measures showed little empirical relationship despite putatively measuring the same construct. While this study did not examine BPD specifically, it provides strong evidence that measures of the same construct do not inherently correspond with each other and that single measures may only capture a piece of the more extensive emotion regulation system. Emotion regulation profiles may help determine why some studies find correspondence between self-report measures and behavior measures of emotion regulation, and others do not.

Physiological measures correspondence with other measures

Correspondence between physiological and self-reported emotion regulation has also shown inconsistent relationships in the literature. Aleknaviciute et al., (2016) found that individuals with BPD reported subjective mood disturbances but experienced blunted HR reactivity, a physiological indicator of functional emotion responding, in response to the Trier Social Stress Test. Rosenthal et al., (2016) reported that BPD individuals, as compared to healthy controls, endorsed higher self-reported arousal to unpleasant stimuli and demonstrated heightened skin conductance responses, though this relationship was not tested directly. There was also no significant differences in heart rate or behavioral differences in expressive facial responses. Kuo et al. (2016) used a multi-method approach to examine emotion regulation abilities in individuals with BPD using physiological, behavioral, and self-report measures. They found that while individuals with BPD differed from healthy controls in baseline HR and HRV, those differences were not present during reactivity tasks. Differences were also not present in self-reported

emotion reactivity or behavioral performance in the implementation of effective regulation strategies. However, Kuo et al., (2016) did not test the correspondence among these measures directly, and therefore, further research is needed. While not BPD specific, Mauss et al. (2005) found that while the correspondence across physiology and subjective experiences was mixed, individual differences seemed to predict the correspondence. This highlights the potential of person-centered approaches to reveal patterns among measures that may be meaningful.

A prominent gap in the BPD emotion regulation literature is studies examining the correspondence among different measures of emotion regulation and dysregulation. Many of the studies that have examined multiple measures of emotion regulation do not test the relationship directly or have failed to find correspondence in the measures, typically showing deficits in one methodology but not the other. Furthermore, the evidence reviewed in this dissertation so far has shown that even within a single measure, there may be inconsistent findings within a BPD sample. Despite this mixed evidence, each of these studies has reported differences in emotion regulation in a BPD sample for at least one type of measurement. Taken together, this suggests that individuals with BPD do experience difficulties with emotion regulation; however, the patterning by which these difficulties can be observed across various emotion regulation measurement approaches appears to vary. Further, the variations across these measurement approaches may be meaningful, as has been demonstrated by others (Chesney & Gordon, 2017; Eftekhari, Zoellner & Vigil, 2007). Using a multi-method approach to examine profiles of *emotion regulation* as well as *emotion dysregulation* in a sample in which half of the participants have elevated BPD symptoms, this study will be able to identify profiles

based on patterns of covariation among emotion regulation measures. As stated earlier, examining emotion regulation and emotion dysregulation profiles with a BPD sample is advantageous given that emotion regulation difficulties are a hallmark feature of BPD as well as many other disorders for which BPD highly co-occurs. Identifying emotion regulation profiles at a single time point represents a first step toward considering the extent to which emotion regulation profiles moderate treatment response.

Specific Aims and Hypotheses

This dissertation will examine emotion regulation and emotion dysregulation using a multi-method approach in a sample of women with elevated BPD and healthy controls. Tests will be conducted on the full sample but then also within the BPD sample only. While the main focus of this dissertation is on differences between women with and without BPD symptoms, there is little research that has examined and directly compared multiple measures of emotion regulation within BPD samples, and therefore characterizing those relationships specifically, significantly contributes to the literature. Further, examining the full sample may obscure variable relationships or profiles that are only present in dysregulated samples. Measures of emotion dysregulation will include self-report measures—DERS, DBT Ways of Coping Checklist and physiological measures—baseline HR, and HRV reactivity. Emotion regulation measures will include self-report measures – Acceptance and Action Questionnaire, behavioral indicators of emotion regulation inhibitory function through the Stroop task, and physiological indicators of emotion regulation through baseline HRV and reactivity HR. The aims and study hypotheses for this study are:

Aim 1a. Compare women with BPD versus non-disordered controls on all emotion regulation and emotion dysregulation scores.

This study will compare measures of physiology, self-report, and behavioral measures of emotion regulation and dysregulation across the BPD group and non-disordered controls. Descriptive statistics (M, SDs) will be reported, and independent sample t-tests will be used to compare means in our sample of 105 women. In the field, these measures are theorized to differ between groups; however, the research reviewed here has shown mixed findings on the differences between BPD groups and non-disordered controls on measures of emotion regulation, with consistent differences observed in self-report measures but inconsistent differences in the other methodologies.

Hypothesis 1a: I hypothesize that there will be significant differences between groups on self-report measures of emotion regulation and dysregulation; however, there will not be differences in physiological or behavioral measures.

Aim1b. Examine the correspondence across self-report, behavioral, and physiological measures of emotion regulation and emotion dysregulation in the entire sample and then compare associations in BPD women versus non-disordered controls.

The study then examines the correspondence of these measures using correlations for the whole sample and then, separately among each group. Because these measures are all putative measures of emotion regulation they are theorized to correlate, however, as reviewed in this dissertation, deficits in emotion regulation can be observed in some domains and not others, and therefore the relationships among these variables will likely vary both for the full sample and within the BPD group. While no differences in the relationships among variables are expected within the BPD group only, I will examine

them separately as there may be relationships within a dysregulated sample that are obscured when looking at the full sample.

Hypothesis 1b: I hypothesize that there will be small to moderate correlations among self-report measures of emotion regulation and dysregulation and among physiological measures as well; however, I hypothesize that self-report, physiological, and behavioral measures will not correlate across methods.

Hypothesis 2b: I hypothesize that correlations within the BPD group will show the same relationships among variables as the full sample.

Aim 2. Identify profiles of emotion regulation and emotion dysregulation using latent profile analyses with the entire sample and then within group.

I will conduct a latent profile analysis of emotion regulation measures and emotion dysregulation measures to examine the unique profiles generated by the observed relationships between measurement methods. I will do this for the entire sample, and then I will examine the BPD group separately to determine if profiles differ in number and nature for BPD persons. The relationships among variables may be different within dysregulated samples, which may lead to more unique profiles.

Hypothesis 1a: I hypothesize that three profiles of emotion regulation will be identified across the whole sample – a profile in which persons generally score high on each measure, a profile in which persons generally score low on each measure and a profile in which persons generally score in the middle of each measure.

Hypothesis 1b: I hypothesize that three profiles of emotion dysregulation will be identified across the whole sample – a profile in which persons generally score high on

each measure, a profile in which persons generally score low on each measure, and a profile in which persons generally score in the middle of each measure.

Hypothesis 1c: I hypothesize that by examining the BPD group separately, we will identify additional profiles of emotion regulation and dysregulation than the three hypothesized above. Particularly, I hypothesize that there will be profiles in which persons score high on measures of emotional reactivity (e.g., baseline HR, HR reactivity) but low on measures of regulation (e.g., DERS, HRV, DWCL-Skills).

Aim 3. Examine the relation between emotion regulation and dysregulation profiles with mental health symptoms.

Emotion regulation and dysregulation profiles will be examined in relation to mental health symptoms (i.e., depression, anxiety, suicide behaviors) using multivariate regression to determine the extent to which specific symptoms are associated with the probability of belonging to a particular profile.

Hypothesis 1: Higher levels of clinical symptoms will predict greater probability of belonging to profiles that indicate lower levels of emotion regulation and profiles that indicate higher levels of emotion dysregulation.

Methods

Data for this dissertation was obtained from a two-site R01 randomized clinical trial underway at the University of Oregon and University of Pittsburgh Medical Center. This two-site study is investigating maternal BPD and its effects on preschool children. Details for the present study and not the larger R01 are described below. Additionally, because this study did not involve children, no child procedures or measure details are described. Because of the R01's study aims, women were recruited based on BPD status

or non-disordered control status (no mental health diagnoses) and who were mothers with at least partial custody of a preschool-aged child. Thus, all participants in this sample are constrained to these criteria.

Participants

Participants were 105 women ranging in age between 22-47 years old (*M*=32.94 (5.04)). Fifty women were classified as participants with elevated BPD, and 55 participants were classified as non-disordered controls. The distribution of total annual income of this sample in quartiles and the racial and ethnic composition of participants in this sample are detailed in Table 1. Sixty percent of the women recruited to the BPD group met full criteria for BPD. Their clinical profiles, including current disorders and disorders present in the past three years, are summarized in Table 2 and self-reported clinical symptom measures in Table 3.

Table 1. Demographic characteristics

	Total Sample	BPD group (n=50)	Non-Disordered Controls (n=55)
Age – M(SD)	32.94(5.04)	32.47(1.15)	33.73(1.49)
Income (%)			
$22,310 or less	25%	79%	21%
Between $22,311 and $30,044	14%	47%	53%
Between $30,045 and $37,777	7%	71%	29%
Between $37,778 and $45,510	13%	50%	50%
Between $45,111 and $53,243	3%	0%	100%
Between $53,244 and $60,976	4%	25%	75%
Between $60,977 and $76,441	4%	25%	75%
More Than $76,442	24%	24%	76%
Ethnicity (%)			
African American	21%	73%	27%
Asian	1%	0%	100%
Caucasian	75%	43%	57%
Latino	4%	50%	50%
Pacific Islander	1%	100%	0%
Other	2%	50%	50%

Table 2. Clinical profiles for BPD participants (n=50)

Current disorder	
Major depressive disorder	42 % (*n* = 21)
Bipolar disorder	10 % (*n* = 5)
Panic disorder	10 % (*n* = 5)
Social anxiety	18 % (*n* = 9)
Agoraphobia	8 % (*n* = 4)
Obsessive compulsive disorders	6 % (*n* = 3)
Post-traumatic stress disorder	24 % (*n* = 12)
General anxiety disorder	28 % (*n* = 14)
Substance use disorder	24 % (*n* = 12)
Alcohol use disorder	10 % (*n* = 5)
Borderline personality disorder	60% (*n*= 30*)*
Any other personality disorder	52 % (*n* = 26)
Met disorder since conception with 3-4-year-old	
Major depressive disorder	90 % (*n* = 45)
Bipolar disorder	16 % (*n* = 8)
Panic disorder	26 % (*n* = 13)
Social anxiety	34 % (*n* = 17)
Agoraphobia	18 % (*n* = 9)
Obsessive compulsive disorders	14 % (*n* = 7)
Post-traumatic stress disorder	62 % (*n* = 31)
General anxiety disorder	50 % (*n* = 25)
Substance use disorder	58 % (*n* = 29)
Alcohol use disorder	32 % (*n* = 16)

Table 3. Descriptive statistics and group differences for symptoms of psychopathology

	n	Total Sample	BPD group (n=50)	Non-Disordered Controls (n=55)	Statistics
Anxiety (HAM-A)**	103	11.98(10.81)	20.98(8.79)	3.81(3.49)	$t(101)=-12.79$, $p<0.001$
Depression (PHQ-9)**	84	8.06(7.00)	13.53(5.44)	2.32(2.16)	$t(55)=-12.32$, $p<0.001$
Suicide Behaviors (SBQ-4)**	84	5.25(3.1)	7.05(3.39)	3.37(0.92)	$t(48)=-6.87$, $p<0.001$

** *Significant at the 0.001 level (2-tailed)*

Participants were recruited from community sources, including a developmental database maintained by the psychology department, craigslist, and local mental health agencies and services. Social media and public mailings were also used to recruit interested participants. Parent R01 eligibility criteria included that the participant was 18 years or older, had no current psychosis or a psychosis-related diagnosis, and was not currently experiencing suicidal ideation with an active suicide plan. Participants were also considered ineligible if they had an IQ score lower than 70 as measured by the Peabody Picture Vocabulary Test-IV (PPVT; Dunn & Dunn, 2007).

Procedures

Experimental procedures in this study and the larger R01 were approved by the Institutional Review Board at both the University of Oregon and the University of Pittsburgh, as well as, reviewed by the study's Data Safety and Monitoring Board.

Participants initially completed a phone screen in which they were screened for initial eligibility. During the phone screen participants were administered the McLean Screener (Zanarini et al., 2003) and were retained if they endorsed 7 or more items, including affective instability and/or anger, or if they endorsed 2 or fewer items. Participants who scored 7 or higher on the McLean screener were also administered the PAI-BOR-AI and were retained if they scored above two standard deviations.

Participants were then scheduled for a clinical intake assessment to determine study eligibility. Consent was obtained prior to participation in the clinical intake. Clinical intakes were conducted by trained staff and supervised by a licensed clinical psychologist. During the clinical intake, participants were administered the Structured Clinical Interview for the DSM5 (SCID-5) and the Structured Interview for Personality

Disorders (SIDP). Participants needed to meet one of two sets of eligibility criteria: elevated BPD symptoms or non-disordered controls.

Elevated BPD Group: Participants who met criteria for elevated BPD were required to have endorsed at least three symptoms of BPD on the SIDP in which one of those symptoms were required to be ‘uncontrollable anger' or ‘affective instability.'

Non-Disordered Control Group: Participants who met criteria for the non-disordered control group did not meet criteria for elevated BPD or any other disorders. Specifically, participants were required to endorse no symptoms of BPD to be eligible.

After participants were assessed and determined eligible, participants were scheduled for an assessment session. Participants were assessed in laboratories at the two universities. Participants' consent was secured prior to participating in the assessment. At the assessment appointment, participants completed tasks and self-report measures in the presence of a research team member in the lab. Self-Report measures were administered via an online Qualtrics Survey, and a research assistant administered behavioral tasks. Participants were also fitted with a heart rate monitor for a portion of the tasks.

Participants were compensated $40 for the initial intake screening appointment and $40 for their assessment appointment.

Measures

Measures were classified as indices of either emotion regulation or emotion dysregulation and are summarized in Table 4. for the total sample and by BPD or non-disordered controls.

Table 4. Descriptive statistics and group differences for emotion regulation and emotion dysregulation measures

	n	Total Sample	BPD group (n=50)	Non-Disordered (n=55)	Statistics
Emotion Regulation					
AAQ**	105	48.35(15.49)	34.95(9.93)	60.53(7.45)	$t(103)=15.01$, $p<0.001$
Baseline HRV	75	6.50(1.00)	6.41(1.16)	6.56(0.87)	$t(58)=0.68$, $p=0.5$
DWCL-Skills	105	1.88(0.49)	1.84(0.49)	1.92(0.49)	$t(102)=0.83$, $p=0.41$
HR Reactivity	68	5.94(8.33)	5.7(9.54)	6.11(7.43)	$t(71)=1.00$, $p=0.32$
Stroop	50	55.52(6.32)	55.76(6.51)	55.28(6.24)	$t(48)=-0.27$, $p=0.79$
Emotion Dysregulation					
Baseline HR	75	73.16(11.56)	72.21(14.32)	73.9(8.93)	$t(73)=0.881$, $p=0.38$
DWCL -Dys**	105	1.51(0.71)	2.07(0.3)	1.00(0.54)	$t(97)=-11.78$, $p<0.001$
DERS**	105	77.89(30.81)	101.42(25.31)	56.49(16.36)	$t(83)=-10.69$, $p<0.001$
HRV Reactivity	68	0.28(1.05)	0.28(0.82)	0.28(1.21)	$t(66)=-0.03$, $p=0.98$

** *Significant at the 0.001 level*

Emotion Regulation

Self-Report - Acceptance and Action Questionnaire. Emotional flexibility, an index of emotion regulation, was measured using the Acceptance and Action Questionnaire (AAQ; Bond et al., 2011), a 10-item self-report measure which asks participants to rate how true statements related to acceptance of undesirable thoughts and feelings are for them on a scale of 1 (never true) to 7 (always true). Higher scores reflect greater emotional and psychological flexibility. Within our sample, the AAQ demonstrated excellent reliability (Cronbach's a=.94).

Self-Report - DBT Ways of Coping Checklist – DBT Skills Subscale. The DBT Ways of Coping Checklist (DWCL; Neacsiu et al., 2010) is a 59-item self-report questionnaire used to measure the frequency of emotion coping skills use over the past 30 days. Items were rated on a scale of 0 (never used) to 3 (regularly used), and a skills-use

index score was produced by averaging across all items. The measure yields two subscales designed to distinguish the use of functional versus dysfunctional skills usage-DBT Skills (DWCL-Skills) and Dysfunctional Coping (DCWL-Dys). The DWCL-Skills subscale was used as a measure of emotion regulation. Higher scores represent higher implementation of effective skills use. Within our sample, the DWCL-Skills subscale was found to have excellent reliability (Cronbach α=.95).

Behavioral - Stroop Color/Word Task. Inhibitory regulation skills were assessed using the Stroop Color and Word Test (Stroop, 1935), which consists of timed trials of Word Reading, Color Naming, and Color-Word Interference. A score for each trial was calculated based on the number of words or colors named correctly in 45 seconds. An interference score, which reflects an ability to inhibit automatic semantic processing, was calculated by subtracting participants' *predicted* Color-Word score (derived from participants' Color and Word scores) from participants' actual Color-Word score (Golden & Freshwater, 2002). Interference scores were then converted to T-scores to produce a continuous score (ranging 21-80) in which higher scores reflect greater cognitive control.

Physiological measures. HR and HRV were collected and used as a physiological index of emotion regulation, specifically baseline HRV and HR reactivity. Data was acquired following MindWare data acquisition system guidelines for the mobile recording units (MindWare Technologies, Inc., Gahanna, OH). Disposable Ag-AgCl electrodes were placed on participants' right clavicle and left and right rib, and the mobile recording unit was clipped to their pants pocket. HR and HRV scores were quantified using the spectral analysis method (range set at.12-.42; Berntson et al., 1997) with Mindware HRV analysis software and expressed in units of $\ln(ms^2)$. After data

acquisition, the data was visually inspected to detect and correct artifacts also following Mindware guidelines. HR and HRV were calculated for 30-sec epochs, and values were only recorded if there was at least 50% of useable data.

Baseline HR and HRV were collected while participants sat alone quietly reading a magazine for 5 minutes. Participants were instructed to sit quietly with their feet flat on the floor and to refrain from moving around. Higher baseline HRV indicates increased emotion regulation.

As an emotional reactivity task, participants completed a task with their children in which they were instructed to complete a complex Lego figure together, using a figure generally considered too complicated for the child to complete independently (adapted from Kerig & Lindahl, 2001). Mothers were instructed to use only verbal commands while helping the child and were asked not to touch any of the pieces. Experimenters left the room while dyads worked on the task and returned 5 minutes later. HR reactivity was calculated by subtracting baseline HR values from the HR value during the reactivity task. Higher HR reactivity is associated with higher cognitive ability (Ginity, Phillips, Der, Deary, & Carroll, 2011; Seery, 2011) and therefore is being used as an index of greater emotion regulation abilities here.

Emotion Dysregulation

Self-Report - Difficulties in Emotion Regulation Scale. Emotion dysregulation was assessed using the Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004). The DERS is a 36-item self-report measure in which participants respond to statements using a scale of 1 (almost never) to 5 (almost always) to rate how true a statement is for them. Total scores range from 0 to 180, with higher scores indicating

higher levels of dysregulation. Six subscales comprise the total score: lack of emotional awareness, lack of emotional clarity, limited emotion regulation strategies, difficulties with impulse control, difficulties engaging in goal-directed behavior, and nonacceptance of emotional responses. The DERS has demonstrated adequate validity and good reliability (Gratz & Roemer, 2004), and in the present study, scale reliability had a Cronbach's alpha of 0.97.

Self-Report - DBT Ways of Coping Checklist – Dysfunctional Coping Skills Subscale. The DBT Ways of Coping Checklist, as described above, also has a Dysfunctional Coping (DWCL-Dys) subscale. The DWCL-Dys was used as a measure of emotion dysregulation in our sample. Higher scores indicate higher use of dysfunctional coping skills. The DWCL-Dys subscale had excellent reliability within our sample (Cronbach α=.93).

Physiological measures. Baseline HR, as described above, indicates higher emotional sensitivity, and therefore, is used here as an index of emotion dysregulation. Higher baseline HR is associated with higher dysregulation. HRV reactivity was collected in the stressor task described above. HRV reactivity was calculated by subtracting baseline HRV values from the average HRV values during the reactivity task. Greater increases in HRV from baseline to the emotion task indicates emotion dysregulation; therefore, higher reactivity HRV indicates greater dysregulation.

Mental Health Symptoms

Anxiety. The Hamilton Anxiety Scale (HAM-A; Hamilton, 1969) is a 14-item measure that assesses physical symptoms of anxiety. The HAM-A was completed by participants as a self-report measure in the present study, though it is commonly

completed as an interview. Participants rated the severity of symptoms ranging from 0 (Not present) to 4 (Very Severe). Scores were summed for a total score ranging from 0 to 56, with higher scores indicating higher levels of anxiety. Scores ranging from 14-24 are indicative of mild or moderate anxiety, and scores above 25 are considered severe anxiety. The HAM-A has demonstrated sufficient reliability and concurrent validity (Maier, Raimund, Philipp, & Heuser, 1988) and within this sample demonstrated excellent reliability (Cronbach α=.92).

Depression. Depression was measured using the Patient Health Questionnaire - depression module (PHQ-9; Kroenke, Spitzer, & Williams, 2001), a 9-item self-report questionnaire in which participants rate how often a symptom has bothered them in the past 2 weeks on a scale of 0 (Not at all) to 3 (Nearly every day). Scores were summed for a total score ranging from 0 to 27 with higher scores indicating higher levels of depressed mood. Scores of 10 or higher have been associated with major depression. In addition, the PHQ-9 has demonstrated reliability and validity as a measure of depression (Kroenke, Spitzer, & Williams, 2001) and within this sample demonstrated excellent reliability (Cronbach α=.92).

Suicide Behaviors. Suicide ideation and behavior were assessed using the Suicide Behaviors Questionnaire-Revised (SBQ-R; Osman et al., 2001) a 4-item self-report measure. The SBQ-R asked participants to report on suicidal thoughts using a variety of scales with higher scores indicating higher levels of symptoms. The SBQ-R total scores range from 3 to 18, with 8 indicating higher levels of suicide ideation and behaviors. The SBQ-R has demonstrated good criterion-related validity and acceptable internal

consistency (Osman et al., 2001). In this sample, reliability statistics showed a Cronbach's alpha of 0.77.

Missing Data

There was no missing data for self-report measures. Stroop data was not attainable from one of the two sites and therefore, available for only half of the participants (n=50). Cases were dropped from analyses when applicable.

Baseline physiological data was missing for 30 participants, and reactivity data was missing for 37 participants due to hardware malfunction, significant data artifacts, or participants declining to wear the physio-monitors. In some cases, a measure of dyadic baseline HR and HRV that was obtained while mothers and children watched a 5-minute TV show clip was available to use in place of the mother only baseline (n=6). Further, some participants did not have data at the initial assessment but had data available from a later assessment (4 months after 1st assessment) collected by the R01 that was could be used (n=5). Otherwise, cases were dropped from relevant analyses.

Analytic Plan

Study variables were assessed for skew and kurtosis. All variables were found to be under 3.0 kurtosis and [0.9] skewness except for baseline HR (kurtosis=4.873, skew=1.28) and reactivity HR (kurtosis=4.243, skew=-0.939). A log transformation was performed on each of these variables to reduce skew, and transformed variables were used for the remaining analyses.

First, the correlations among the emotion regulation and the emotion dysregulation variables were examined for the full sample and then by group.

Differences in means were also compared between groups using independent samples t-tests.

Latent profile analysis (LPA) was then conducted to identify emotion regulation and emotion dysregulation profiles in our sample using Mplus 8.3 (Muthén & Muthén, 1998–2017). To further examine if profiles were more diverse or more numerous for clinical samples, profiles were first identified for the whole sample and then examined for BPD participants only. Beginning with a two-class model, the number of classes was increased iteratively until the best classification was identified. The number of classes that best fit the model was determined by examining information criterion statistics including Bayesian information criterion (BIC, Schwarz, 1978), sample-adjusted Bayesian information criterion (SABIC; Sclove, 1987), and Akaike information criterion (AIC, Akaike, 1973), with decreasing statistics suggesting an improved model. Entropy was furthered examined, with values approaching one suggesting superior class identification (Celeux & Soromenho, 1996). Finally, profiles that were based on less than 10% of the sample were considered a poor fit. The resulting profile probabilities were then used in regression analyses to identify which mental health symptoms may predict which profile an individual belongs in.

Results

Differences Between Groups: BPD Versus Non-Disordered Controls

First, we examined if groups differed from each other significantly on the emotion regulation and dysregulation measures. Groups significantly differed from each other on most measures of self-report (i.e., AAQ, DERS, and DWCL-Dys). However, there were no significant differences found when comparing groups on the physiological measures

(HR, HRV) or the behavioral measure (Stroop; See Table 4). Finally, the groups significantly differed across all symptom measures (Table 3).

Correlations among Emotion Regulation and Dysregulation Variables

Correlations were examined among variables classified as emotion regulation measures for the full sample (Table 5). Baseline HRV was negatively correlated with HR reactivity, $r(68)= -0.335$, $p=.005$. None of the remaining emotion regulation measures were significantly related to each other. When examining relationships among variables classified as emotion dysregulation within the full sample, DERS was found to positively correlate with DWCL-Dys, $r(105)=0.778$, $p<0.001$. None of the remaining emotion dysregulation variables were found to be significantly related to each other. Across emotion and dysregulation measures, self-report measures tended to correlate negatively with each other, and physiological measures tended to correlate with each other both positively and negatively (see Table 5).

Table 5. Correlations among emotion regulation and dysregulation measures

Measure	1	2	3	4	5	6	7	8	9
1. AAQ									
2. DWCL-Skills	.1								
3. Baseline HRV	.09	.07							
4. HR Reactivity	.15	-.02	-.34*						
5. Stroop	-.1	.01	.12	-.14					
6. DERS	-.87**	-.26*	.001	-.05	.12				
7. DWCL-Dys	-.85**	.12	-.04	-.02	.09	.78**			
8. Baseline HR	.03	.07	-.45**	.71**	-.07	-.1	-.02		
9. HRV Reactivity	.04	.07	-.47**	.28*	-.29	-.07	-.02	.03	

Note. The red box highlights correlations among emotion regulation measures; blue is emotion dysregulation measures.

** Correlation significant at the 0.05 level (2-tailed)*

*** Correlation significant at the 0.001 level (2-tailed)*

Next, correlations were examined within groups to understand if the relationships between emotion regulation or emotion dysregulation measures differed based on clinical vs. normative status. For emotion regulation measures, there was a significant inverse relationship between baseline HRV and HR reactivity for the BPD group only, $r(29) = -0.431$, $p=0.02$, and not for non-disordered controls, $r(39) = -0.236$, $p=0.149$. No other significant relationships were found for either group for remaining emotion regulation variables. For both non-disordered controls, $r(55)=0.557$, $p<0.001$, and the BPD group, $r(50)=0.534$, $p<0.001$, only DERS and DWCL-Dysfunctional Coping Skills were found to be significantly correlated for emotion dysregulation measures.

Descriptively, when considering the pattern of correlations among the full sample compared to the correlations presented by groups, it suggests that clinical vs. normative status does not significantly change the relationships between these variables. That is, these measures do not relate more strongly for one group over another.

Latent Profile Analyses

Latent profile analysis was conducted for emotion regulation measures and emotion dysregulation measures, first for the full sample, and then within the BPD sample only. Full information maximum-likelihood estimation was used to account for missing data. Therefore all profile analyses of the whole sample were conducted with 105 cases, and all profile analyses of the BPD group were conducted with 50 cases.

Emotion regulation profiles – full sample

Three latent emotion regulation profiles were identified for the entire sample (see Figure 1.). While statistics changed only slightly between a three-class model and a four-class model, the three-class model was chosen over the four-class model due to the

slightly improved statistics and the small participant sizes of the four-class model (see Table 6).

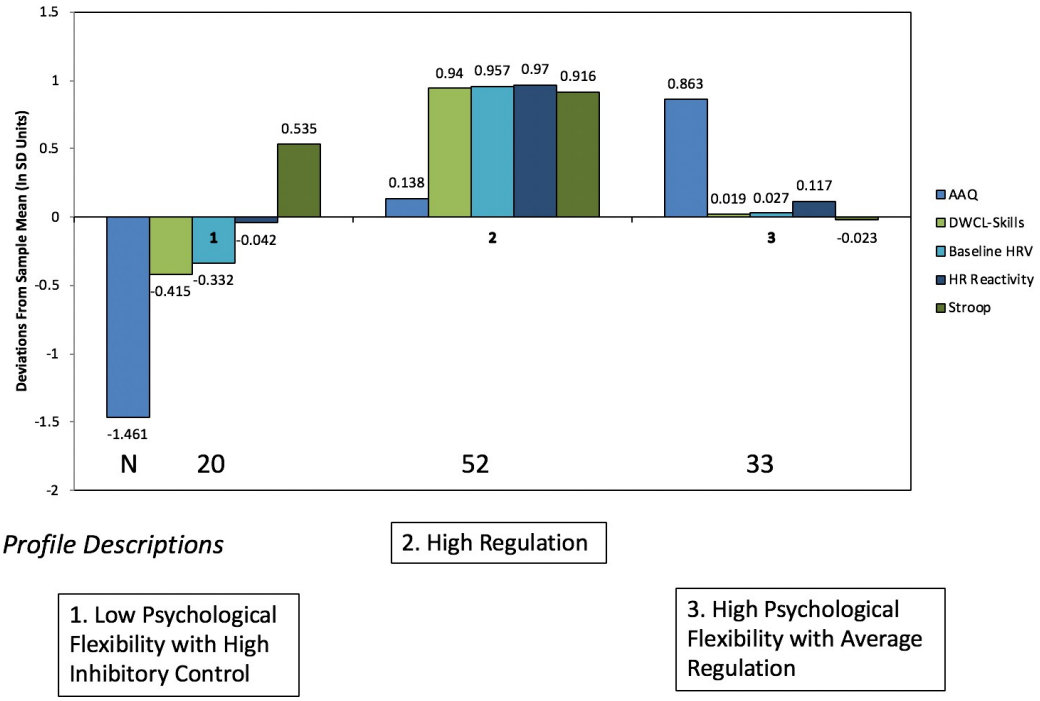

Figure 1. Three-class model of emotion regulation profiles for the full sample.

Table 6. Summary of information criterion measures for latent profile analyses of emotion regulation measure profiles for the full sample

No. Classes	BIC	AIC	Sample Adjusted - BIC	Entropy
2	1204.72	1162.257	1154.173	0.794
3	**1214.761**	**1156.374**	**1145.259**	**0.84**
4	1232.712	1158.401	1144.255	0.803
5	1255.696	1255.696	1148.284	0.71

In the three-class solution, Profile 1 (*n*=20) was characterized by levels at or slightly lower than the sample means for physiological measures of emotion regulation and use of skills, with particularly low psychological flexibility and a slight increase in Stroop score compared to other participants. This profile is described as *Low*

Psychological Flexibility with High Inhibitory Control. Profile 2 (*n*=52) was characterized by generally higher levels of emotion regulation across measures and might be considered as a *High Regulation* group. Profile 3 (*n*=33) was characterized by levels generally at the mean of the sample, with superior levels on the AAQ. This profile group might be described as *Average Regulation with High Psychological Flexibility.* Means and standard deviations for each profile are displayed in Table 7.

Table 7. Means and standard deviations for emotion regulation profiles for the full sample

	n	AAQ	Baseline HRV	DWCL-Skills	HR Reactivity	Stroop
Profile 1	20	25(5.24)	6.23(0.94)	1.67(0.43	1.82(8.28)	57.71(5.73)
Profile 2	52	61.85(5.43)	6.55(0.97)	1.89(0.5)	3.57(14.54)	56(6.9)
Profile 3	33	41.23(5.26)	6.65(1.06)	1.99(0.48)	7.2(7.82)	54.09(6.26)

Probabilities of emotion regulation profile membership were then correlated with mental health symptoms and tested for group differences. Participants who were more likely to be in the *Low Psychological Flexibility with High Inhibitory Control* profile (Profile 1) reported significantly higher levels of anxiety ($r(103)=0.62$, $p<0.001$), depression ($r(84)=0.66$, $p<0.001$), and suicide behaviors, $r(84)=0.49$, $p<0.001$). BPD participants ($M=0.41(0.43)$) were significantly more likely to belong to this profile than non-disordered controls ($M=0.002(0.02)$), $t(49)= -6.68$, $p<0.001$, equal variances not assumed.

Participants who were more likely to be in the *High Regulation* profile (Profile 2) reported significantly less levels of anxiety ($r(103)= -0.77$, $p<0.001$), depression ($r(84)= -0.76$, $p<0.001$), and suicide behaviors, $r(84)= -0.55$, $p<0.001$). Non-disordered controls

(*M*=0.89(0.28)) were significantly more likely to belong to this profile compared to BPD participants (*M*=0.06(0.18)), *t*(103)=17.52, *p*<0.001, equal variances assumed.

Finally, participants more likely to be in the *High Psychological Flexibility with Average Regulation* profile (Profile 3) reported higher anxiety (*r*(103)= 0.37, *p*<0.001), depression (*r*(84)= 0.31, *p*<0.001), and trended towards reporting higher suicide behaviors (*r*(84)=0.21., *p*=0.053). BPD participants (*M*=0.53(0.41)) were more likely to belong to this profile than non-disordered controls (*M*=0.11(0.28)), *t*(85)= -6.18, *p*<0.001, equal variances not assumed.

Emotion dysregulation profiles – full sample

Four latent emotion dysregulation profiles were identified for the entire sample (see Figure 2.). A four-class model was chosen over a three or two-class model because of its improved information criterion and entropy. While information criterion continued to improve slightly in a five-class model, some group sizes begin to drop below 10% of the sample; therefore, a four-class model was chosen as the best fit (see Table 8).

Profile 1 (*n*=34) was characterized by below-average dysregulation levels for self-report measures and average dysregulation levels for physiological measures. This profile might be considered the *Low Subjective Dysregulation* group. Profile 2 (*n*=30) was characterized as levels within less than half a standard deviation away from the sample mean on all measures of dysregulation. This profile might be considered the *Average Dysregulation* group. Profile 3 (*n*=14) was characterized by particularly high levels of self-reported dysregulation and around average levels of dysregulation as captured by physiological measures. This profile might be considered the *High Subjective Dysregulation* group. Profile 4 (*n*=27) was characterized by moderately

higher levels of dysregulation on self-report measures and average physiological levels. This profile might be considered the *Moderate Subjective Dysregulation* group. Means and standard deviations for each profile are displayed in Table 9.

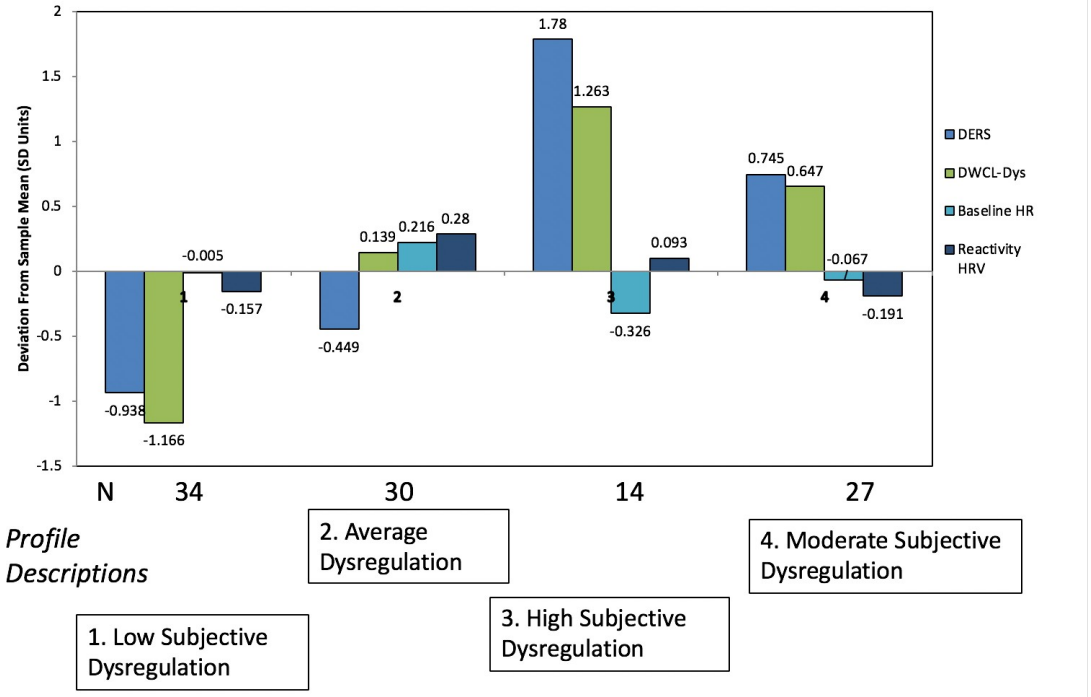

Figure 2. Four-class model of emotion dysregulation profiles for the full sample.

Table 8. Summary of information criterion measures for latent profile analyses of emotion dysregulation measures profiles for the full sample

No. Classes	BIC	AIC	Sample Adjusted - BIC	Entropy
2	957.267	922.765	916.197	0.904
3	942.607	894.836	885.742	0.862
4	**933.49**	**872.449**	**860.829**	**0.887**
5	932.178	857.867	843.721	0.839

Table 9. Means and standard deviations of emotion dysregulation profiles for the full sample

	n	DERS	DWCL-Dys	Baseline HR	HRV Reactivity
Profile 1	34	48.94(8.99)	0.67(0.33)	73.19(7.52)	-0.55(2.59)
Profile 2	30	64.33(8.68)	1.63(0.33)	74.86(10.25)	0.39(1.32)
Profile 3	14	132.71(10.58)	2.43(0.19)	70.49(13.47)	0.03(0.92)
Profile 4	27	100.97(8.6)	1.96(0.14)	75.59(16.44)	-0.68(2.8)

Probabilities of emotion dysregulation profile membership were then correlated with mental health symptoms and tested for group differences. Participants who were more likely to be in the *Low Subjective Dysregulation* profile (Profile 1) reported significantly lower levels of anxiety ($r(103)= -0.63$, $p<0.001$), depression ($r(84)= -0.59$, $p<0.001$), and suicide behaviors, $r(84)= -0.42$, $p<0.001$). Non-disordered controls ($M=0.6(0.43)$) were significantly more likely to belong to this profile than BPD participants ($M=0.02(0.13)$), $t(64)= 9.48$, $p<0.001$, equal variances not assumed.

Participants who were more likely to belong to the *Average Dysregulation* profile (Profile 2) were not significantly associated with anxiety ($r(103)= -0.19$, $p=0.06$), depression ($r(84)= -0.12$, $p=0.07$), or suicide behaviors, $r(84)= -0.06$, $p=0.57$). Non-disordered controls ($M=0.35(0.42)$) and BPD participants ($M=0.22(0.4)$) did not differ significantly in their probability of belonging to this profile, $t(103)=1.63$, $p=0.11$, equal variances assumed.

Participants that were more likely to belong to the *High Subjective Dysregulation* profile (Profile 3) reported significantly higher levels of anxiety ($r(103)= 0.49$, $p<0.001$), depression ($r(84)= 0.49$, $p<0.001$), but not suicide behaviors ($r(84)=0.17$, $p=0.12$). BPD

participants (M=0.26(0.42)) were more likely to belong to this profile than non-disordered controls (M=0.02(0.13)), $t(58)$= -3.87, p<0.001), equal variances not assumed.

Finally, participants that were more likely to belong to the *Moderate Subjective Dysregulation* profile (Profile 4) reported significantly higher levels of anxiety ($r(103)$= 0.46, p<0.001), depression ($r(84)$= 0.39, p<0.001), and suicide behaviors ($r(84)$=0.35, p=0.001). BPD participants (M=0.51(0.47)) were more likely to belong to this profile than non-disordered controls (M=0.04(0.19)), $t(63)$= -6.63, p<0.001, equal variances not assumed.

Crosstabulation of emotion regulation and emotion dysregulation – full sample

A crosstabulation table was created to observe profile membership across emotion dysregulation and emotion dysregulation (Table 10). Individuals that belonged to the *Low Psychological Flexibility with High Inhibitory Control* (Emotion Regulation Profile 1) profile belonged to either the *High Subjective Dysregulation* (Emotion Dysregulation Profile 3) or the *Moderate Subjective Dysregulation* (Emotion Dysregulation Profile 4) profile. Members of the *High Regulation* (Emotion Regulation Profile 2) profile belonged either to the *Low Subjective Dysregulation* (Emotion Dysregulation Profile 1) or *Average Dysregulation* (Emotion Dysregulation Profile 2) profile. Members of the third Emotion Regulation Profile, *High Psychological Flexibility with Average Regulation,* had members spread across all emotion dysregulation profiles except for the *Low Subjective Regulation* (Emotion Dysregulation Profile 1) profile.

Members of the *Low Subjective Regulation* (Emotion Dysregulation Profile 1) exclusively belonged to the *High Regulation* (Emotion Regulation Profile 2) profile. The *Average Dysregulation* (Emotion Dysregulation Profile 2) members belonged to either

the *High Regulation* (Emotion Regulation Profile 2) or the *High Psychological Flexibility with Average Regulation* (Emotion Regulation Profile 3) profile. Neither the *High Subjective Dysregulation* (Emotion Dysregulation Profile 3) nor the *Moderate Subjective Dysregulation* (Emotion Dysregulation Profile 4) profile had members that belonged to the *High Regulation* (Emotion Regulation Profile 2) profile. Both, however, had members who belonged to either the *Low Psychological Flexibility with High Inhibitory Control* (Emotion Regulation Profile 1) or the *High Psychological Flexibility with Average Regulation* (Emotion Regulation Profile 3) profile.

Table 10. Crosstabulation of emotion regulation and emotion dysregulation profiles for the full sample

	Emotion Regulation			
Emotion Dysregulation	1	2	3	Total
Profile 1	0	34	0	34
Profile 2	0	18	12	30
Profile 3	10	0	4	14
Profile 4	10	0	17	27
Total	20	52	33	105

Emotion regulation profiles – BPD sample only

Two latent profiles of emotion regulation were identified within the BPD sample (Figure 3.). Adding a third class increased BIC and AIC statistics, but decreased SABIC, though marginally. Because the information criterion did not clearly improve by adding a third class and the third profile contained less than 5% of the sample, the two-class model was chosen as the best fit, though entropy is particularly low in this model (see Table 11).

Profile 1 (*n*=19) was characterized by low levels of regulation on self-report measures, average heart rate levels, and high behavior levels compared to the BPD sample means. Members of this group might be considered as *BPD Low in Psychological Flexibility with High Cognitive Control.* Profile 2 (*n*=31) was characterized by sample mean average levels of emotion regulation measures, with low levels of psychological flexibility. This profile might be considered *Average BPD Regulation.* Means and standard deviations for each profile are displayed in Table 12.

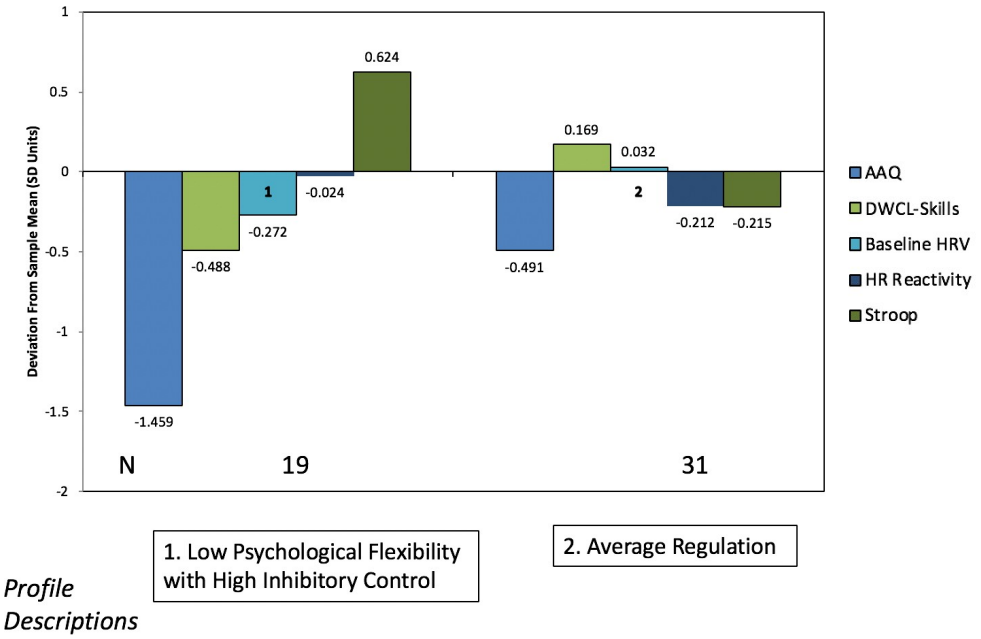

Figure 3. Two-class model of emotion regulation profiles for BPD only.

Table 11. Summary of information criterion measures for latent profile analyses of emotion regulation measures profiles for BPD group only

No. Classes	BIC	AIC	Sample Adjusted - BIC	Entropy
2	**563.794**	**533.202**	**513.573**	**0.637**
3	579.006	536.941	509.951	0.781

Table 12. Means and standard deviation of emotion dysregulation profiles for BPD group

	n	AAQ	DWCL-Skills	Baseline HRV	HR Reactivity	Stroop
Profile 1	19	24.68(5.19)	1.65(0.43)	6.33(0.92)	3.97(4.21)	60.29(6.47)
Profile 2	31	41.24(6.12)	1.95(0.49)	6.46(1.31)	6.76(11.68)	54(5.77)

Profile membership probabilities were then correlated with symptom measures to test for associations. Those who were more likely to be in the *BPD Low in Psychological Flexibility with High Cognitive Control* profile (Profile 1) tended to report higher levels of anxiety ($r(49)= 0.35.$, $p=0.01$) and depression ($r(43)= 0.39$, $p<0.001$), but had no significant association with suicide behaviors ($r(43)=0.26$, $p=0.09$). Those who were more likely to belong to the *Average BPD Regulation* profile (Profile 2) were less likely to experience anxiety ($r(49)= -0.35.$, $p=0.01$) and depression ($r(43)= -0.39$, $p<0.001$), but had no significant association with suicide behaviors ($r(43)= -0.26$, $p=0.09$).

Emotion dysregulation profiles – BPD sample only

Two latent emotion dysregulation profiles were identified for the BPD sample (Figure 4.). A two-class model was selected over the three-class model because the change in information criterion was only slight, but entropy was larger for the two-class model, and the three-class model had a group with less than 5% of the sample (see Table 13).

Table 13. Summary of information criterion measures for latent profile analyses of emotion dysregulation measure profiles for BPD group only

No. Classes	BIC	AIC	Sample Adjusted - BIC	Entropy
2	**393.224**	**368.367**	**352.419**	**0.839**
3	395.485	361.068	338.986	0.703

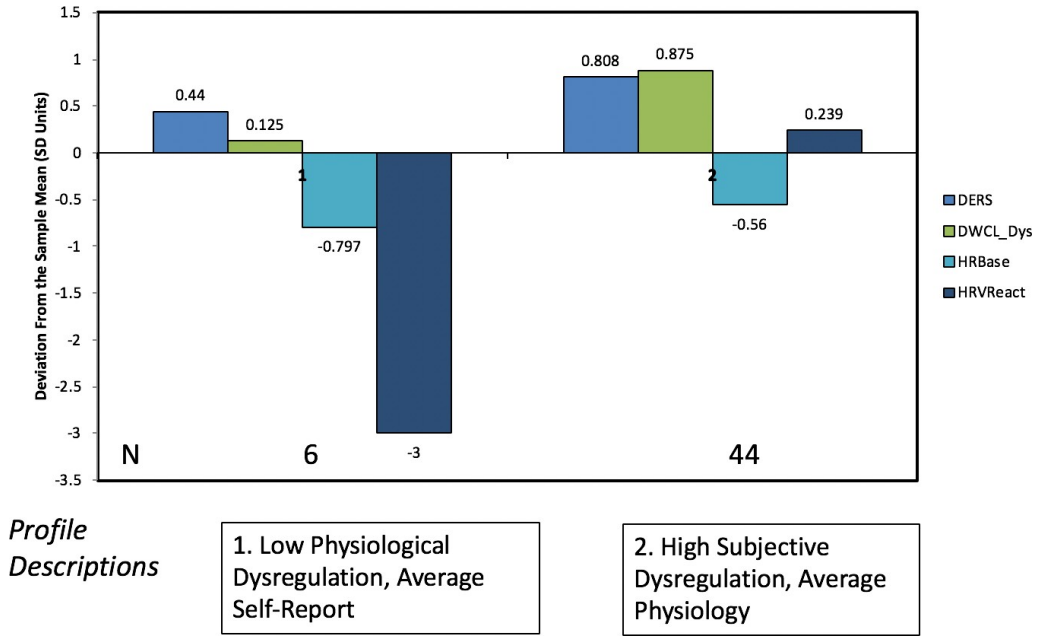

Figure 4. Two-class model of emotion dysregulation profiles for BPD only.

Profile 1 (*n*=6) was characterized by average BPD levels for self-report measures of emotion dysregulation and levels lower than the BPD sample mean for heart rate measures, with notably decreased HRV reactivity. This profile might be considered *Low Physiological regulation with Average Self-Report*. Profile 2 (*n*=44) was characterized by higher self-reported dysregulation and average measures of physiology within the BPD sample. This profile might be considered *High in Subjective Dysregulation, Average Physiology.* Means and standard deviations for each profile are displayed in Table 14.

Table 14. Means and standard deviations of emotion dysregulation profiles for BPD group

	n	DERS	DWCL-Dys	Baseline HR	HRV Reactivity
Profile 1	4	94(23.76)	1.48(0.42)	64.67(7.7)	-6.69(0.97)
Profile 2	66	102.43(25.6)	2.15(0.3)	72.97(14.68)	0.31(0.85)

Profile membership probabilities were then correlated with symptom measures to test for associations. Probability to belong to the *Low Physiological regulation with Average Self-Report* profile (Profile 1) was not significantly associated with anxiety ($r(49)= -0.12.$, $p=0.31$), depression ($r(43)= 0.86$, $p=0.58$), or suicide behaviors ($r(43)=0.27$, $p=0.08$). Probability to belong to the *High in Subjective Dysregulation, Average Physiology* profile (Profile 2) was also not significantly associated with anxiety ($r(49)= 0.12.$, $p=0.31$), depression ($r(43)= -0.86$, $p=0.58$), or suicide behaviors ($r(43)= -0.27$, $p=0.08$).

Profile Relations to Mental Health Symptoms

Multivariate general linear model tests were then used to test the predictive power of mental health symptoms on profile membership. As the probabilities of profile membership are not independent and are best captured through g-1 (where g is the number of groups), one profile was removed from each test to reduce redundancy. Anxiety, depression, and suicide behaviors were used as predictors in each analysis, and profile probabilities were examined as dependent variables. For emotion regulation profiles, higher symptoms of depression predicted probability of membership for the *Low Regulation with High Inhibitory Control* (Profile 1) profile, $\beta=.027$, $t=3.47$, $p=.001$, and higher anxiety symptoms predicted probability of membership to the *Average Regulation with High Psychological Flexibility* (Profile 3) profile, $\beta=.016$, $t=2.34$, $p=.02$. For emotion dysregulation profiles, no symptom measures significantly predicted probability of membership to the *Average Dysregulation* (Profile 2) profile or the *Moderate Subjective Dysregulation* (Profile 4) profile. Higher symptoms of depression, $\beta=.018$, $t=2.15$, $p=.04$, and anxiety, $\beta=.011$, $t=2.05$, $p=.04$ and lower symptoms of suicide

behaviors, β= -.025, t= -1.95, p=.05, indicated trends towards probability of membership for the *High Subjective Dysregulation* (Profile 3) profile.

Discussion

It is recognized that emotion regulation is a multifaceted construct involving dynamic systems and processes and therefore necessitates a multi- measurement approach to capture these complexities (Gross, 2015). It is also well established that emotion regulation is a transdiagnostic symptom of psychopathology that plays a prominent role in disorders such as BPD, and as such is an important target of intervention (Sloan et al., 2017). However, it is less well understood how different measures of emotion regulation correspond with one another and how these variations among the measures may form unique emotion regulation profiles that may be meaningful in the understanding and treatment of mental disorders. The present study aimed to examine how different measures of emotion regulation and dysregulation may differ between a BPD sample compared to non-disordered controls, how these various measures may correspond with one another, and if there are identifiable patterns among the variations in these measures that constitute unique emotion regulation or dysregulation profiles. By using a multi-method approach in which the relationships among these measures are directly tested, this study expands the field's understanding of emotion regulation more broadly. Further, by examining the patterns of variation in emotion regulation measures, this study advances scientific knowledge regarding this transdiagnostic feature of psychopathology. This knowledge will contribute to the long-term goal of understanding how these variations may be used to predict symptom severity or prognosis and to inform and improve psychological treatment.

Overview of Findings

Broadly, results of this study demonstrate a lack of correspondence among measures of emotion regulation and dysregulation which suggests that emotion regulation may optimally be understood using multi-measure or person-centered approaches rather than single-measure or variable-centered approaches. When compared directly, many measures of emotion regulation did not correspond, even within measurement type (i.e., all self-report measures or all physiological measures). The degree of correspondence between measurement types did not differ when examining disordered versus non-disordered samples separately. Findings of this study also demonstrated that emotion regulation and dysregulation varied between BPD versus non-disordered controls only as measured through self-report and not the physiological or behavioral measure. While more recent empirical work generally supports the study findings (Bortolla, Cavicchioli, Fossati, & Maffei, 2018), they are not consistent with the longstanding theories in the field that posit that BPD individuals would be highly emotionally reactive, presumably observed across all methodologies. The lack of group differences across some measures then may suggest that individuals with BPD may be highly variable in the domains they experience emotion regulation disturbances in and highlights the need for further research on individual differences of these measures.

Person-centered profile analyses revealed distinct profiles for emotion regulation and emotion dysregulation measures providing preliminary evidence that there may be meaningful patterns in the variations of correspondence among these measures. Three latent profiles of emotion regulation were identified, and four latent profiles of emotion dysregulation. These profiles differed in their relationships with mental health symptoms

such that profiles indicative of higher functioning were negatively correlated with mental health symptoms, profiles that were characterized by average emotion regulation or dysfunction were associated with a more varied pattern of relationship of mental health symptoms, and profiles characterized by more deficient emotion regulation or more significant emotion dysregulation were positively associated with mental health symptoms. Taken together, these findings suggest that unique patterns among emotion regulation measures may form distinct emotion regulation profiles that appear to be meaningful in understanding the relationship between emotion regulation capabilities and psychopathology. It also suggests that multi-method approaches are useful towards gaining insight into if and how an individual experiences difficulties with emotion regulation. Further, this study's findings of both a lack of correspondence among measures and a lack of group differences also calls for further consideration of the construct validity of these measures.

Relationships among Variables and Differences between Groups

The first aim of this study was to compare women with BPD versus non-disordered controls on emotion regulation and emotion dysregulation measures and then to examine the correspondence across self-report, physiological, and behavioral measures of emotion regulation and emotion dysregulation for the full sample and then within BPD participants only. Independent sample t-tests were conducted to examine group differences. Results of these mean comparisons revealed that group differences were only present among the self-report measures, which supported the study's hypothesis. These findings are consistent with the literature which has generally shown consistent differences in BPD samples and non-disordered controls on self-report measures

(Axelrod et al., 2011; Gratz et al., 2006; Silvers et al., 2016), but mixed findings when testing the differences of physiological measures and behavioral measures between groups (Bortolla et al., 2018; Carr, de Vos, & Saunders, 2017). However, these results do not match the theorized differences commonly proposed in the field, which has hypothesized differences across all measures used in this study.

One explanation for these lack of group differences may be related to a fault in the underlying theory behind the hypothesized differences. Much of the research has based their theories of emotional responding in BPD population off of Linehan's biosocial theory (Linehan, 1993), which emphasizes emotion reactivity in individuals with BPD. Recent research, however, has failed to find support for this theory and has generally shown null to small differences in physiological and behavioral measures within the BPD literature (Bortolla et al., 2018). However, another explanation may be that individuals with BPD are emotionally reactive but that this reactivity is particularly sensitive to context and only occurs in the presence of negative emotion, social stressors, or other relevant environmental contexts, as opposed to the general reactivity that is often induced in laboratory settings. Indeed, literature has found that deficits in behavioral measures are sometimes only observable after negative emotion induction (Chapman, Dixon-Gordon, Layden, & Walters, 2010; Peters, Upton, & Baer, 2013), and other research has shown reactivity differences are more consistently shown when interpersonal emotional stimuli are used (Dixon-Gordon Chapman, Lovasz, & Walters, 2011; Sauer, Arens, Stopsack, Spitzer, & Barnow, 2013). It may also be that the variable comorbidity and diverse range of mental health symptoms that an individual with BPD

may experience affects how and what disruptions in emotion regulation may occur. This is a theory that should be tested in future research.

To test the correspondence among emotion regulation and dysregulation measures, I examined correlations for the full sample. The study hypothesized that measures of the same methodology (i.e., all self-report measures or all physiological measures) would correlate with each other, but not across methods. In partial support of the hypothesis, self-report measures tended to correspond with each other and some of the physiological measures correlated with each other, though not all self-report nor all physiological measures correlated with each other. No correlations were found across methods. This aligns with the literature that has shown inconsistent relationships among measures of emotion regulation at the bivariate level (Gratz et al., 2006; Iverson et al., 2012; Visted et al., 2017). Correlations within groups were also examined and, descriptively, neither group showed greater correspondence than the other. The lack of correspondence in the non-disordered group is not in line with research in the field which has shown some evidence that higher coherence of self-report and physiological indices of emotion regulation is associated with well-being and thus may be suspected to occur in non-clinical groups (Brown et al., 2019).

The most commonly posited rationale for the observed lack of correspondence is that each of these indices evaluates different processes of emotion regulation and that these may operate through separate systems (Bradley & Lang, 2000). This also implies that these systems operate independently of each other, such that an individual can feel emotionally activated but have no physiological response or have increased heart rate and HRV but experience no subjective distress. Different measures may be sensitive to

different dimensional aspects of emotion regulation (i.e., valence, arousal) and therefore not always strongly related to each other (Mauss & Robinson, 2009). This is an important consideration for variable-centered research investigating emotion regulation. Unless researchers are only interested in a single response system of emotion regulation, there is limited inference that researchers can make about emotion regulation broadly when using a single measure (Larsen & Prismic-Larsen, 2006). Furthermore, relationships may exist among these measures, but they may not be linear or easily interpreted. Person-centered methods that examine the patterning in variation among these variables may help reveal relationships that are otherwise obscured in variable centered approaches.

A final consideration for explaining both the lack of group differences and lack of correspondence on these measures is that one or more of these variables may not have adequate construct validity. While there is theoretical evidence to support that these measures may be related to emotion regulation functioning, it remains possible that a measure may capture only related activity and not aspects of the emotion regulation system itself. The Stroop, for instance, is not a measure of emotion regulation, but of inhibitory control, which has been recognized as a related aspect of emotion regulation but is not a direct measure (Eisenberg & Zhou, 2016). Heart rate physiology may, similarly, capture activity related to emotion regulation processes but may not be a direct index of emotion regulation abilities generally. This may explain the lack of correspondence among measures, as well as, the variable findings in the field that sometimes show group difference and sometimes do not. Further consideration on the measures used as emotion regulation indices is warranted.

Latent Profiles of Emotion Regulation

The second aim of this study was to examine latent profiles of emotion regulation and emotion dysregulation measures hypothesizing that each will yield three profiles – low, average, and high. Latent profile analyses (LPA) were conducted to examine these emotion regulation profiles for the whole sample and then within the BPD group only. In partial support of the study hypotheses, three latent emotion regulation profiles were identified for the full sample. Also, as expected, the profiles identified were characterized by individuals scoring low on measures, average on measures, and high on measures. Emotion regulation profiles were also examined for the BPD only sample, and two unique profiles were identified, which is in contrast to the study hypotheses, which predicted more variation in BPD profiles of emotion regulation. Each of the profiles and its possible interpretation is described below.

The *Low Psychological Flexibility with High Inhibitory Control* (Profile 1) profile generally demonstrated lower than average emotion regulation scores, indicating more difficulties with emotion regulation. The exception to this was that this profile generally had scores of inhibitory control that were above the mean of the full sample. All of the members of this profile were from the BPD group. Typically, low inhibitory control would be theorized in individuals with BPD because it is thought to be associated with more difficulties in emotion regulation, as well as, with impulsivity, another prominent symptom of BPD (Domes et al., 2006; Fertuck et al., 2006). In contrast to this theory, evidence has been amassing that generally shows that individuals with BPD do not exhibit inhibitory performance deficits (LeGris, Links, van Reekum, Tannock, & Toplak, 2012; Rentrop et al., 2008; Sprock, Rader, Kendall, & Yoder, 2000). Therefore,

this study's findings that individuals with BPD may score low on emotion regulation measures in general but show no deficits in inhibitory control aligns with more emerging views within the current literature.

The *High Regulation* (Profile 2) profile was comprised of only non-disordered controls who generally scored high on all measures indicating increased emotion regulation abilities. These results match the literature in that higher scores on these measures have been associated with higher levels of functioning and well-being (Ginty, Phillips, Der, Deary, & Carroll, 2011; Neacsiu et al., 2010; Thayer, Hansen, Saus-Rose, & Johnsen, 2009; Thayer et al., 2012). Individuals in this profile tended to score approximately one standard deviation above the sample average on almost all measures of emotion regulation. The fact that nearly all healthy controls fell within this profile and scored high on these measures provides some evidence that these measures do capture aspects of a functioning emotion regulation system.

The last latent profile of emotion regulation measures, *High Psychological Flexibility, and Average Regulation* (Profile 3) tended to have scores close to the average of the full sample. Most members of this profile were from the BPD group. Interestingly, members of this profile tended to have significantly higher psychological flexibility as measured by the AAQ, which is counterintuitive to what would be expected in individuals with BPD. Part of this may stem from inherent problems with the measure, which has been shown to have questionable discriminant validity in the literature (Wolgast, 2014), and has suggested the AAQ items relate more to experiences of distress than to acceptance factors. When examining latent profiles of emotion regulation in the BPD group only, however, results showed a similar profile but scores closer to average

on psychological flexibility rather than higher, which may mean that the non-disordered controls in the full sample profile were contributing significantly to the higher AAQ mean.

The large portion of BPD individuals who belonged to this profile was unexpected. In fact, more than half of the BPD group belonged to this profile. A tendency for a portion of BPD individuals to fall in the average range of emotion regulation measures may help explain why there are such inconsistent findings in the literature, as well as, explaining why the current study did not find many significant differences between groups. This idea is somewhat supported by the literature in that closer examination of the cumulative BPD research findings (Bortolla et al., 2018; Rosenthal et al., 2008) has indicated that consistent differences are usually found in self-reports measures but are inconsistently observed in other measurement approaches. Another consideration in the interpretation of these results is the distinction between emotion regulation and dysregulation (Beauchaine, 2015). It's possible that individuals belonging to this profile score within the average range on measures of emotion regulation, but higher on emotion dysregulation measures. The way in which these individuals experience disruptions in the emotion regulation system may be observable only in observations of emotion dysregulation. This highlights the importance of including both types of measures in research.

Latent Profiles of Emotion Dysregulation

LPA revealed four latent profiles of emotion dysregulation. Only three profiles were hypothesized initially – profiles low, average, and high on measures of emotion dysregulation. These three profile types were identified in addition to a fourth profile

characterized by more moderate scores. When examining the BPD group only, only two profiles of emotion dysregulation were identified, which is counter to the study's hypothesis that BPD individuals may yield profiles characterized by less correspondence among measures. It is worth noting that physiological measures did not seem to differ much across profiles suggesting that the self-report measures were driving most of the differences in profiles. Each profile and possible interpretations are reviewed below.

The *Low Subjective Dysregulation* profile (Profile 1) had lower self-reported difficulties of emotion regulation and reported using less dysfunctional coping skills. Members of this profile were all non-disordered controls. This matches the literature which has shown control participants typically score lower on the DERS when compared to clinical populations (Ritschel et al., 2015; Silvers et al., 2016; Wilks et al., 2016); however only 34 participants belonged to this profile, meaning more than a third of non-disordered controls fall into other profiles of emotion dysregulation. This suggests that there may be more variability in emotion dysregulation profiles even among non-disordered individuals and that person-centered approaches are just as important for detecting individual differences in normative populations as it is for dysregulated populations. Overall this further suggests that these measures do not correspond linearly.

The second profile, *Average Dysregulation,* was composed of both BPD and non-disordered control participants, and neither group was more likely to belong to this profile than the other. One possibility for why these groups have individuals with the same emotion dysregulation profile but substantially different clinical symptoms is that the BPD participants in this profile may struggle with systems related more to emotion regulation rather than dysregulation, and therefore group differences are not observable

between these measures. It may also be that the BPD individuals in this group are not reliable reporters of their emotion dysregulation experiences. BPD has sometimes been associated with difficulties in emotional awareness (Levine et al., 1997) and may not have insight into their emotional deficits. Self-reports have occasionally been found to elicit negative emotions in reporters, and BPD individuals may be more prone to emotional avoidance leading to under-reporting on their emotional difficulties (Gratz et al., 2006; Rosenthal et al., 2008). Further, use of medications, cannabis use, dissociation, or other coping mechanisms may all have numbing effects that diminish the individual's experience of emotions (Krause-Utz & Elzinga, 2018).

The *High Subjective Dysregulation* profile (Profile 3) was characterized by subjective reports of increased difficulties with emotion regulation and subjective reports of using more dysfunctional coping skills and included only BPD group participants. The *Moderate Subjective Dysregulation* profile (Profile 4) is similar to this profile except that the elevation in the self-reported difficulties in emotion regulation and use of dysfunctional coping skills was not as pronounced. BPD participants were more likely to belong to this profile. This aligns with the literature that has generally demonstrated higher DERS scores in both BPD populations (Gratz et al., 2006; Silvers et al., 2016; Wilks et al., 2016) and clinical populations generally (Ehring & Quack, 2010; Mennin, Holaway, Fresco, Moor & Heimberg, 2007; Van Rheenen, Murray, & Rossell, 2015). That this profile is characterized by high subjective emotion dysregulation but average physiological responses, provides further evidence of the discordance between these measures.

Examining emotion dysregulation profiles of the BPD group identified only two latent profiles. The majority of individuals (n=44) fell within the profile that demonstrated high levels of self-reported dysregulation and a smaller number of participants fell within a profile that demonstrated average self-reports of dysregulation and notably decreased HRV reactivity (n=6). This generally indicates that individuals with BPD may not show a lot of variation in profiles of emotion dysregulation and usually tend to be characterized by high levels of subjective reports. Definitive conclusions cannot be made; however, as this sample is likely too small to evaluate meaningful variations across measures effectively. Further research will be needed with larger samples to determine if other profiles may emerge.

As a final note, physiological measures do not appear to be differing between profiles or corresponding with measures in general, and this calls for further consideration. The literature has shown inconsistent group differences on these measures. It is possible that cardiophysiology measures are not reliable indices of emotion dysregulation within this population and that other physiological measures, such as skin conductance response, may be more sensitive to physiological changes associated with emotion dysregulation (Bortolla et al., 2018). It may also be that our research design did not control for confounds that are necessary to observe these differences. Factors that have known to be associated with variation in cardiophysiology, such as the use of psychotropic medications (Ebner-Priemer et al., 2007), were not controlled for in the current study and may impact results.

Crosstabulation of Emotion Regulation and Dysregulation Profiles

A crosstabulation table of emotion regulation and dysregulation profiles was created to observe group membership across the two constructs. No statistical tests were conducted on this data, but descriptively, we see that individuals who belonged to the *High Regulation* profile tended to belong in either the *Low* or *Average* emotion dysregulation profiles. Individuals who belonged to the *Low Psychological Flexibility with High Inhibitory Control* profile belonged to either the *High* or *Moderate* emotion dysregulation profile. These two findings generally suggest that profile membership on both constructs is related such that if persons who are found to have high emotion regulation skills are likely to have low or average levels of dysregulation, and those who have higher emotion dysregulation will tend to have lower emotion regulation abilities. However, members belonging to the *High Psychological Flexibility with Average Regulation* profile were spread across the *Average, Moderate,* and *High* emotion dysregulation profiles. This finding demonstrates that individuals with average emotion regulation abilities may still experience dysfunction in emotion dysregulation domains. This in an interesting finding that may have implications for predicting symptoms or treatment response and further research is needed.

Latent Profiles and Mental Health Symptoms

The final aim of this study was to examine the relationships of mental health symptoms with the identified emotion regulation and emotion dysregulation profiles. Using a general linear model multivariate test, the study examined mental health symptoms as predictors of the likelihood of belonging to a particular profile. For emotion regulation profiles, when controlling for anxiety and suicide behaviors, higher

symptoms of depression predicted probability of membership for the *Low Regulation with High Inhibitory Control* profile. This is consistent with literature that has found relationships between depression (Joormann & Stanton, 2016) and difficulties in emotion regulation but is counter to research that has found deficits of inhibitory control in depression (Goeleven, De Raedt, Baert, & Koster, 2006; Joormann & Gotlib, 2009).

Controlling for depression and suicide behaviors, higher anxiety symptoms predicted probability of membership to the *Average Regulation with High Psychological Flexibility* profile. Generally, research has shown an inverse relationship between the AAQ and anxiety symptoms which is opposite to the effect observed here (Fledderus, Bohlmeijer, & Pieterse, 2010; Fledderus, Oude Voshaar, Klooster, & Bohlmeijer, 2012). Some research has demonstrated that higher levels of worry or rumination have been associated with greater productivity and functioning in school or work environments for some individuals (Sweeny & Dooley, 2017), and this may contribute to these results.

For emotion dysregulation profiles higher depression and anxiety symptoms and lower suicide behaviors were significant covariates in the probability of membership to the *High Subjective Dysregulation* profile. The association of higher depressive and anxiety symptoms supports current literature which shows links between these symptoms and high emotion dysregulation (Joormann & Stanton, 2016; Jazaieri, Morrison, Goldin, & Gross, 2015). Mental health symptoms were not predictive of other profiles.

Overall, investigating how mental health symptoms may be related to profiles of emotion regulation and dysregulation is an important area of research with implications for interventions. The investigations of profiles and mental health symptoms in this study were relatively exploratory and not adequately powered to test these effects efficiently.

Further research is needed with larger samples to examine these relationships thoroughly; therefore, these findings and interpretations should be treated as very preliminary.

Implications for Intervention

The findings that emotion regulation and dysregulation measures do not correspond has several important clinical implications. First, clinicians will need to consider that a client's self-report measures may not translate to other behavioral or physiological emotional responses. As subjective experiences do not always correlate with behavior or physiology, an individual may be experiencing distress while appearing calm and functional. Clinicians, therefore, should not assume a client is not experiencing distress based on appearance or report – this aligns with the common dialectic in BPD of apparent competence (Linehan, 1993), which is when an individual seems very capable or competent because they are generally functioning well, but they are actually experiencing much more difficulties with their emotional distress internally. When not addressed, this can exacerbate symptoms and lead to more problems.

Findings that unique profiles of emotion regulation and dysregulation can emerge when using multi-method approaches provides a potential way forward for research to investigate and understand why some individuals don't respond to treatment. Given that approximately 30% of individuals do not respond to treatment regardless of intervention type (Reuter et al., 2016; Westen & Bradley, 2005), this has a particularly important impact in its potential to improve the effectiveness of mental health treatment. Examining individual differences through emotion profiles affords the opportunity to utilize an individual's strengths and weaknesses within the treatment process.

Study Strengths

The current study provides several contributions to the literature on emotion regulation broadly and on BPD specifically. A primary strength of this study is the study population, which was recruited based on BPD symptoms. First, BPD is a disorder that is characterized by severe difficulties with emotion regulation (Linehan, 1993), making it an excellent population to examine emotion regulation disruptions. Second, BPD is often co-morbid with multiple diagnoses making it an ideal population to consider a transdiagnostic framework (Shah & Zanarini, 2018). In our sample, most of the BPD participants met full criteria for BPD and all off them endorsed clinically significant difficulties with either affective instability or uncontrollable anger. Further, we see a multitude of other disorders represented within the study sample, suggesting these results may generalize transdiagnostically.

As the BPD literature demonstrates mixed findings on several measures of emotion regulation (Bortolla et al., 2018; Rosenthal et al., 2008), including physiology and behavioral, this study expands the field's knowledge of the differences between BPD individuals and healthy controls by using a multi-method approach. Few studies have used a multi-method approach to examine emotion regulation differences in a BPD population, and fewer have tested the relationship between those measures directly. This study, therefore, furthers the field's understanding of how these measures correspond.

This study's use of person-centered approaches is also a strength. Examining profiles of emotion regulation may capture meaningful relationships among these variables that might otherwise be lost in traditional linear approaches. Also, while several studies have examined profiles of emotion regulation within the same measurement type,

such as self-report, to the best of this author's knowledge, this is the first study to examine emotion regulation profiles in adults using multiple measurement methods.

Limitations

The current study also had several limitations that should be considered when interpreting the results of this study and when considering future research on this topic. While some aspects of the sample were strengths of this study, there are also some limitations of the sample. The sample of this study was recruited from an ongoing R01 clinical trial on maternal BPD and its effects on their preschool children. As such, this study was constrained to the eligibility criterion of the R01, which included recruiting mothers of preschool-aged children. Though not expected, there may be something unique about how emotion regulation functions in mothers or particular ways they become dysregulated. Additionally, the sample was all women, limited this studies generalizability. Men may have different emotion regulation profiles and should be included in future samples. This study is also limited by its modest sample size of 105 women, which may have limited the power of this study to identify additional profiles. This could also have contributed to a lack of additional profiles identified when examining the BPD group only.

This study is also limited by the measures used in this study. While measures commonly used in the field were chosen for this study, there are many other measures as well as measurement types that were not used in this study. The current study examined three common methodological approaches to the study of emotion regulation – self-report, behavioral, and physiological, but there are many other measurement approaches that are providing further insight into the emotion regulation system such as

neuroimaging and endocrinology. Additionally, different measures of self-report, physiology, and behavior exist, and these results should be generalized to all measures within a single method until further studies are done. Different aspects about the measures we used may have also influenced results, such as if they measured emotion regulation at baseline or in response to emotional prompts. The Stroop was also used as a behavioral measure, but it is not generally considered an emotion regulation measure which may contribute to lack of correspondence between some measures. This study had a substantial amount of missing data, including having Stroop data for only half of participants. Heart rate data was also missing for about 25% of the sample.

Confounding variables may have also influenced the results of this study. This study did not control for the use of medication, a factor that has shown to have a significant impact on HRV (Ebner-Priemer et al., 2007) and may affect other aspects of emotional functioning. Medication use for mental health symptoms is common in BPD samples. About 75% of persons with BPD are estimated to be regularly taking psychotropic medications (Zanarini et al., 2004) so including individuals who are currently taking psychotropic medications increases external validity but may inversely affect internal validity. Treatment status was also not controlled for, and some women may have been participating in mental health services that affected the severity of their symptoms, as well as, emotion regulation functioning.

Finally, this study is limited by the diagnostic category and mental health symptoms examined in this study. The emotion regulation and emotion dysregulation profiles identified in this study and their relationships with mental health symptoms may be limited to a BPD sample only. Other profiles may emerge with other diagnostic

categories. Only three mental health symptoms were examined, and therefore, this study provides a limited understanding of how mental health symptoms relate to different emotion regulation profiles.

Future Directions

Findings of the current study provide support for the necessity of using multiple methods in the study of emotion regulation and the benefits of person-centered approaches. Specifically, results provide evidence for the lack of correspondence among emotion regulation measures, particularly across measurement type. (i.e., self-report, physiological, or behavioral). Further studies are warranted to replicate these findings and to examine the correspondence of other measures of emotion-regulation and different measurement methods (e,g, neuroimaging, hormones). To date, few studies have examined emotion regulation in a BPD sample using multiple levels of analysis, and even fewer have examined the relationships among those measures directly. Future studies are needed to broaden the scope of this research to directly test the relationships among different measures of emotion-regulation and in additional populations.

Findings of the current study also provide evidence for the benefit of using person-centered approaches to examine the individual differences in emotion regulation in a BPD sample. Additional studies are needed to examine emotion regulation profiles using other measures of emotion regulation and within more diverse samples, such as in men or women who are not mothers, as well as, within different diagnostic categories. Additionally, future studies using larger sample sizes are necessary to determine if there are additional profiles that this study was not able to reveal due to its modest sample size.

This study also examined emotion regulation profiles within the BPD group only, which did not reveal additional profiles that were not present in the full sample. However, the group size is particularly small for this type of analysis, and so results are not definitive, and future studies are needed within a much larger sample size to determine if there are different emotion regulation profiles unique to BPD individuals. Further, to tease out if the findings of this studies are unique to BPD or are more related to mental health problems in general, future research could test the differences between individuals with BPD and other co-occurring symptoms and individuals without BPD but who are matched on other mental health symptoms.

Emotion regulation profiles were examined in relation to mental health symptoms and provided some preliminary evidence that different profiles may be associated with particular symptoms. However, these profiles need to be examined with additional symptoms, as well as diagnostic profiles to determine if symptoms or diagnoses are associated with specific profiles of emotion regulation. This information could be informative in understanding an individual's particular struggles in emotion regulation, as well as what strengths they may have. This can then be used in treatment planning to tailor treatment to the individual, potentially improving overall treatment effectiveness.

Lastly, research should examine how emotion regulation profiles change following psychological intervention and whether changes in profiles are associated with subsequent reduction of other mental health symptoms. This could increase understanding of the mechanism of particular interventions by identifying what components of emotion regulation change with treatment. It may also determine if there

are profiles that respond differentially to treatment and if specific interventions are more effective than others on a given profile.

Conclusion

The current study makes several contributions to the literature. Through examining emotion regulation using multiple units of analysis, findings of this study provide empirical evidence of the lack of correspondence among emotion regulation measures, addressing critical gaps in the literature and answering several calls for further research (Fernandez et al., 2016; Kuo et al., 2016). In testing the relationships of these measures directly, this study provides novel findings on the relationships of these measures and expands on the emotion regulation literature as a whole. Self-report measures were found to generally correlate, as well as, some physiological measures, but measures did not correspond across methodologies. The discrepancy between the findings of the current study and the theoretical relationships purposed in the literature points to the need for further research employing multi-method approaches to understand the variations of dysfunction in the emotion regulation system. The findings that unique profiles of emotion regulation and dysregulation can be observed and the preliminary evidence that suggests these profiles could differentially relate to symptoms is an important finding that calls for further research using additional measures and across other diagnostic groups. The current study also contributes to the BPD emotion regulation literature, supporting findings of differences in self-report and providing further evidence of the lack of consistent difference in heart rate measures and inhibitory control.

Overall, these findings suggest that different processes within the emotion regulation system as a whole may vary in functioning, that emotion regulation profiles can demonstrate how different aspects of emotion regulation may relate meaningfully, and highlight the potential for these profiles to be used to understand psychopathology more broadly and inform the improvement and effectiveness of psychological treatment.

CHAPTER III

NEURAL CORRELATES OF EMOTION REACTIVITY AND EMOTION REGULATION IN BORDERLINE PERSONALITY DISORDER: A MULTI-METHOD APPROACH

Increased emotional reactivity and disturbances in regulatory processes of emotions have been identified as core to the pathology of borderline personality disorder (BPD; Linehan, 1993; Schmahl et al., 2014). This theoretical framework has resulted in a growing body of neuroimaging data on BPD populations, primarily examining two dynamic and interrelated domains of emotion regulation (ER): reactivity and regulation. Key neural deficits have been associated with these domains, including hyperactivity in limbic structures such as the amygdala and insula, as well as attenuated activity in prefrontal cortex, respectively. While BPD neuroimaging studies have examined both of these domains, there has been more a focus on the neural correlates of reactivity in BPD, and less on regulation.

Partly explaining the reason why neuroimaging studies may have focused more on reactivity is that Linehan's (1993) theory of emotion dysregulation in BPD particularly highlights the role of enhanced emotion sensitivity, also known as the hyperreactivity hypothesis in BPD. The neuroimaging literature has generally provided evidence in support of this theory. Interestingly, other measures of ER, such as physiological indicators and behavioral performance, have provided mixed evidence for this theory, suggesting that the evidence for the emotional reactivity hypothesis underlying BPD be reconsidered (Bortolla et al., 2018). However, this may partly be

explained in that ER is a complex construct that involves multiple response systems. Disruptions in one system may not be observed in another. To thoroughly understand how ER deficits manifest in BPD, a multi-method approach may be required. Little research has examined direct tests of the relationships of other ER measurement methods with putative neural correlates of ER, however. The present study addresses two gaps in the literature. First, it contributes to the limited number of BPD studies examining the neural correlates of regulation and second, this study will explore how additional measures of ER, including self-report, heart rate physiology, and behavioral tasks, may be associated with neural findings of ER.

Prior work has examined the neural correlates of emotion reactivity and regulation in BPD populations (see critical review van Zutphen, Siep, Jacob, Goebel, & Arntz, 2015). The majority of this research has focused on the hyperreactivity theory indicating that persons with BPD are particularly sensitive to emotional material as compared to healthy controls. Increased activity of the amygdala has been the most consistent finding in BPD studies of reactivity (Schulze, Schmahl, & Niedtfeld, 2015; van Zutphen et al., 2015). Several studies have not found differential reactivity activation in this region, however (Guitart-Masip et al., 2009; Koenigsberg et al., 2009). Studies of emotion regulation in BPD have showed less consistency, as hypothesized decreases in regulatory areas such as anterior cingulate and the medial and dorsolateral prefrontal cortex have been observed in some studies and not others (Koenigsberg et al., 2009; Lang et al., 2012; Schulze et al., 2011; Silvers et al., 2016).

The associations between ER neuroimaging measures and other measurement methods of ER within a BPD population have only recently been examined. Several

studies have found correspondence between self-reported trait ER (e.g., Difficulties in Emotion Regulation Scale, Affective Lability Scale) and theorized neural reactivity and regulation regions (Niedtfeld et al., 2010; Goodman et al., 2014; Silvers et al., 2016). For example, Silvers et al. (2016) found that self-report measures of affective lability and emotion regulation did not correlate with each other but did correlate with amygdala and Inferior Frontal Gyrus activity, respectively, suggesting that these different BPD features may have different neural substrates. However, several studies have found enhanced amygdala and insula effects but did not find group differences in subjective ratings of valence and arousal (Koenigsberg et al., 2009; Lang et al., 2012; Mier et al., 2013; Schulze et al., 2011). It may be that the neural activity in these regions reflects ER activity that is not captured in self-report either because participants are not aware of changes in their emotions or are not reporting them. Either way, this calls for further multi-method research so that the correspondence among these measures may be examined. Understanding how these various measures are related may have important clinical implications in terms of how ER is assessed and its role in the development and maintenance of BPD symptomology.

Neuroimaging studies have enhanced the understanding of ER mechanisms and underlying neural substrates in BPD; however, more is known about the neural correlates of emotion reactivity in BPD, and there is less research examining functional changes related to emotion regulation. Neuroimaging findings generally support the hyperreactivity theory of BPD, but other measures of ER in the field have shown mixed results. Currently, little research has examined the relationships of neuroimaging findings among different measurement methods of ER directly. As the field shifts to

examining individual differences, it becomes increasingly important to understand how additional measures of ER relate. These are both critical gaps in the literature that need to be addressed to improve both the assessment and treatment of BPD. As ER is a prominent transdiagnostic symptom of psychopathology (Sloan et al., 2017), these findings have implications for the understanding of psychopathology broadly.

The primary aims of this study are as follows:

1) Examine functional changes in neural networks associated with emotion reactivity and emotion regulation in women with and without BPD during a visual emotion task. BPD individuals, as compared to healthy controls, are hypothesized to show patterns of hyperreactivity, such as increased activation of regions associated with emotion reactivity (i.e., amygdala, posterior cingulate cortex), when viewing negatively valenced images, and demonstrate blunted activation in regions associated with inhibitory control (i.e, dorsolateral prefrontal cortex) when attempting to use regulation strategies in response to negative stimuli.

2) Examine the correlations between neural activity associated with reactivity (e.g., amygdala) and neural activity associated with regulatory processes (e.g., prefrontal cortex) and other measures of ER including self-report, behavioral, and physiology across the whole sample. Basing our hypotheses on the putative construct tested by the measures we would hypothesize increased activity in regions associated with reactivity to correlate with higher baseline HR, higher HR reactivity, higher reports of negative valence, and higher scores on the

DERS, and inhibited activity in regions associated with inhibitory control to correlate with poor performance on the Stroop measure, lower HRV reactivity, increased use of dysfunctional coping, and decreased use of regulatory skills.

Methods and Materials

We recruited 34 women to participate in this study. Two women were removed from the analyses because of scan malfunctions that resulted in a loss of data. Our final sample was 32 women, 17 in the BPD group, and 15 healthy controls. Participants for this study were a subgroup of women participating in a larger, longitudinal study on mothers with young children. These participants were recruited from several sources, including a department developmental database and community mental health and social service agencies.

To be enrolled in the longitudinal study, women needed to pass a phone screen, in which women had to either have high levels of BPD or few or no symptoms of BPD on the McLean Screener (Zanarini et al., 2003). Additionally, women needed to be the mother and have custody of a 3-year-old child. After passing the phone screen, participants completed a clinical intake to determine study eligibility, in which they were administered the Structured Clinical Interview for DSM-5 (SCID-5) and the Screening Instrument for Disorders of Personality (SIDP). Trained clinicians conducted all clinical intakes. To be eligible in the BPD group, women had to endorse 3 or more symptoms of BPD, one of which had to be either ‘uncontrollable anger' or ‘affective instability' and could not be actively psychotic or imminently suicidal. To be eligible as a healthy control, women could not meet criteria for any mental disorders since conceiving their 3-

year-old child, nor could they meet criteria for any BPD symptom. All participants completed the Peabody Vocabulary Test-IV (PPVT-IV; Dunn & Dunn, 2007) and had to score an IQ standard score of 70+. Finally, as part of the longitudinal study, all enrolled participants completed an initial assessment, of which self-report, behavioral and physiological emotion reactivity and regulation data on the women were collected and later shared with this study. Once enrolled in the longitudinal study, participants were informed about the fMRI study and invited to participate, after which they were screened for additional eligibility which included no history of neurological disorders and no conditions incompatible with magnetic resonance imaging (MRI).

Demographic data for the 34 women participating in this study are presented in Table 15. Eleven women met full criteria for BPD, and eight endorsed 3 or more symptoms. Participants were not asked to refrain from medications during this study, as such, 10 participants were currently taking psychotropic medications.

Table 15. Demographic characteristics

	Total Sample	BPD group (n=17)	Healthy Controls (n=15)
Age – M(SD)	33.03(5.32)	32.47(1.15)	33.73(1.49)
Income (n)			
$22,310 or less	9	9	0
Between $22,311 and $30,044	8	4	4
Between $30,045 and $37,777	4	0	4
Between $37,778 and $45,510	5	3	2
Between $45,111 and $53,243	1	0	1
Between $53,244 and $60,976	2	0	2
More Than $76,442	3	1	2
Ethnicity			
African American	2	2	0
Asian	2	1	1
Caucasian	30	16	14
Latino	1	1	1
Pacific Islander	1	0	1
Other	1	1	0

All procedures were approved by the Institutional Review Board of the University of Oregon. Participants provided written consent at each session. Participants were compensated at each component of the study as follows - $40 for the clinical intake, $40 for the lab assessment, $90 for the fMRI session.

Measures

Self-report, behavioral, and physiological measures were classified as either a measure of emotion reactivity or emotion regulation. See Table 16.

Table 16. Means and standard deviations for emotion reactivity and regulation measures

	Total Sample	BPD group (n=17)	Healthy Controls (n=15)
Emotion Reactivity			
Baseline HR	76.23(13.09)	78.68(17.35)	74.39(8.53)
HR Reactivity	6.23(9.78)	4.02(13.03)	7.83(6.56)
Affect Instability (PAIBOR-AI)**	6.29(4.22)	9.23(3.51)	2.94(1.57)
Anger (BP-Anger)**	18.88(7.93)	22.78(8.76)	14.5(3.56)
Emotion Regulation			
DBT-WCCL -Dys**	1.57(0.65)	2.04(0.31)	1.04(0.53)
DBT_WCCL-Skills	2.15(0.4)	2.06(0.39)	2.25(0.38)
DERS**	73.52(29.71)	94.26(24.15)	50.19(13.55)
Baseline HRV*	6.45(1.05)	5.99(1.16)	6.82(0.82)
HRV Reactivity	0.22(0.92)	0.31(0.73)	0.16(1.06)
Stroop	54.5(5.12)	55.06(5.86)	53.79(4.32)

**significant at p<0.05; **significant at p<.001*

Neuroimaging

To assess the putative neural changes of emotion reactivity and regulation, participants performed an established regulation paradigm to assess differences in emotion reactivity, emotion suppression, and cognitive reappraisal. Participants viewed neutral and negative images and were instructed to use one of three regulation strategies: View, Suppress, Reappraise. The View instruction asked participants to view the picture as they usually would, allowing any emotion or thought to arise. The regulation trials

asked participants to either Suppress, try not to feel or think anything at all, or Reappraise, try to decrease their emotional response by imagining the content of the image is not real or think objectively about the image as a detached observer.

Participants were presented the instruction, a single word in the center of the screen, for 2 seconds, followed by the image for 5 seconds, and then asked to rate their subjective levels of distress on a scale of 1-5 (5 being more negative) using a button pad response (See Figure 5). Prior to the scanning, all participants were trained on instructions for the various conditions and what their instructional cue will be. Participants were verbally tested on their understanding of the regulation strategies. Participants were further instructed to look at the picture the entire time and not avert their gaze.

Figure 5. Emotion regulation task design.

The stimuli were selected from the International Affective Picture System (IAPS) (citation) and were composed of 45 unique negative images (e.g., scenes of violence, threat, distress) and 45 unique neutral images (e.g., scenes of people in daily life). Images were selected based on their valence and arousal levels. Additionally, all images selected contained humans. There were 15 trials for each pairing of instruction and

stimuli type. There were two runs, and each run contained approximately equivalent pairings.

Physiological

Baseline HR and HRV were collected as participants sat quietly for 5 minutes reading a book or magazine. For a stressor task, heart rate was monitored while participants completed a task with their young child in which they were instructed to complete a dyadic Lego task shown to induce emotional frustration and stress (adapted from Kerig & Lindahl, 2001).

HR and HRV data were acquired with mobile recording units following MindWare data acquisition system guidelines (MindWare Technologies, Inc., Gahanna, OH). HRV scores were quantified using the spectral analysis method (range set at.12-.42; Berntson et al., 1997) with Mindware HRV analysis software and expressed in units of $\ln(ms^2)$. After data acquisition, the data was visually inspected to detect and correct artifacts also following Mindware guidelines. HR and HRV were calculated for 30-sec epochs, and values were only recorded if there was at least 50% of useable data.

HR and HRV reactivity scores were calculated by subtracting baseline HR and HRV from the average HR and HRV during the stressor task, respectively. As HR, has been indicated as an index of sympathetic nervous system activity, and HRV as an index of parasympathetic nervous activity, HR measures were considered a measure of reactivity where HRV measures were considered regulation.

Behavioral

Women completed a behavioral task of inhibitory control as measured by the Stroop Color-Word Task (Stroop, 1935). Interference scores were used as a measure of inhibitory control were converted to T-scores to produce a continuous score (ranging 21-80) in which higher scores reflect greater cognitive control. As inhibitory control has most commonly been associated with regulatory abilities, the Stroop was classified as a measure of emotion regulation in this study.

Self-Report

Several self-report measures were used to assess aspects of emotion reactivity and regulation. The Difficulties in Emotion Regulation Scale (DERS; Gratz & Romer, 2004) was used to assess trait emotion dysregulation, and the Dialectical Behavioral Therapy Ways of Coping Checklist (DWCL; Neacsiu et al., 2010) was used to assess the use of dysfunctional (DWCL-Dys) and effective (DWCL-Skills) regulation strategies. The Personality Assessment Inventory – Borderline Features Scale Affective Instability subscale (PAIBOR-AI; Morey, 1994) and the Buss Perry Aggression Anger subscale (BP-Anger, Buss & Perry, 1992) were used as self-report measures of emotion reactivity.

Magnetic Resonance Imaging

Scans were conducted on a 3.0 Tesla Siemens Skyra scanner equipped with a 32-channel head coil. Scan sessions begin with a 17s, T2-weighted scout that allows slice prescriptions for all subsequent scans. A high-resolution anatomical T1-weighted MPRAGE scan (TR/TE= 2500/3.41ms, 256x256 matrix, 1mm thick, 176 sagittal slices, FOV=256), functional images with a T2*- weighted echo-planar sequence (72 axial

slices, TR/TE=2000/25.0ms, 90-deg flip, 100x100 matrix, 2mm thick, FOV=200), and in-plane gradient-echo field map magnitude and phase images to correct for magnetic field inhomogeneities (72 axial slices, TR/TE=6970/60.0ms, 90-deg flip, 100x100 matrix, 2mm thick, FOV=200) were acquired.

Imaging Analysis

Raw DICOM image files were converted to the NifTI format with MRIConvert and then organized in the Brain Imaging Data Structure (BIDS; Gorgolewski et al., 2016). Preprocessing was then performed using *fMRIPrep* 1.3.1 (Esteban et al., 2019), which is based on *Nipype* 1.1.9 (Gorgolewski et al., 2011; Gorgolewski et al., 2018) and which also utilizes FSL, ANTs, AFNI, and FreeSurfer software packages to implement preprocessing steps including, motion correction, slice timing, co-registration, and normalization. The data were then smoothed with a 6 mm Gaussian kernel using SPM 12 (Wellcome Department of Imaging Neuroscience, London, UK).

First-level analyses were conducted in SPM 12. Event-related effects were estimated for each subject using the general linear model and convolved with the canonical hemodynamic response function. Regressors were entered for each condition (Look Negative, Look Neutral, Suppress Negative, Suppress Neutral, Reappraise Negative, and Reappraise Neutral) and modeled during the image presentation period. Framewise Displacement was included as a motion regressor in the models as a covariate of non-interest. Data were thresholded using a voxelwise threshold of $p < 0.001$ and cluster-size criterion of $k > 69$ voxels. These parameters were selected to correct for multiple comparisons to reach familywise error (FWE) corrected at $p < 0.05$, determined

by conducting whole-brain Monte Carlo simulations using 3dClustSim in AFNI version 18.2.04 (Cox, 1996; Cox, Chen, Glen, Reynolds, & Taylor, 2017). Linear contrasts were created at the first level for focal comparisons: Look Negative > Look Neutral, Suppress Negative > Look Negative, Reappraise Negative > Look Negative. Second-level random-effects inference with one-sample t-tests was conducted for each contrast to obtain group-level main effect estimates. To examine differences between groups on each contrast, we used a two-sample *t*-test. To examine relations between emotion measures and BOLD signal, we added continuous regressors to the model (each separately) and specified a contrast to test the positive or negative relation.

Results

Independent sample t-tests were used to test group differences for symptoms and for reactivity and regulation measures; Levene's Test for Equality of Variances at $p<0.05$ were used to determine equal variances assumed vs. not assumed. The Harvard-Oxford Cortical and Subcortical Atlases were used to identify regions.

Emotion Reactivity and Regulation Measures

For emotion reactivity, BPD scored significantly higher from control participants only on self-report measures: PAIBOR-AI $t(24)= -6.92$, $p<.001$, and BP-Anger $t(23)= -3.68$, $p=.001$. For emotion regulation measures, group differences were found on the DERS $t(27)= -6.65$, $p<.001$, DWCL-Dys $t(24)= -6.61$, $p<.001$, and Baseline HRV $t(25)=2.19$, $p=.04$. No differences were observed in other HR and HRV measures nor the Stroop. Groups also did not differ in their use of effective regulation skills. Means and standard deviations are reported in Table 16.

Behavioral Results

Self-reported negative affect during the scan (Figure 6) demonstrated a main effect for stimuli type; negative words were rated as being experienced more negatively than neutral words. There was also a main effect for strategy type, such that suppress and reappraise differed from look but did not differ from each other. A significant interaction between stimuli and strategy revealed that this was only true for negative stimuli. No significant group differences or interactions were found.

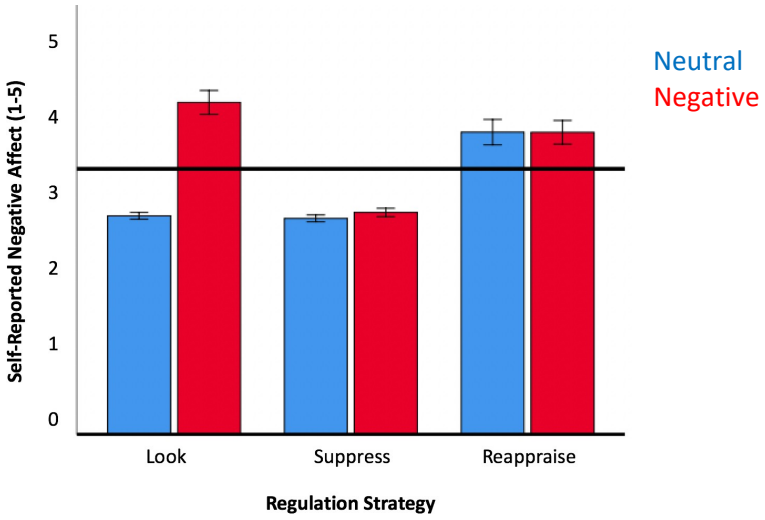

Figure 6. Self-reported negative affect during emotion regulation task. Includes standard error bars and line at the sample mean.

Imaging Results

Because this study's focus is particularly on differences in reactivity and regulation in the presence of negative stimuli, imaging findings are reported for the negative images such that the main comparisons of interest were Look Negative > Look Neutral, Suppress Negative > Look Negative, and Reappraise Negative > Look Negative.

These conditions were examined for the full sample then by group and finally contrasted to examine group differences.

Differences in the three comparisons of interest were first examined in the whole-brain. For the Look Negative > Look Neutral contrast, greater activation in the Occipital Fusiform Gyrus, Superior Frontal Gyrus, Lateral Occipital Cortex, and Precentral Gyrus was observed when viewing negative compared to neutral images (Table 17). No differences were found for the Suppress Negative > Look Negative or Reappraise Negative > Look Negative contrasts.

Table 17. Significant contrast effects for the full sample

		Coordinates			
Region	k	x	y	z	T
Look Negative > Look Neutral					
Occipital fusiform gyrus	3103	26	-78	-8	6.57
Superior frontal gyrus	336	2	32	54	5.3
Lateral occipital cortex, superior	121	-30	-76	22	5.14
Lateral occipital cortex, superior	107	-24	-74	52	4.37
Precentral gyrus	74	-44	8	30	4.19

Group differences were then examined in each contrast (Table 18) in the whole-brain. Each group was examined separately, and then groups were compared and contrasted to examine group differences. In the Look Negative > Look Neutral contrast, BPD participants showed activation in the Lingual gyrus when viewing negative compared to neutral images. Healthy controls had greater activation for negative vs. neutral images in the paracingulate gyrus, occipital fusiform gyrus, inferior frontal gyrus, superior parietal lobule, lateral occipital cortex, precentral gyrus, and the frontal orbital cortex. There were no differences found in HC > BPD or BPD > HC contrasts. When

Table 18. Significant effects for two-sample t-test contrasts

		Coordinates			
Region	k	x	y	z	T
Look Negative > Look Neutral					
Non-Disordered Controls					
Paracingulate gyrus	581	0	14	50	6.18
Occipital fusiform gyrus	3823	-32	-80	-18	6.12
Inferior frontal gyrus	113	-56	18	-2	5.1
Superior parietal lobule	218	30	-52	56	4.94
Paracingulate gyrus	154	0	30	36	4.83
Lateral occipital cortex, superior	320	-24	-78	54	4.47
Precentral gyrus	84	-36	-20	66	4.42
Lateral occipital cortex, superior	70	32	-70	26	4.18
Frontal orbital cortex	74	52	22	-8	4.08
Precentral gyrus	89	-46	2	36	4.07
BPD					
Lingual gyrus	71	4	-78	-12	4.09
Controls > BPD					
None	-	-	-	-	-
BPD > Controls					
None	-	-	-	-	-
Reappraise Negative > Look Negative					
Group 1					
None	-	-	-	-	-
Group 2					
None	-	-	-	-	-
Controls > BPD					
None	-	-	-	-	-
BPD > Controls					
Right putamen	81	14	12	-12	4.51

comparing negative images participants were trying to suppress to negative images they were passively viewing, none of the contrasts showed differences in activation for groups separately or comparisons between groups. For the condition in which participants were

trying to use the reappraise strategy in the presence of negative images as compared to viewing negative images, only the BPD > HC contrast showed differences; BPD participants showed greater activation than healthy controls in the right putamen.

Table 19. Significant relations between neural findings and measures of emotion reactivity and regulation

		Coordinates			
Region	k	x	y	z	T
Suppress Negative > Look Negative					
BP-Anger					
Angular gyrus	778	-46	-58	44	5.06
Inferior Frontal gyrus	186	50	26	10	4.82
Superior parietal lobule	147	18	-52	62	4.71
Parahippocampal gyrus	73	-14	-26	-10	4.57
Middle temporal gyrus	181	-44	-54	10	4.46
Occipital fusiform gyrus	91	-40	-70	-16	4.2
Cuneal cortex	73	-18	-74	16	4.09
DWCL-Dys					
occipital pole	934	10	-90	30	6.19
lateral occipital cortex superior	124	-16	-88	34	5.28

Relationships between activation and measures of reactivity and regulation were then examined in each group separately and then between groups in the whole-brain. No differences in activations were found in any of the Look Negative > Look Neutral contrasts for either group or between groups, nor for the Reappraise Negative > Look Negative contrasts. In the Suppress Negative > Look Negative contrast relationships between activation differences and the BP-Anger and DWCL-Dys were found (Table 19). Activation in the angular gyrus, inferior frontal gyrus, superior parietal lobule, parahippocampal gyrus/left hippocampus, middle temporal gyrus, occipital fusiform gyrus, and cuneal cortex was related with increases in the BP-Anger measure. Activation

in the occipital pole and lateral occipital cortex were related to increases in the DWCL-Dys.

Discussion

The current study aimed to contribute to the neuroimaging literature on the disruptions in emotion reactivity and regulation in BPD and to compare neural findings of ER with other self-report, behavior, and physiological measures of ER to understand how different ER response systems relate to one another.

Behavioral Observations

Overall, participants rated their subjective affect as more negative when viewing negative images as compared to neutral. Across regulation strategy, participants rated their negative affect as higher for images they were passively viewing versus trying to suppress or reappraise. There were no differences between regulation strategies. This suggests that participants may have experienced a subjective benefit of implementing regulation strategies when viewing negative images. Is also possible that participants were sensitive to demand characteristics and did not respond with their actual affect. There were no differences between groups, which is in line with some prior research (Koenigsbergetal et al., 2009; Lang et al., 2012; Mier et al., 2013; Schulze et al., 2011).

Emotion Reactivity

To examine reactivity, passive viewing of negative images was compared to neutral images. Results for the full sample showed activation in distinct areas that suggest participants experienced negative images as more salient and arousing. Greater activation in the visual areas including the occipital fusiform gyrus and superior lateral

occipital cortex is in line with research that has found these regions to be associated with visually evocative stimuli (Phan, Wager, Taylor, & Liberzon, 2001). The superior frontal gyrus has been associated with inferring others' mental or emotional state (Mak, Hu, Zhang, Xiao, & Lee, 2009; Völlm et al., 2006) and greater activity for negative images in this region might indicate individuals spent a greater time considering the mental state of people in the negative images.

Examining groups separately showed that activation differences for the Look Negative > Look Neutral condition was primarily found in the healthy control group. In addition to the areas mentioned above, healthy controls showed increased activation in the paracingulate gyrus, inferior frontal gyrus, superior parietal lobule, and the frontal orbital cortex. The only differences between groups showed that BPD participants had greater activation in the lingual gyrus compared to healthy controls. Lingual gyrus activity is frequently reported in fMRI studies of emotion, suggesting it plays some role in emotional processing, but its particular role is not often discussed. Connections between lingual gyrus and amygdala have been shown, and tentatively may be associated with reactivity (Perlman et al., 2012; Roy et al., 2009).

The lack of hypothesized amygdala activity in the reactivity contrasts in counter to the literature findings (van Zuthphen et al., 2015). Several factors may have affected our results. Amygdala responses are difficult to detect (Morawetz et al., 2008), and some studies have only found an amygdala effect after using an ROI analysis (Koenigsberg et al., 2009; Schulze et al., 2011), which can increase the detection sensitivity (Poldrack, 2007). It is possible that a more sensitive analysis method may yield different findings.

Further, about half of our BPD participants were currently taking medications, and so our findings may have been influenced by the effects of psychotropic medications, which research has demonstrated to be a confounding factor in neuroimaging (Arce et al., 2008; Murphy et al., 2009). Most of the neuroimaging BPD literature has been done in non-medicated samples, which may explain why our findings were in contrast to the literature. For example, the van Zutphen et al. (2015) review reported that 10 out of the 15 studies reviewed excluded participants who were currently or recently taking psychotropic medications. Requiring individuals with BPD to stop medication use is an ethical problem faced by researchers, and including only BPD persons who are medication-free induces sampling bias and reduces external validity.

Emotion Regulation

Two regulation strategies were examined in this study – suppress and reappraise. It was hypothesized that regulation attempts would show increased activation in inhibitory controls regions as compared to the passive viewing of negative images and that these healthy controls would show increased activation as compared to BPD participants. In contrast to the study's hypotheses, there was minimal activation observed in any of our regulation contrasts. No differences in the Suppress or Reappraise contrasts were observed for the full sample. The only significant finding at second-level analyses was that the BPD group showed greater activation in the right putamen when reappraising negative images as compared to viewing them. The putamen has been implicated in approach or implementation of behavior, increased activation in this region is counter to the BPD literature, but has been observed in several studies and interpreted as activation related to the preparedness to respond such as to approach or to escape

(Lamers et al., 2019). There may be something unique about trying to reappraise versus suppress or viewing images that makes BPD individuals want to respond.

Neural Findings and Other Emotion Reactivity and Regulation Measures

Only two measures were found to be associated with neural activity in the study's comparisons of interest. Self-reported anger and self-reported dysfunctional coping skills were positively associated with greater activation in the Suppress Negative > Look Negative contrast. In the absence of other contrast and measure effects, it is difficult to interpret why these measures would be particularly associated with suppressing negative images and not with activation in other contrasts. The regions observed to have increased activation are not generally associated with the hypothesized inhibitory control, making interpretation even more difficult. Results do not suggest that higher anger and higher dysfunctional coping skills predicted successful suppression, however. These findings are preliminary, and additional studies are needed before inferences can be made about these findings; however, this is a first step to examining multiple measures of emotion regulation to neural findings.

Conclusion

Overall this study contributed to the neuroimaging literature on BPD and uniquely examined multiple measures of emotion reactivity and regulation with neural findings. Future research should control for medication use through recruitment or as a covariate in the analysis. Additional research implementing multi-method approaches is needed before we can begin to understand how these different measures relate and capture emotion regulation functioning as a whole.

CHAPTER IV

CONCLUDING SUMMARY

The aim of this dissertation was to use multi-method approaches to better understand the correspondence among different measures of emotion regulation. The first study examined self-report, behavior, and physiological measures of emotion regulation in women with and without BPD. The second study used neuroimaging to identify the putative neural correlates of emotion reactivity and regulation in women with BPD compares to non-disorder controls and then tested for the relationships between neural findings and other measures of emotion reactivity and regulation.

Study 1 Summary

The first study examined the differences between BPD and non-disordered controls on nine different measures of emotion regulation and dysregulation hypothesized that group differences would only be observed for self-report measures. Next, correspondence of the measures was examined, testing the hypothesis that measures of self-report would correlate with each other and physiological measures would correlate each other but measures across methods would not correspond. Latent profile analysis was then used to identify profiles of emotion regulation and dysregulation for the full sample and then within the BPD group separately. Three profiles were hypothesized to be identified in both emotion regulation and emotion dysregulation measures, and BPD participants were predicted to have additional profiles above and beyond the three. Finally, these profiles were then examined in relation to mental health symptoms, and higher symptoms of mental health were hypothesized to predict increased probability of

belonging to profiles that indicate difficulties with emotion regulation and increased emotion dysregulation. These hypotheses were partially supported.

In support of the study's hypothesis and consistent with prior research, BPD participants differed significantly from control participants on measures of self-report. A lack of differences in behavioral and physiological measures is in line with the literature which has shown inconsistent effects on these measures. Correlations between self-report measures and between physiological measures were found, but no correlations across measures were observed.

Latent Profile Analyses identified three profiles of emotion regulation and four profiles of emotion dysregulation. For emotion regulation measures, the three profiles generally showed a profile in which measures were low, average, or high. However, there were also measures within each of those profiles that were either higher or lower than expected. Further, more than half the BPD participants were grouped within the average regulation profile. When examined separately, only two profiles were identified for emotion regulation and emotion dysregulation measures in the BPD group in which participants either showed low regulation/high dysregulation or average regulation and dysregulation. Anxiety and depression symptoms were associated with profiles low in regulation and high in dysregulation.

The results of this study provided evidence for the lack of correspondence among emotion regulation measures, which suggests that emotion regulation involves multiple response systems which may differentially experience disruptions. This highlights the importance of multi-method approaches in the understanding of emotion regulation

functioning. Further, this study demonstrated that even within a sample characterized by extreme difficulties in emotion regulation, the way in which those disturbances are experienced can be quite variable. This has important clinical implications in understanding psychopathology and informing treatment. Further research is needed incorporating other methods of emotion regulation and examining additional mental health symptoms and disorders.

Study 2 Summary

The second study used fMRI to examine putative neural correlates of emotion reactivity and regulation in women with BPD compared to non-disordered controls in an emotion regulation paradigm. Regions that have been associated with reactivity including the amygdala and insula were hypothesized to show greater activation for passive viewing of negative images, while regions associated with inhibitory control including prefrontal and frontal regions were hypothesized to be active during regulation. BPD participants were hypothesized to show greater reactivity and blunted regulation activation in associated regions. Self-report, behavior, and physiological measures were also examined in relation to neural findings. Measures that capture aspects of emotion reactivity were hypothesized to be associated with activation differences related to reactivity and measures that capture regulation abilities were hypothesized to be associated with activation in regulatory regions. These hypotheses were not well supported by results.

In support of the study's hypotheses, viewing negative images as compared to neutral was associated with greater activation in regions that suggested participants were

more responsive to negative stimuli, such as the fusiform gyrus, lateral occipital cortex, and superior frontal gyrus. However, activation in limbic regions commonly associated with reactivity, such as the amygdala, were not observed. In contrast to the study's hypotheses, there were no group differences observed in this comparison. This is not in line with research which has generally reported these differences between groups, though it is possible that a whole-brain vs. region of interest analysis, as well as, medication use of BPD participants contributed to these results.

Hypothesized activation differences in inhibitory regions were not observed. No activation differences were detected for the full sample for the regulation contrasts comparing suppression or reappraisal of negative images to passive viewing of negative images. In group contrasts, BPD participants had greater activation in the right putamen compared to non-disordered controls for reappraisal vs. viewing comparisons. As the activation in the putamen has been associated with action/response, this may indicate that BPD participants experienced increased urges to approach or escape during reappraisal attempts, which may imply difficulties with regulation.

The only observed relationships between neural findings and other measures of emotion reactivity or regulation were found during the suppression comparison. Measures of anger (BP-Anger) and dysfunctional coping skills (DWCL-Dys) were found to be positively associated with activation related to suppressing negative images versus passively viewing them. These are novel findings that may suggest the relationships between neural activity and other measures of emotion regulation may be meaningful in understanding psychopathology.

The findings of this study suggest that further research is still needed on the neural correlates of reactivity and regulation in BPD. Results tentatively show evidence for lack of correspondence between neural findings and other measures of emotion regulation but these results should be interpreted carefully and seen as preliminary. Further research employing multi-method approaches is needed to understand how neural activity corresponds to other measures of emotion regulation. This research has important implications for understanding emotion regulation disturbances in psychopathology, as well as, eventually leading to the improvement of assessment and treatment of emotion regulation difficulties.

Future Directions

There are many different ways future research can build on these results; however, I have identified several next tangible steps that I will take following this dissertation. Study 1 should be replicated with a larger sample and examined in relation to mental health more thoroughly. The R01 study in which data for Study 1 was obtained in ongoing. At the end of data collection, the sample will have approximately 320 women. This analysis will be able to be repeated with a larger sample and with the complete Stroop data. Further, we will be able to examine emotion regulation profiles in relation to diagnostic categories with the goal to identify if patterns of comorbidity are related to specific regulation profiles. Additional studies should prioritize, including other measures not captured here such as neuroimaging, as well as, additional mental health symptoms and disorders.

For Study 2, next steps include conducting region of interest analysis to examine effects that may have been too small to be observed in the whole-brain approach. Additionally, other contrasts can be examined to explore differences within this sample. Further research is needed, which replicates this study with a larger sample and more efficient control or measurement of confounding variables such as medication use.

Conclusion

The studies presented in this dissertation identify the importance of a multi-method approach in the study of emotion regulation. Results demonstrating a lack of correspondence between measures provides evidence that emotion regulation is a multi-dimensional construct composed of different response systems, and therefore, necessitates multiple measures to capture functioning. Single method approaches are useful for understanding functioning within a particular domain, but multiple methods are required to understand the emotion regulation system broadly. How these systems relate to each other may vary, and further research is needed to continue to examine the differential patterns among emotion regulation systems and how they may be meaningfully related to dysfunction or well-being. This has important clinical implications in how emotion regulation difficulties are assessed and may provide insights into how treatment can be changed to meet individual differences and increase treatment effectiveness.

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