Cognitive Therapy and Research
https://doi.org/10.1007/s10608-021-10284-8

ORIGINAL ARTICLE

From Social Avoidance to Substance Use: Working Memory and Negative Affectivity Predict Maladaptive Regulatory Behaviors in Daily Life Across Diagnostic Groups

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Accepted: 1 December 2021
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Abstract

Background We identified common maladaptive regulatory behaviors including substance use, binge eating, and social avoidance, across healthy adults and those diagnosed with prevalent affective disorders and then tested two theoretical models (Two-dimensional Model and the Emotional Cascade Model) of cognitive-emotional processes underlying the enactment of these behaviors in daily life. These behaviors are frequent in patients and present significant challenges in treatment, thus understanding common underlying processes is essential to improving patient outcomes.

Methods Adults with current diagnosis of depression and/or social anxiety (with common comorbidities, n = 31) or without any current/past psychiatric disease (n = 21) completed one lab session to index baseline variables, including tasks indexing cognitive control, then completed 14-days of experience sampling, reporting emotion and risk-related maladaptive regulatory behaviors five-times daily.

Results The Two-dimensional Model, encompassing the interaction of cognitive control, indexed as working memory, and trait negative affectivity, had advantages in describing the processes underlying the enactment of maladaptive regulatory behaviors. However, a fully inclusive model, including elements of both theoretical models, was the most predictive.

Conclusion These findings suggest that the most robust model of cognitive-emotional processes driving maladaptive regulatory behavior in daily life includes both cognitive control and trait negative affectivity. This model appears useful across diagnostic groups and findings provide preliminary support for the consideration of these behaviors as a class. These results suggest key targets for future research, including the consideration of these behaviors as a class, in treatment.

Keywords Regulation · Affective disorders · Maladaptive behaviors · Working memory · Negative emotion

Introduction

There is broadening consensus that emotion-related processing, including emotion regulatory processes and related regulatory behaviors underlie risk, persistence and maintenance of emotion-related or affective disorders (Kring, 2008). Indeed, large swaths of emotion-related or affective psychiatric diagnoses are caused in part by a failure of emotion regulation, including mood, anxiety, stress, substance use, eating, and certain personality disorders (Nolen-Hoeksema & Watkins, 2011). In particular, there are a range of maladaptive behaviors that are commonly enacted in the service of emotion regulation that are viewed as transdiagnostic phenomena (Johnson et al., 2013). These behaviors co-occur with other emotion-related disruptions such as negative mood (Birrell et al., 2016), predict disease progression (Needham, 2007), and interfere with treatment (Mischoulon et al., 2011). Although these behaviors, inclusive of consumption (e.g. binge eating), risk-taking (e.g., overspending) or avoidance of fear-eliciting contexts (e.g., social avoidance), have been termed "mis-regulation" (Wagner & Heatherton, 2014) and "impulsive reactions" to distress (Johnson et al., 2013), they are relatively normative and also occur in the lives of psychologically healthy individuals. However, importantly, they likely manifest at a higher frequency and have greater consequences in those with affective diseases (Johnson et al., 2013).

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Published online: 13 January 2022

Independently, researchers focused on specific disorders (e.g., substance use, eating, anxiety) have identified similar theoretical models underlying those behaviors most associated with the disorder. Across disorders, models broadly suggest that these behaviors are enacted in response to heightened negative emotions that are uncomfortable, and engaging in these behaviors provides some relief which reinforces their habitual use (e.g., social avoidance: Heimberg et al., 2010; Binge eating: Haedt-Matt & Keel, 2011). Despite theoretical consensus, there remains a lack of empirical data demonstrating, in real time, how maladaptive behaviors, such as substance use, binge eating, or social avoidance, could manifest as a function of disrupted regulatory processing across patients with more common (or prevalent) affective disorders (i.e., depression, anxiety, stress disorders) and in psychologically healthy individuals. To do this would provide a preliminary platform for considering them as transdiagnostic phenomena driven by similar cognitive-emotional processes across the spectrum of psychological health, informing the development of more effective treatments and models of psychiatric disease.

Maladaptive Regulatory Behaviors

Researchers across a range of psychiatric disorders and disciplines have been interested in the ways that individuals engage in behaviors as a regulatory response to heightened negative emotion and/or distress. Although much of the clinical research on these behaviors as a *class* has focused on patient populations where engagement in *many* of the riskiest behaviors (e.g., self-injury; substance use; binge eating, etc.) is most likely (Borderline Personality Disorder: Selby et al., 2008), it is clear that engagement in maladaptive behaviors is common across affective disorders broadly. For example, substance use or disrupted patterns of eating (i.e., binges) are common in patients with depression, anxiety and stress disorders, and there is co-occurrence of eating or substance use disorders at substantial rates (Kessler et al., 2005, 2011). Indeed, there is also genetic and behavioral evidence of shared transmission, such that disruptions in emotion-related processing that drive affective disorders appear to manifest with these behaviors at the same time (e.g., anxiety and eating disorders: Keel et al., 2005). In particular, many of these maladaptive regulatory behaviors are enacted for the first time during adolescence, which coincides with increases in negative emotionality and first onset of affective disorders (e.g., first alcohol use and depression or anxiety: Birrell et al., 2016; Zinbarg et al., 2016). Moreover, maladaptive regulatory behaviors and affective disruptions appear driven by broader dispositional failures in self-regulation (Acuff et al., 2019). Although the evidence more clearly suggests that affective disorders precede the behavioral disorders associated with these maladaptive regulatory behaviors (e.g., substance use addiction: Fichter et al., 2009), there is considerable evidence that the presence of these behaviors increases the severity of affective disorders and present additional challenges in treatment (Howland et al., 2009; Mischoulon et al., 2011).

Given the evidence of shared manifestation of clinically significant emotion disturbances with this class of maladaptive behaviors, it is likely that the emotion-related deficits now well-understood to be a central feature underlying affective disorders, may also underly the enactment of these behaviors as regulatory actions. For example, there is evidence that behaviors such as substance use (alcohol: Cooper et al., 1995), binge eating (Heatherton & Baumeister, 1991; Telch & Agras, 1996), social avoidance (Heimberg et al., 2010) and even overspending (Zander et al., 2016) manifest as attempts to regulate elevated distress and negative emotion. This has been demonstrated across community and clinical samples, and is consistent with dominant, well-supported, theoretical models of self-regulation, including models of self-control (Baumeister et al., 2007) and affect-linked regulatory processes (Carver & Scheier, 1998), as well as, specific cognitive and emotion-regulation models that focus on eating disorders (Fairburn et al., 2003), substance use (Kober, 2014), and social avoidance (Heimberg et al., 2010). Across all of these regulatory models, there is the foundational premise and corresponding evidence that negative emotions likely precede enactment, and individuals resort to these behaviors (instead of adaptive regulatory strategies) in part because of depleted resources and/or underlying deficits in regulatory capacity.

Importantly, this potential class of behaviors are also largely considered to be *maladaptive* because they contribute to poor long-term outcomes. For example, a dominant consensus in models of social anxiety disorder is that although social avoidance or withdrawal can regulate immediate discomfort by providing short-term relief, there are secondary more pernicious consequences including reinforcement of the behavior (and increased frequency of use) and later resurgence of negative emotions such as guilt or shame for enacting the behavior (Clark, 2001; Clark & Wells, 1995; Heimberg et al., 2010). In the case of social avoidance, there is also an increase in loneliness and lack of social connection (Heimberg et al., 2010). Similar processes have been theorized and empirically demonstrated to underlie other maladaptive behaviors such as binge eating (Haedt-Matt & Keel, 2011), substance use (Bickel et al., 2014), and impulsive behaviors such as overspending (Workman & Paper, 2010), where reliance on these behaviors reinforces their continued use, and secondary consequences can lead to additional distress and even disease. Indeed, some psychiatric disorders are defined by the frequency with which an individual relies upon these behaviors, precisely because extreme reliance is disease and infrequent use can be more normative (APA,

2013). Finally, a growing body of meta-analytic evidence supports the role of *adaptive* emotion regulatory processes in reducing reliance on these behaviors, including evidence of an *inverse* association between some specific adaptive emotion regulation strategies, such as reappraisal of experiences, and these behaviors (e.g., Compas et al., 2017).

Recent theoretical models of the processes that underlie this group of behaviors has begun to shed light on the dynamic relationship between executive cognitive control processes and negative emotion that may be central to their enactment. For example, The Emotional Cascade Model (Selby et al., 2008) proposes that immediately preceding these behaviors, is an increase in negative emotion that is heightened by ruminative cognition, or the tendency to repetitively and passively focus attention on sources of one's distress (Nolen-Hoeksema et al., 2008). This model posits that without other means to down-regulate this discomfort, individuals engage in behaviors to distract from discomfort, thereby reinforcing the behavior's use. This model has been tested predominately in high-risk, clinical populations (e.g., Borderline Personality) where these behaviors are common and frequent, but researchers have also accumulated evidence in support of the model in behaviors as wide-ranging as self-injury to over-spending, in the general population (Jungmann et al., 2016).

Broadly, failures in executive cognitive control have been linked to this same set of maladaptive behaviors across dominant theories and research oriented towards the construct of self-regulation (Nigg, 2017). Indeed, an alternative, yet *complimentary* model that describes the processes preceding the enactment of this class of maladaptive behaviors relies, instead, on the interplay of what are often termed "bottom-up" motivational tendencies with "top-down" executive cognitive control. Prior research in nonclinical populations has demonstrated the ways in which bottom-up reactivity (also described as trait negative affectivity or neuroticism) interacts with momentary top down executive cognitive resources in the ability to tolerate and/or attend to distress or threat. In particular, there is evidence implicating the interplay of heightened bottom-up (limbic region) reactivity to negative content with limited top-down (pre-frontal) resources in the inefficient or maladaptive processing of negative emotional content (e.g., Dennis & Chen, 2007). Although mostly this model has been applied to early attentional and threat related biases, new research has suggested how this may also predict maladaptive behavioral outputs (Okon-Singer et al., 2015). For example, Coifman et al. demonstrated that adults reporting higher threat sensitivity suggestive of greater bottom-up activation who were indexed as having lower top down control (assessed as set-shifting ability) exhibited maladaptive social behavior during a simulated social threat paradigm (Coifman et al., 2018).

These two models, the emotional cascade and the two-dimensional, suggest an interaction between cognitive control and negative emotion that could describe the processes that underlie the enactment of this class of maladaptive regulatory behaviors. A clearer understanding of this interaction is essential at both a practical and theoretical level, guiding further research and models of disease processes, as well as facilitating more effective intervention in the clinic. However, this has yet to be tested in individuals with affective disorders and individuals evaluated as psychologically healthy. Moreover, although these models differ in their emphasis on whether to target specific cognitive processing deficits (i.e., rumination) versus cognitive control resources, they are quite similar. For example, the emotional cascade model argues that it is the in-the-moment interaction of ruminative cognition with negative emotion that spirals into a cascade that leads to maladaptive regulatory behavior. The emphasis on ruminative cognition reflects the tendency in clinical science to focus on deficits (here in executive cognitive control) when explaining phenomena linked to disease, a feature common in disease-models of these same behaviors (e.g., substance use: Lechner et al., 2018). The two-dimensional model focuses instead on cognitive control resources or what is available to that individual (at that moment). Importantly, both cognitive control resources or ruminative tendencies can be understood as differentiating between individuals, but they also vary *within* individuals to some degree, as both state emotional and cognitive processing vary within persons. Finally, that both models emphasize cognitive control processes is consistent with evidence that differences in working memory and other executive functions are associated with maladaptive behaviors (e.g., substance use: Lechner et al., 2018; maladaptive eating: Israel et al., 2015; social avoidance: Judah et al., 2013; overspending: Derbyshire et al., 2014). Indeed, dominant models suggest that working memory can contribute unique variance to cognitive control performance (Miyake & Friedman, 2012). Moreover, working memory is often theoretically and practically, inversely associated with ruminative cognition (Baddeley, 2013) and has been directly linked to regulatory responses to negative emotion (Coifman et al., 2019). Importantly, however, these models have not previously been compared empirically and evidence of an effective model across the spectrum of psychological health could broadly guide future research. Indeed, even though it is increasingly evident that emotion and cognition-related processing are neurobiologically intertwined with complex associations to behavior and to disease (Okon-Singer et al., 2015), there is clear need for theoretically grounded, empirically supported frameworks from which to understand these maladaptive regulatory behaviors, in order to develop more sophisticated and targeted therapeutic approaches.

Current Investigation

In this investigation, we had two key goals. First, we identified and evaluated the commonality of maladaptive regulatory behaviors in both healthy adults and adults diagnosed with prevalent affective disorders to determine if they operated as a class. Next, we tested models describing the cognitive-emotional processes that underlie the enactment of maladaptive regulatory behaviors in daily life across the same sample of patients with diverse, but common, affective disruption, as well as in psychologically healthy adults.

We targeted patients with common (or prevalent) affective disorders (inclusive of depression, anxiety and stress disorders) because prior research on these behaviors as a *class* has focused on patients with more severe, and rare emotion-related disease (e.g., Bipolar, Borderline Personality) or has been investigated in community and college samples where factors relating to psychological health are unknown. Moreover, given the heterogeneity within categories of more common disorders (e.g., MDD: Zimmerman et al., 2015) as well as high co-occurrence across common disorders (e.g., depression, anxiety and stress, Gao et al., 2013; Kessler et al., 2005) it did not make practical or scientific sense to target one specific affective disorder. There is a considerable need to examine factors that cross diagnostic categories encompassing a range of affective disorders (Kring, 2008). Indeed, depression, anxiety, stress, substance use, and some eating disorders have common underlying dimensions reflective of affective processing (e.g., elevated neuroticism: Zinbarg et al., 2016) as well as evidence of common emotion-related deficits, most notably elevated negative affect and limited emotion regulatory resources (Kring, 2008; Nolen-Hoeksema & Watkins, 2011). However, there is important variability amongst disorders as well. For example, anhedonia, which appears to dampen emotional reactivity across negative and positive valence (Rottenberg et al., 2002, 2005) is most common in depression, and fear over-generalization, which broadens the sources of fear responses, is dominant in anxiety and stress disorders (Lissek, 2012; Naczkurkin et al., 2017). Finally, there is documented reliance on this range of maladaptive regulatory behaviors across all of these disorders. Hence, we opted for a transdiagnostic framework, aiming to model processes underlying the enactment of this class of behavior across the most common or prevalent emotion-related disorders, so as to be able to generalize these theoretical models more broadly.

Importantly, this research must be considered preliminary, given the lack of empirical precedent. We focused on behaviors likely to be common in our clinical and our healthy adult groups, and we considered regulatory behaviors as a *class* for two reasons. First, it is likely that individuals rely on one or maybe two, but not all behaviors equally for reasons as wide-ranging as dispositional differences, to environmental reinforcement, to availability. However, prior research and theory suggests that these behaviors have common triggers and serve comparable functions (i.e. Johnson et al., 2013; Okon-Singer et al., 2015). Hence, considering these behaviors as a class has theoretical and practical utility, as it allows for testing these behaviors transdiagnostically. Second, although individuals likely enact only particular behaviors, it is clear that more severe affective disease is associated with broader and more frequent use of behaviors within this class (Kerr et al., 2013) and there is increasing evidence of use of multiple behaviors, or replacement of one set of behaviors for another, even in patients with the disorders representing extreme reliance on these behaviors (e.g., binge eating disorder, Wolfe & Maisto, 2000). Indeed, this is so much the case, that facilitating alternatives to these behaviors is a dominant target across third-wave behavioral treatments that are broadly applied (e.g., Hayes et al., 1999). However, for commonly used treatments to be adapted and/or improved, greater understanding of the underlying factors and dynamics is essential.

We employed two versions of the Reading Span task (RSPAN) as working memory assessment and primary index of cognitive control and we compared statistical models testing the Emotional Cascade (Selby et al., 2008) and the Two-dimensional theoretical models to evaluate if one model offered benefit over the other in explaining processes underlying the enactment of these behaviors. Notably, we did not evaluate *explicit* motivations for engaging in these behaviors. Considerable theory and evidence suggest that self-regulatory action often proceeds outside of awareness, automatically or habitually, and sometimes in direct contradiction to stated motives (Baumeister et al., 2007; Carver & Scheier, 1998). Moreover, prior research on these behaviors has indicated that hedonic regulatory motivations (to down regulate negative affect or to up-regulate positive affect) encompass a large proportion of what individuals report (e.g., Lac & Donaldson, 2017; McCabe et al., 2019) although there may be multiple, alternative motivations for each behavior (e.g., using substances to be social). Finally, current research also indicates that explicit attention to motivation during momentary assessments may shift maladaptive regulatory behaviors (e.g., Blevins et al., 2020).

Given the preponderance of evidence implicating working memory in affective and behavioral dysregulation, we used two task versions. A neutral and emotional version of the assessment would allow us also see if cognitive control deficits due to interference from negative emotional content (Matthews & MacLeod, 2005) were more predictive of behaviors (e.g., substance use, binge eating, social avoidance) that manifest from negative emotion, rather than in neutral contexts. These particular tasks were selected because of prior evidence validating their utility when predicting spontaneous emotion regulatory processes in daily life (Coifman et al., 2019). Moreover,

because most prior evidence has suggested that working memory may have particular relevance to understanding emotion regulatory processes (Barrett et al., 2004; Schmeichel & Tang, 2015) we also estimated verbal IQ and included an emotion-word Stroop to test if findings were not better accounted for by variability in IQ or by executive functioning indexed more broadly as opposed to working memory specifically.

The primary goal of this project was an examination of the underlying processes associated with maladaptive regulatory behaviors. First, we aimed to test the associations of these behaviors within and across individuals in our samples to identify common correlates in order to support their consideration as a class. Second, we aimed to compare two dominant theoretical models, the Emotional-cascade model and the Two-dimensional model, to see which best captured variance in these behaviors across samples. Although the models share considerable overlap, there is some nuance that divides them. Identifying the best-fitting model would support efforts to enhance treatment approaches relating to these behaviors in these disorders and advance the understanding of the emotion-cognitive processes that underlie the manifestation of these behaviors in daily life.

We did not have a-priori hypotheses, but tested for specific main effects and the related interactive effects theoretically proposed in each model on subsequent report of maladaptive regulatory behaviors. For the Emotional Cascade model this was the direct and interactive effects of state negative affect and rumination (such that increased negative affect and rumination would be associated with greater report of maladaptive behaviors). For the Two-dimensional model this was the direct and interactive effects of trait negative affect and working memory (such that greater negative affect but lower working memory would be associated with greater report of maladaptive behaviors). We tested these associations across both patient and healthy adult subgroups and co-varied group assignment. We explicitly included adults evaluated to be psychological healthy, given the absence of research on these behaviors in adults clinically evaluated to be healthy, and the importance of extending models across the spectrum of psychological health. We did not assume that processes underlying the enactment of behaviors would vary by group, only the frequency at which individuals engaged in these behaviors. Indeed, past research has suggested that this set of behaviors is present in community adults and patient populations. However, we planned to do exploratory analysis to determine the relevance of group status in analytical models consistent with each theory.

Method

Participants and Procedure

Adults were recruited from the community for a study on "Emotion in Daily Life" using flyers and online posting. Interested participants completed a detailed phone-screening including questions relating to current symptoms and medication associated with the specific target clinical groups (depression and social anxiety) for this project. Interested participants were deemed appropriate to be invited for an in-person session for possible inclusion in the clinical group if they reported four or more symptoms associated with current major depressive disorder and/or heightened anxiety and fear in three or more specific situations related to generalized social phobia, (e.g. contexts that were identified as making them feel more fearful, anxious or nervous than most other people). Interested participants who denied experiencing depression or anxiety in the past year, denied addiction or substance use problems, reported no psychiatric medication use in the past year, denied bipolar and manic-depressive symptoms, and schizophrenia or schizoaffective disorder were deemed appropriate to be invited for an in-person session for possible inclusion in the healthy control group. Individuals (n = 158) likely to be eligible for the clinical group *or* the healthy group, were then invited for an in-person diagnostic interview to confirm eligibility. Following that diagnostic assessment, still eligible participants (n = 75) completed two lab sessions, with a 14-day experience sampling diary between. The current study relies on data collected in questionnaires/tasks during the first session and the 14-days of experience sampling that began the following day.

Participants were adults (Mage = 33.83, SD = 13.71; 75% female; 90% White; 100% Non-Hispanic) from the community who met diagnostic criteria for at least one of two common or highly prevalent affective disorders: Major Depressive Disorder (MDD) and/or Generalized Social Phobia (now Social Anxiety Disorder) *without excluding* common comorbidities such as other anxiety, stress, substance use, or eating disorders -or- individuals who showed no evidence of psychiatric disease via structured clinical interviews. Seventy-five participants initially met the eligibility criteria for either group. However, 11 participants withdrew prior to the first lab session (n = 7 from the clinical group; n = 4 from the healthy group) and 5 didn't complete requisite study activities (e.g., opted out of the diary or didn't complete a questionnaire). We excluded an additional four because of invalid task performance on the RSPAN and n = 3 had too low diary compliance, leaving a final sample of n = 52. Thirty-one participants met

diagnostic criteria for MDD and/or Social Anxiety and constituted the clinical group. Twenty-one participants were eligible for the healthy control group with no significant psychiatric symptoms in the past year, no past psychiatric disease, and no current or past use of psychotropic medication. There was no difference in age, sex, race, nor educational attainment by group (Table 1). Finally, there was no difference on any key variable between participants included and those dropped from analysis.

Diagnostic Interviews

The Structured Clinical Interview for the Diagnosis of DSM-IV TR, Research Version[1] (SCID-I-RV, First et al., 2002) was administered by advanced doctoral students in clinical psychology following extensive training. All interviews were supervised by a licensed clinical psychologist (first author). Reliability was assessed by having interviewers code five randomly-selected interview videos. Inter-rater reliability was good at the symptom and diagnostic level (average Kappa = .91). Eligibility for the clinical group required that participants meet current diagnostic criteria for *either or both* of the two most prevalent affective disorders: Major Depressive Disorder and/or Generalized Social Phobia (now Social Anxiety Disorder, APA 2013). Both disorders have been shown to have common (e.g., elevated distress, reduced regulatory resources) and unique (e.g., anhedonia in depression, fear over-generalization in social anxiety) contributions to the range of emotion-related disruption and affective disease (Kessler et al., 2011). These disorders also frequently present together and co-occur with other disorders, including other anxiety and stress disorders. Indeed, only 13% of the clinical group had only one diagnosis. For example, 65% of the clinical sample also met diagnostic criteria for Generalized Anxiety Disorder (see Table 1 for details for other comorbidity). Hence, the sample was representative of common affective disturbance and comorbidities (Kessler et al., 2005). In addition, all participants were assessed with the SCID-II (First et al., 1997), to evaluate personality disorders. We deliberately excluded individuals with Bipolar, Borderline Personality, and Psychosis. Bipolar and Borderline Personality have already been studied with regard to this class of behaviors and are characterized by more extreme emotion-related disruption that can be quite distinct (e.g., Bipolar and circadian rhythm disruption: Alloy et al., 2017), and we aimed to test our models in more prevalent disorders, with common underlying dimensions of emotion and behavioral disruption. Eligibility for the healthy group, required no evidence of current or past psychopathology (per the SCID-I-RV), no personality pathology (a maximum of two symptoms on any single personality disorder, per the SCID-II-PD), no current or past use of psychiatric medication, and high levels of functioning, as indicated by a clinician-rated Global Assessment of Functioning Score equal to at least 80[2] consistent with prior research (Coifman et al., 2012).

All participants also completed an interview assessing their lifetime treatment history to document their record of mental health treatment and notably 61% of the clinical sample had or was receiving treatment of some kind. See Table 1 for diagnostic and treatment information.

Measures

Trait Rumination

Participants completed the Ruminative Responses Scale (Treynor et al., 2003). The Brooding subscale ($\alpha = .84$) is an index of trait ruminative tendencies, a factor identified in the Emotional Cascade Model (Selby et al., 2008).

Psychological Symptoms

Participants completed the Depression, Anxiety, and Hostility sub-scales from the Symptom Check List-90-R (Derogatis, 1983) to obtain a continuous index of symptoms. The scale exhibited excellent internal consistency and scores within the typical range for clinical and community samples ($\alpha = .97$).

Crystallized Intelligence Estimate (IQ)

Intelligence was assessed as a co-variate. Participants were administered a computerized version of the "Spot the Word" Task (Baddeley et al., 1993) which can reliably index premorbid intelligence. Participants detect a valid word from non-word foil and after six practice trials, are presented with 60 pairs of words. Scores reflect correct responses and were consistent with norms for this age range (Baddeley et al., 1993).

[1] The following modules were administered to all participants regardless of phone screening status: Current/Past Major Depressive Episode; Dysthymic Disorder; and Bipolar; Psychosis; Substance Use; the remaining modules were administered by applying the SCID-IV screener during the in-person interview, so that only if the participant screened in (with Yes/Maybe responses) to an initial questions was the entire module administered: Generalized Anxiety Disorder; Social Phobia; Agoraphobia; Panic Disorder; Obsessive Compulsive Disorder; Post-traumatic Stress Disorder; Bulimia and Binge Eating Disorder.

[2] We also administered the Marlowe–Crowne Social Desirability Scale (Crowne & Marlow, 1960) to ensure that we did not include individuals just "reporting" good health. Healthy adults were eligible with scores less than 25.

Table 1 Descriptive characteristics of study participants

Descriptive characteristics	Clinical sample ($n=31$)	Healthy control ($n=21$)	Clinical v. healthy	CI_{95} lower, upper
Age	M = 35.86, SD = 4.18	M = 30.86, SD = 12.71	$t(50) = -1.29$, p = .201, d = .371	−12.71, 2.75
Sex	22(71.0%) Female	17(81.0%) Female	$\chi^2(1,n=52) = .666$, p = .415	
Race				
Caucasian	26(86.67%)	21(100.0%)	$\chi^2(1,n=52) = 3.75$, p = .154	
African American	3(0.10%)	0		
Asian	2(0.06%)	0		
Education				
Some college	19(61.29%)	7(33.33%)	$\chi^2(1,n=52) = 4.79$, p = .31	
BA/BS	7(22.58%)	7(33.33%)		
Above	5(16.13%)	7(33.33%)		
Rumination	M = 12.33, SD = 3.99	M = 7.90, SD = 2.22	$t(46.81) = -5.03$, p < .001, d = 1.37	−6.21, −2.66
Symptoms	M = 1.43, SD = 0.79	M = 0.23, SD = 0.20	$t(47) = -6.79$, p < .001, d = 2.08	−1.59, −0.87
IQ estimate	M = 12.23 SD = 7.96	M = 11.57 SD = 5.85	$t(50) = -.322$, p = .749, d = 0.09	−4.736, −3.427
Negative Stroop	M = 0.77 SD = 0.17	M = 0.72 SD = 0.14	$t(46) = -1.07$, p = .291, d = 0.32	−.144, .047
Neutral Stroop	M = 0.75 SD = 0.15	M = 0.72 SD = 0.16	$t(46) = -0.64$, p = .53, d = 0.20	−.118, .062
Negative affect	M = 1.53 SD = 0.49	M = 1.11 SD = 0.15	$t(37.98) = -4.41$, p < .001, d = 1.16	−0.609, −0.226
Positive affect	M = 2.21 SD = 0.58	M = 2.82 SD = 0.55	$t(50) = 3.80$, p < .001, d = 1.08	0.289, 0.935
RSPAN-N	M = 0.63 SD = 0.19	M = .66 SD = 0.15	$t(50) = 0.66$, p = .52, d = 0.18	−0.07, 0.13
RSPAN-E	M = 0.51 SD = 0.19	M = 0.60 SD = 0.16	$t(50) = 1.71$, p = .09, d = .52	−0.01, 0.18
Overspending[a]	M = 0.03 SD = 0.04	M = 0.04 SD = 0.13	$t(50) = -0.30$, p = .765, d = .08	−0.04, 0.06
Misuse of medication[a]	M = 0.00 SD = 0.00	M = 0.00 SD = 0.00	$t(50) = -.820$, p = .416, d = .25	−0.001, 0.001
Binge eating[a]	M = 0.04 SD = 0.05	M = 0.02 SD = 0.03	$t(49.89) = -1.61$, p = .086, d = .48	−0.05, 0.01
Substance use[a]	M = 0.04 SD = 0.05	M = 0.03 SD = 0.05	$t(50) = -.80$, p = .428, d = .23	−0.04, 0.02
Social avoidance[a]	M = 0.15 SD = 0.23	M = 0.01 SD = 0.02	$t(30.57) = -3.39$, p = .002, d = .86	−0.24, −.04
All maladaptive behaviors acts only	M = 0.25 SD = 0.23	M = 0.09 SD = 0.15	$t(49.86) = -3.06$, p = .004, d = 0.83	−0.27, −0.06
All maladaptive behaviors acts + urges only	M = 0.48 SD = 0.41	M = 0.13 SD = 0.17	$t(42.84) = -4.21$, p < .001, d = 1.11	−0.54, −0.16
Major depressive episode	20 (65%)	0%		
Post-traumatic stress disorder	5 (16%)	0%		
Generalized anxiety disorder	20 (65%)	0%		
Generalized social phobia (social anxiety disorder)	29 (94%)	0%		
Obsessive compulsive disorder	1 (3%)	0%		
Panic/Agoraphobia	6 (19%)	0%		
Binge eating disorder	2 (7%)	0%		
Substance abuse/dependence Abuse/ Dependence	3 (10%)	0%		
Psychiatric treatment				
Current psychotherapy	19 (61%)	0%		
Current medication	19 (61%)	0%		

RSPAN Reading Span Task

[a]Behaviors are reported as *rates* of acts (frequency over diaries completed)

Working Memory: Reading Span Task

Participants were administered two versions of the Reading Span or RSPAN Task an affectively neutral version, the RSPAN-N (Bailey, 2012), and an affectively negative version, the RSPAN-E (Coifman et al., 2019). RSPAN tasks measure working memory by evaluating the process of holding information in a temporarily accessible state, regulating interference from other content, in the service of a specified goal. Participants are presented with fifteen sets of 2–7 sentence-word pairs, they must read the sentence, report whether it is logical or "correct", then read an unrelated to-be-remembered neutral target word, and then view the next sentence-word pair. At the end of each set of sentence-word pairs, participants produce the target words in correct serial order. The proportion of correctly recalled words is the primary score (Conway et al., 2005). In the RSPAN-E, the affective quality of the sentence content in each sentence-word pair is negative, but the neutrality of the target word remains. In addition to the score, response accuracy to the logical (versus non-logical) nature of the sentence represents an index used to "clean" the data. Following procedures outlined in Coifman et al. (2019), we dropped individuals who had response accuracy below 2 SDs from the mean to maximize variability in the sample. This resulted in four participants dropped from analysis (n = 3 clinical, and n = 1 healthy). RSPAN tasks were administered to participants in counterbalanced order and participants viewed three-minute, positive mood-inducing videos between.

Internal consistency across both tasks was good (α = .86), task (RSPAN-E versus N) scores were correlated as expected, r = .75, and comparable to other samples (Coifman et al., 2019). In particular, there was decrease in scores from the RSPAN-N to the RSPAN-E: Mean change = .09, SD = .13, t(52) = 5.15, p < .000, 95%CI 0.06, 0.12 as is typically the case when incidental negative emotional content is introduced. Unexpectedly, however, we did detect an order effect. Those presented with the RSPAN-E first scored higher on that task relative to those who were presented with the RSPAN-E second. We then tested if task-order impacts on scores varied by diagnostic group, using repeated measures ANCOVA. The results indicated that although the order effect impacted the RSPAN-E scores it did not interact with group membership, F(1,45) = 1.17, p = .29. We did explore order as a covariate in the primary analysis but it was not significant, nor did it meaningfully impact other associations, so it was not considered further.

Cognitive Inhibition: Emotion-Word Stroop Task

This Stroop (Williams et al., 1996) provides an estimate of cognitive inhibition to negative, positive, and neutral words. The task consists of 60 trials each of negative, positive, or neutral words presented as one set, randomized by valence. Participants are directed to label the text color (red, green, yellow, or blue) by button press as quickly as possible and to ignore word meaning. Before each trial, participants see a white fixation cross on a black screen for 500 ms, followed by the stimulus (affective or neutral word). Stimuli remain on-screen until the participant responds. All participants did practice trials before progressing with the task. Error rates were low and there were no differences in errors by word type (neutral %error M = 2.46, SD = 0.03; negative %error M = 2.69, SD = 0.03; positive %error M = 2.98, SD = 0.03). Re-test reliability for this task in prior research (Strauss et al., 2005) has been high and internal consistency in this sample was excellent α = .97. Two participants were dropped from the analysis because reaction times were greater than 2 SDs from the mean. Reaction times from correct responses to negative and neutral words were used in the analyses.

Experience Sampling Diary

Following the lab session, participants completed 14-days of experience sampling via handheld, palm computers. Palms were programmed to signal five-times daily at semi-random intervals, totaling 70 possible assessments over the 14 days. This sampling structure, both intensity and duration is consistent with conventions in affective and cognitive science as well as with recommendations (e.g., Bolger & Laurenceau, 2013) and previously demonstrated to be sensitive to affective and behavioral dynamics without causing too much burden in clinical populations (e.g., Seah et al., 2020). At each signal, participants were prompted to rate current emotional state and behaviors they engaged in since the previous diary signal. Diaries were no more than 4-h apart (typically 2–3) and participants could delay responding if they were engaged in activity that prohibited them from responding. Participants were trained during the lab session and practiced the diary before leaving. They were given a manual and contacted every 2–3 days by phone to maintain engagement. Diary compliance was good: 81.79%, Mean = 57.25, SD = 22.09. Three participants were dropped from analyses because their diary compliance was less than two SDs below the mean (Bolger et al., 2003). Individuals in the clinical group, M = 63.35, SD = 15.67, were as compliant as the healthy group, M = 56.48, SD = 19.55, t(50) = − 1.41, p = .17, d = .39, 95%CI − 16.71, 2.96.

Emotional State Participants rated on a 7-point Likert scale "how they were feeling right now" using a list of discrete negative and positive emotion words. The ratings of negative (fear, sadness, anger, guilt, disgust, shame) and positive words (affection, amusement, contentment, happiness, interest) were aggregated into negative and positive affect scores, that were each parsed into a person-mean, reflecting aver-

age affect across the whole diary, and into a person-centered score, reflecting signal-level or state deviations from their own mean. Scores were parsed this way, per recommendations (Bolger & Laurenceau, 2013) to be able to disentangle trait-level negative affectivity from state deviations. Primary focus was on negative affect, however we explored scores for each valence in the analyses. Between-person reliability (R_{kf}) and within-person reliability (R_c) were good: Negative affect: $R_{KF}=.99$; $R_C=.75$; Positive affect: $R_{KF}=.99$; $R_C=.83$ (Cranford et al., 2006).

Maladaptive Regulation-Related Behaviors At each diary signal, participants were prompted to identify behaviors they had performed or had strong urges to perform since the previous diary signal by responding to the following prompt: "Please indicate if you performed any of the following actions since the last diary." We assessed the following: substance use, use of medication for means other than prescribed/packaged, binge eating, social avoidance, and overspending of money. Participants were trained on definitions for each behavior and were reminded at each diary prompt (five times daily for 14 days) each definition (e.g., "Since the last diary, did you spend too much money? This refers to making expensive or unplanned purchases online or in stores"; "Since the last diary, did you binge on food? This refers to eating an amount of food larger than most people would eat in the same amount of time while feeling a lack of control."). They were able to endorse "Yes", "No", or "No but I had a strong urge" for each behavior, at every signal. The exact diary prompts were based on prior research (Coifman et al., 2012; Kerr et al., 2013) and are reported in their entirety in the supplemental materials. Previous research has indicated that strong urges and endorsements are very close in their association (Hofmann et al., 2012). Since various contextual factors could limit feasibility of enactment, we considered both reported acts of behaviors as well as strong urges meaningful. Indeed, there was a strong correlation ($r=0.70$) between acts, and acts + urges in our sample. At each signal, we derived a summed score (0–5) that reflected the enactments of all possible behaviors as "acts", and a separate score reflecting the sum of reports of all "acts" and "urges".

Participants reported urges and acts at rates consistent with population levels and prior research. For example, reports of misuse of medication were the most rare, no healthy participants reported them, but 25% of the clinical sample did (e.g., prior research suggests rates between 0.3 and 11% in nonclinical samples: McCabe et al., 2019; Schepis et al., 2019). Reports of overspending occurred at least one time in 50% of healthy adults and 82% of the clinical sample, consistent with prior research (Hausman, 2000). The percentage of individuals who reported urges and acts of substance use (45% of healthy adults; 69% of patients), avoid social contexts (30% of healthy adults; 81% of patients), and binge eat (40% healthy adults; 60% of patients) were also fairly consistent with prior research and expectations.

Data Analytic Strategy

We performed preliminary analysis to explore how each study variable differed by group as well as to examine associations between rates for each type of behavior within the proposed class and other variables. We sought to demonstrate relative consistency across each behavior in their association to key variables, such as negative affect and symptoms of affective disease. However, to evaluate both theoretical models of cognitive-emotional processing, we used a mixed-model statistical framework. Mixed models allow for the prediction of low-frequency behaviors as they are enacted in real life, while also considering both within- and between-person variability in factors underlying their enactment (Bolger & Laurenceau, 2013). In addition, mixed models have tremendous utility by allowing for more effective modeling of error (variance) and handling of missing data, maximizing measurement sensitivity and the power to detect even small effects. Finally, mixed-models allow for *time* to play a role in the analysis, and to confirm the sequence of effects so that we could test how within- and between-person factors could predict behaviors from one diary signal to the next, including modelling immediate past use of behaviors, reducing the possibility of reverse causation in our models. We confirmed our sample size ($n=52$) and parameter estimates would provide us with adequate power, given the proposed level 1 and level 2 parameters. Based on both convention and estimates derived using power estimation software, we superseded recommendations of $n=50$ participants and $n=50$ responses for the lowest standard error estimates for our proposed models (PinT 2.1: Snijders & Bosker, 1993). Finally, given potential for over-dispersion of counts of low-frequency behaviors, we applied a negative binomial distribution (Bolger & Laurenceau, 2013).

We tested each theoretical model separately and compared the model fit statistics and effect sizes of interest to determine the best fitting model. We ran the initial models including all key variables as described above and tested theoretically informed interactions, including the moderation of person-centered deviations of (state) negative emotion by trait rumination (i.e., the Emotional Cascade model), as well as working memory by mean (trait) negative emotion (i.e., the two-dimensional model). Finally, we considered key covariates such as age, sex, race, education, and verbal IQ and we reran analyses switching out RSPAN scores with Stroop scores to test if any associations for working memory would be present for broader indices of executive functioning. Importantly, we did not anticipate that the underlying cognitive-emotional processes driving these behaviors, as

tested in each model, would be different depending on diagnostic status (patients diagnosed with affective disorders versus healthy adults). Indeed, prior research has demonstrated the presence of these behaviors in community samples where we can presume a range of psychological health. However, diagnostic status likely would be predictive of the frequency of behavioral enactment as patients rely on maladaptive regulatory behaviors at far greater rates. Accordingly, we did plan to include diagnostic status in all of our models. However, to be sure that we were not confounding any associations, we did also explore whether associations were maintained without diagnostic status. We did not test for moderation by group status not only because there is little empirical precedent to suggest it, but also because our sample size was not adequate to support rigorous testing of a three-way interaction for each theoretical model.

To test each theoretical model we used mixed-level linear modeling, applying a negative-binomial distribution and a lagged approach, predicting behaviors as a summed score, 0–5, (reflecting total reported acts, then also acts + urges) of the five behaviors within the class *in the next diary* signal (typically 2–3 h later) within the Proc Glimmix procedure (SAS, 9.2). Several variables remained consistent across theoretical and statistical models and all model equations are reported in the supplemental materials. Current person-centered negative emotion and current reported behaviors were entered at Level 1 of every model. Level 2 always included diagnostic status (healthy v. clinical) and trait negative affect (person-means across the diary). Moreover, we also initially included IQ, treatment status (current mediation and/or current psychotherapy), positive emotion, age, sex, and race as co-variates, but none meaningfully impacted any associations, nor were significant, apart from sex, and thus all (except sex) were not considered further. All level 2 variables were grand-mean centered, and level 1 variables were person-centered. We employed a spatial-power error structure, and degrees of freedom were restricted to the number of participants (Bolger & Laurenceau, 2013). In preliminary tests, we ran simple models, one with RSPAN-E scores and then one for RSPAN-N scores and the results were similar. We default to reporting RSPAN-E findings and all RSPAN-N models are presented in the supplemental materials.

Results

Preliminary Analysis

We tested group differences for all study variables. As expected, the clinical sample had higher trait rumination, psychological symptoms, reported greater negative affect, lower positive affect, and reported higher rates (sum of reports divided by number of diary signal responses) of maladaptive behaviors (Table 1). There was no difference in rate of substance use, IQ, RSPAN, nor Stroop.

Primary Analysis: Maladaptive Regulatory Behaviors as a Class

To confirm that the group of five behaviors were operating as a class, we examined associations using zero-order correlations (Table 1—Supplemental Materials). Using the mean rate of the enactment of each behavior across the 14-day diary period, we aimed to confirm that each behavior was positively associated with negative affect and symptoms. Positive associations between behaviors and predicted variables were found for each type of behavior except for substance use, which although positively associated with symptoms and negative affect, did not reach significance. In addition, there was an association between RSPAN and negative Stroop scores and social avoidance and substance use. Moreover, as we anticipated both RSPANs were correlated with each other, and inversely with rumination.

Finally, descriptive statistics indicated that most individuals from both groups endorsed some behaviors (only n = 3 healthy and n = 1 clinical reported *no* enactments although the n = 1 clinical did report urges), and there was limited association amongst behaviors. In only 17% of diary signals participants reported more than one behavior (37% clinical/6% healthy). However, we tested this explicitly by performing within-subject comparisons of rates of each behavior using a 5-level within-subject ANOVA, employing contrast coding and Greenhouse Geisser correction due to sphericity assumptions. The dependent variables were rates of each maladaptive regulatory behavior by participant, across the diary. Results indicated a within-subject effect, $F(2.388, 121.78) = 7.39$, $p < .001$, partial $eta^2 = .13$. Across all comparisons, there were two exceptions where the within-person comparison did not reach significance: binge eating and substance use $F(1,51) = 0.69$, $p = .41$; social avoidance and overspending $F(1,51) = 3.50$, $p = .07$. Thus, there was sufficient evidence supporting the practical use of these behaviors as a *class* with clear convergence in common correlates, but significant person-level variability in use.

Primary Analyses: Testing Models of Cognitive-Emotional Processes Driving Maladaptive Behaviors

The Emotional Cascade Model

To test the interaction of ruminative cognition with state negative affect in the probability of engaging in behaviors in the next diary signal (i.e., dependent variables were either acts reported in the next signal -or- acts + urges reported in the next signal), we included the following variables at

Table 2 The solution for fixed effects testing act + urges for each theoretical model with sex as a covariate

Predicting maladaptive behaviors in the next diary signal						Effect size[a]
Fixed effects	Estimate	(SE)	*t*	*p*	95% C.I.	
Emotion cascade model (acts + urges with sex)						
Intercept	−2.10	0.19	−11.04	< .001	−2.48, 1.72	1.53
Sex	0.38	0.12	3.16	< .01	0.14, 0.63	0.16
Current reported maladaptive behaviors	−0.37	0.15	−2.47	0.02	−0.87, −0.07	0.14
Current person-centered negative affect	−0.38	0.17	−2.27	0.03	−0.71, 0.04	0.14
Mean negative affect	0.77	0.13	6.09	< .001	0.52, 1.02	0.34
Trait rumination	0.03	0.02	1.83	0.07	−0.003, 0.06	0.12
Diagnostic status *	0.37	0.10	3.58	< .001	0.16, 0.58	0.36
Rumination × *current* person-centered negative affect	0.0002	0.02	0.01	0.99	−0.04, 0.05	0.00
Two-dimensional model (acts + urges with sex)						
Intercept	−2.20	0.22	−10.24	< .001	−2.63, −1.76	1.56
Sex	0.43	0.14	3.08	< .01	0.15, 0.70	0.18
Current reported maladaptive behaviors	−0.29	0.15	−1.97	0.05	−0.58, 0.01	0.12
Current person-centered negative affect	−0.34	0.15	−2.22	0.03	−0.64, −0.03	0.13
Mean negative affect	0.76	0.13	5.96	< .001	0.50, 1.01	0.34
RSPAN-E	−0.88	0.40	−2.24	0.03	−1.67, −0.09	0.15
Diagnostic status*	0.45	0.09	4.75	< .001	0.27, 0.67	0.46
RSPAN-E × *mean* negative affect	0.14	0.72	0.20	0.84	−1.27, 1.55	0.01

RSPAN Reading Span Task

*Diagnostic Group Membership was coded: Clinical = 1 Healthy = 0

[a]Effect size is the standardized raw score of the fixed effect (Baldwin et al., 2014)

level 1: current person-centered negative affect (state), current person-centered reported behavioral "acts". At level 2 we included: mean negative affect (trait), trait rumination, and diagnostic status (all grand mean centered). We also included a cross level interaction, between state negative affect and trait rumination. The results were consistent across both dependent variables (acts, or acts + urges).

For reported acts in next signal, diagnostic group $B = 0.32$, SE = .12, $p = .009$, trait negative affect, $B = .30$, SE = .16, $p = .058$, and trait rumination $B = 0.05$, SE = 0.02, $p = .036$ all were positively associated with the report of behavioral acts. In addition, state deviations in negative affect (momentary increases) were inversely associated with acts, $B = -.39$, SE = 0.19, $p = .044$. The interaction between state negative affect and trait rumination, a key feature of the emotional cascade model was not predictive of behaviors, $B = -0.03$, SE = 0.02, $p = .28$. Moreover, the report of behaviors in the prior signal, $B = -0.20$, SE = 0.16, $p = .22$, were not predictive of future behaviors.

We reran the model and instead used *reported acts + urges in next signal* as the dependent variable. Most effects were stronger but quite consistent. Specifically, diagnostic group $B = 0.41$, SE = .11, $p = .0003$ and trait negative affect, $B = .63$, SE = .11, $p < .0001$ predicted greater behavioral enactments. Trait rumination, $B = 0.02$, SE = 0.02, $p = .36$ was not a significant predictor of behavior. As in the previous model, momentary increases, or state deviations, in negative affect were inversely associated with acts + urges reported in the next diary signal, $B = -.34$, SE = 0.17, $p = .052$. However, unlike the previous analysis, report of behaviors in the prior signal, $B = -0.38$, SE = 0.15, $p = .016$ *was* predictive of acts + urges in the next signal. As above, the interaction between state negative affect and trait rumination, a key feature of the emotional cascade model, $B = -0.03$, SE = 0.02, $p = .17$, was not a significant predictor of acts + urges in the next diary signal. The inclusion of sex as a covariate did not impact any of the other associations above, but sex was a significant predictor of acts, and acts + urges, $B = 0.37$, SE = 0.14, $p = .011$, such that males had greater reports of acts and urges. These results are reported in their entirety in the supplemental materials and for act + urges with sex in Table 2.

The Two Dimensional Model

To test the interaction of cognitive control (indexed as working memory) with trait negative affect in the probability of engaging in behaviors in the next diary signal, we included the following variables at level 1: current person-centered negative affect (state), current person-centered reported behavioral "acts". At level 2 we included: mean negative affect (trait), RSPAN score, and diagnostic status (all grand

mean centered). We also included the interaction of trait negative affect and RSPAN. The results were fairly consistent across both dependent variables (acts, or acts + urges).

For reported acts in next signal, diagnostic group $B = 0.51$, SE = .11, $p < .001$, and trait negative affect, $B = .35$, SE = .15, $p = .026$, were positively associated with the report of behavioral acts. In addition, state deviations (momentary increases) in negative affect were inversely associated with acts reported in the next signal, $B = -.56$, SE = 0.17, $p = .002$. Moreover, the report of behaviors in the prior signal, $B = -0.12$, SE = 0.16, $p = .46$, was not significant. There was no significant main effect for RSPAN score, $B = -0.72$, SE = 0.48, $p = .14$. However, the interaction term, RSPAN by trait negative affect, the core element of the two dimensional model, was significant, $B = 1.97$, SE = 0.87, $p = .028$. A probe of the interaction revealed that the effects were as predicted by the two-dimensional model (see Fig. 1 in the supplemental materials) suggesting that the fewest maladaptive behaviors were endorsed when RSPAN-E scores were high and trait negative affect was low. We reran the models using *reported acts + urges in next signal as the dependent variable*. Effects were similar for diagnostic group $B = 0.48$, SE = .10, $p < .001$ and trait negative affect, $B = .69$, SE = .11, $p < .0001$, in that both were positively associated with acts and urges. State deviations in negative affect were still inversely associated acts and urges, $B = -.39$, SE = 0.16, $p = .014$, and the report of behaviors in the prior signal, $B = -0.25$, SE = 0.15, $p = .10$, remained non-significant. In this model, there was both a significant main effect for RSPAN score, $B = -1.31$, SE = 0.38, $p = .001$, such that higher working memory was associated with fewer acts and urges. Moreover, the interaction term, RSPAN by trait negative affect the core element of the two-dimensional model, was significant, $B = 1.70$, SE = 0.64, $p = .011$ and a plot of the interaction again revealed effects consistent with the model such that as negative affect increased, individuals with higher RSPAN scores had lower enactment of behaviors (acts + urges). However, the inclusion of sex as a covariate did impact the interaction term, but not other associations. When we included sex in the model, it was a significant predictor of acts and urges, $B = 0.43$, SE = 0.14, $p = .003$ and the interaction term no longer reached significance, $B = 0.14$, SE = 0.72, $p = .84$, but the main effects for both RSPAN and trait negative affect were consistent. The results with sex are reported in Table 2.

Comparison of Theoretical Models

Fit statistics were used to compare statistical models reflecting each theoretical model. Both models had the same degrees of freedom and we relied most on the BIC (Bayesian Information Criterion) and the CAIC (Consistent Akaike Information Criterion) per recommendations (Whittaker & Furlow, 2009). Comparison of values across the analysis for behavioral acts and the analysis for acts + urges, revealed that statistical models based on the two-dimensional theoretical model consistently better fit the data (BIC and CAIC < 7–12) but the difference was minor. However, we calculated effect sizes to aid with comparisons using standardized raw scores for the fixed effects (Baldwin et al., 2014) and because the two dimensional model slightly better fit the data, the overall effect sizes were also larger (see Table 2).

Next, we ran one fully inclusive model predicting acts + urges, to see if the addition of trait rumination into the two-dimensional model would contribute to even better model fit. The fit statistics indicated the model fit improved (BIC and CAIC < 48–52, plus 1df). The results of this all-inclusive model revealed findings consistent with prior analyses, including: significant positive associations between diagnostic status, $B = 0.32$, SE = 0.12, $p = .009$, trait negative affect, $B = 0.42$, SE = 0.16, $p = .010$, and trait rumination, $B = 0.08$, SE = 0.02, $p < .001$. A significant inverse association with state deviations in negative affect, $B = -.41$, SE = 0.17, $p = .018$. Although there was no significant main effect for RSPAN, $B = -.44$, SE = 0.51, $p = .39$, the interaction of trait negative affect and RSPAN remained significant, $B = 3.08$, SE = 0.95, $p = .001$, suggesting that even when considering rumination-specific deficits, the two-dimensional framework was uniquely predictive of maladaptive regulatory behaviors in daily life.

Post hoc *Exploratory Analyses*

We returned to the original models and replaced the RSPAN score with a Stroop score to test if effects present for working memory would also be there for inhibition as indexed in the Stroop. The results indicated no significant association between the negative word Stroop score, B = 0.48, SE = .62, p = .45, nor the neutral word Stroop score, B = 0.15, SE = .66, p = .82 and regulatory behaviors, all other associations remained intact.

In a separate post-hoc analysis, we also explored whether the associations held if we tested enactments of each individual behavior (rather than the behaviors as a class) as the dependent variables. The results were consistent with the primary analysis, such that the main associations were present in the expected direction, though not reaching significance (e.g., RSPAN-E was inversely associated with social avoidance, $B = -2.22$, SE = 1.13, $p = .055$, substance use, $B = -2.77$, SE = 1.48, $p = .067$, binge eating, $B = -1.64$, SE = 1.64, $p = .32$, and misuse of medication, $B = -2.99$, SE = 1.91, $p = .12$).

Finally, we also tested if the associations held if we dropped diagnostic status from our models. In general, all patterns of associations remained consistent, although model fit was worse. However, as expected, variables that are often

a proxy for affective disorders such as trait negative affect and rumination did change somewhat and predicted significantly greater variance in maladaptive regulatory behaviors, yet all other associations remained the same. For example, when testing the Emotional Cascade Model, the effects for rumination, B = 0.04, p = .01, and trait negative affect, B = 0.83, p < .0001 were significant, yet the interaction of state negative affect and rumination remained nonsignificant, B = .002, p = .90 when diagnostic group was excluded. We also explored modeling behaviors in each group separately and the general pattern of findings was consistent across groups albeit not always significant given the small sample sizes.

Discussion

In this investigation, we tested two theoretical models that aim to describe the cognitive-emotional processes underlying the enactment of maladaptive regulatory behaviors in the daily lives of adults with and without current affective disorders, including depression, anxiety and stress disorders. We focused on behaviors previously demonstrated to be enacted in response to high levels of distress and that would be common in both healthy adults and individuals with affective disorders. These behaviors included: binge eating, substance use, social avoidance, overspending, and misuse of medication. Overall, there was sufficient preliminary evidence to support the consideration of these behaviors as a *class*. They demonstrated consistent correlates with elevated negative affect and symptoms as well as in relation to cognitive-emotional processes outlined in dominant theoretical models. They were reported at frequencies consistent with prior research, as patients reported these behaviors at higher rates relative to healthy adults, although the healthy group did report behaviors as well. Moreover, our analysis suggested that individuals routinely enacted one behavior individually, but switched behaviors over time, so broadly consistent with recent theory (Johnson et al., 2013) and the conceptual understanding of these behaviors manifesting as a class.

We compared two theoretical models describing the cognitive-emotional processes that drive this class of behaviors. The first model, the Emotional Cascade Model (Selby et al., 2008) posits that momentary increases in negative emotion are heightened by ruminative cognition, ending in engagement in maladaptive behaviors to distract from or diminish discomfort. The second, the Two-dimensional model, suggests that behavioral regulatory action may be determined by the interaction of bottom-up reactivity, here measured as trait negative affectivity, and top-down executive cognitive resources, measured here as working memory, such that with greater trait negative affectivity, greater top-down cognitive resources are need to effectively regulate the impacts of negative emotion. Overall, both models generally fit the data, however the two-dimensional model appeared to predict greater variance in behaviors. In particular, there was preliminary support for the core element of the two-dimension model: the interaction of top down cognitive control with bottom up reactivity as a significant predictor of reported enactment of these behaviors *as well as* urges to enact these behaviors. Indeed, our data showed a significant increase in the probability of enacting these behaviors with both components of the two-dimensional model, as predicted. In contrast, statistical models testing the Emotional Cascade framework, did not demonstrate the interactive effect of state deviations in negative affect and trait rumination—the core element of the Emotional Cascade Model. There was evidence supporting main effects for rumination, in particular when modelling actual behavioral enactment across the diary. Finally, we also tested a fully inclusive model, integrating trait rumination into the two-dimensional model framework, and found the best model fit, predicting the greatest variance in maladaptive behaviors (acts + urges) over the diary period. In this model, the core component of the two-dimensional model, the interaction of trait negative affect and working memory, as well as trait rumination were all significant predictors of maladaptive regulatory behaviors across the diary. This findings suggests that even when considering a key clinical indicator of regulatory deficits (i.e., ruminative brooding) the two-dimensional model predicted unique variance in maladaptive regulatory behaviors. Importantly, all effects remained consistent even when considering treatment status and diagnostic group.

Although our results provided slightly less support for the Emotional Cascade Model, they did not conflict with it either. The majority of prior research in support of the Emotional Cascade has depended on markedly different methods in different populations. In particular, our models were able to parse state and trait affect and also carefully account for immediate prior use of behaviors. This allowed us to better isolate cognitive-emotional processing facilitating these behaviors in real time, as well as to reduce the probability of reverse causation. Moreover, we targeted individuals with prevalent affective disorders as well as those evaluated to be psychologically healthy. Prior research on the Emotional Cascade Model has either tested it in broader community samples with cross-sectional tools or in high-risk groups with far rarer disorders, such as patients with Borderline Personality. Here, we tested these models in individuals less likely to report multiple behaviors in a given diary signal, as comparted to what is often the case in rarer, high risk disorders where the emotional cascade model has proven quite useful. Importantly, the fully inclusive model, which

incorporated rumination from the emotional cascade model was the most meaningful predictor of maladaptive regulatory behaviors across the 14-day sampling period.

We considered a variety of other factors in our models, to clarify alternative explanations. For example, we tested specifically to see if working memory uniquely predicted variance in behaviors by replacing working memory scores with cognitive inhibition (from an emotion-word Stroop). Stroop scores did not predict behaviors in our models suggesting that working memory may uniquely capture the cognitive control processes underlying the association to regulatory behaviors. We also did find a consistent effect of sex, such that males generally reported greater use of these behaviors. This finding is broadly consistent with a large literature on sex effects relating to externalizing behaviors (some of which were included here). Moreover, notably, the inclusion of sex did diminish the strength of the interaction that is the core of the two-dimensional model. We would argue that this may be power-related rather than evidence of a difference between the sexes in cognitive-emotional processes. Future research, in larger samples with more even gender distribution will be essential to better understanding.

A particular advantage of our approach was that by disentangling moment-level deviations in negative emotion from trait-level tendencies we could test if state increases in negative emotion precede these behaviors. Interestingly, our data did not support that pattern of findings. Indeed, we found that state deviations in negative affect appeared to *decrease* just prior to behavioral enactments. Although this may seem unlikely, there is prior evidence of a similar affective dynamic in research that has closely examined a severe behavior within this class: non-suicidal self-injury (NSSI). Indeed, because of the high risks associated with NSSI, it has received considerable research attention and some findings have indicated a drop in negative affect just before enactment (Houben et al., 2016). However, importantly, we did not prompt diary responses more than 5 times daily over the 14 days because of concerns about burden on participants and our sample size was limited. Thus, we may not have been able to capture state increases in negative emotion given the sampling framework within the limits of variability in this sample. This will be important to test with higher intensity sampling protocols in future research as well as with laboratory-based paradigms, a current target for our research team. That being said, the data suggest that greater trait negative affectivity predicted these behaviors. However, it is possible, and theory would suggest, that capturing *momentary increases or decreases just before enactment* are clinically relevant and may need to be indexed in closer proximity to the behaviors of interest.

Our results are relevant to the consideration of maladaptive regulatory behaviors as transdiagnostic regulatory phenomena (Johnson et al., 2013). Prior research on maladaptive regulatory behaviors has largely targeted clinical samples at very high risk or only focused on one specific behavior at a time. Our research advances this work by suggesting that there may be common factors predicting all of these behaviors, and that these factors may not be bounded by health status. Indeed, although healthy participants endorsed these behaviors at lower rates, the same processes appeared to predict them. Notably, one key element of all models was that trait negative affectivity, which differed significantly by group, was strongly associated with increased maladaptive regulatory behaviors, which also differed significantly by group (whereas working memory did not differ by group). Accordingly, it will be important in future research to continue to parse explicitly how frequency differences for these behaviors manifest, whether strictly by differences in emotional intensity, or rather the interplay of cognitive-emotional processes as predicted by both theoretical models.

Importantly, these preliminary data help broaden the frame from behavior-specific disease models to the consideration of this as a *class* of maladaptive regulatory behaviors, spanning the spectrum of psychological health. However, although our findings were consistent irrespective of consideration of diagnostic status in our models, they remain preliminary. A formal test of moderation is needed to confirm these effects, and thus replication in a far larger sample that can support a rigorous test of a three-way interaction is an important next step. Moreover, our recruitment strategy, which was guided by practical as well as scientific aims, targeted patients with current depression and/or social anxiety given both common and unique emotion-related disruption in these disorders. This led to a sample with a range of anxiety, depression, stress, and even substance use and eating disorders. It is possible that an alternative recruitment approach might result in a different combination of disorders that could impact findings. As such, replication in additional samples is certainly warranted.

We also found evidence suggesting a unique role for working memory in maladaptive behaviors. Indeed, we did not find that simply inhibitory processes (as indexed via Stroop task) predicted variance in behaviors. However, though the effects for working memory are compelling, we only found limited difference in results between the emotional versus neutral versions of the RSPAN. The RSPAN-E effect sizes were slightly larger, consistent with prior research (Coifman et al., 2019). Additional work will need to clarify this further. Moreover, it will be important to verify if similar associations are present with other emotional working memory tasks or alternative cognitive control indices, such as set-shifting.

Finally, there were key limitations to this research. Our sample groups, although likely adequate for these analyses were too small and non-diverse to look within-group for meaningful variability and too small to test three-way

interactions. Indeed, future research oriented towards replication and explication must aim to understand how diagnostic groups or even sub-groups could manifest differently, as well as include greater racial and ethnic diversity. Moreover, we only indexed a small subset of what is a broad class of maladaptive behaviors, and we did not attend to participants' explicit motivations for those behaviors. Those we included are both common behaviors and previously demonstrated to be initiated in response to distress. However, there are other behaviors that might be important to consider in future research, as well as the varied explicit motives that drive them. In addition, our treatment of each of the five behaviors as equally maladaptive may not always be appropriate and hence this should be tested more explicitly in future research. Another concern is that it is increasingly clear that cognitive processing styles and cognitive resources, including ruminative brooding and working memory, do vary over time. Using a trait rumination measure and a one-time index of working memory limited our ability to test variations from moment-to-moment, indeed state indicators of both constructs will be important for future research testing these theoretical models. Finally, we must be cautious and not interpret the lack of significant findings for the interaction in the emotional cascade model, we may have been underpowered to detect this interaction effect.

Despite the limitations, there is clinical significance and utility to even these preliminary results. Most notably, these data provide *novel* evidence of this set of maladaptive behaviors operating as a class in common affective disorders and healthy adults. Given the increasing evidence of behavioral replacement in some disorders (e.g., replacing maladaptive eating behavior with substances: Killeen et al., 2015; Wolfe & Maisto, 2000) or reliance on multiple behaviors (e.g., substance use and social avoidance in social anxiety: Aurora & Coifman, 2020), these data advance the theory that these behaviors relate to each other, and provide preliminary evidence of common underlying emotion-cognitive processes. Importantly, these findings also support the role of working memory within the context of emotion that may be most relevant to understanding regulatory behaviors in daily life. Overall, the results could support treatment development in a variety of ways. Notably, they support the movement to develop treatment protocols that are not disorder or behavior specific, and highlight the way in which cognitive regulatory resources interact with intense negative emotion leading directly to maladaptive behavioral action. Indeed, this finding alone, suggests a need to consider a possible range of behaviors in patients, as well as specific interventions targeting regulatory resources as a driving force underlying the manifestation of these behaviors. Specifically, the results support efforts to build more adaptive regulatory skills in patients and to replace current maladaptive behavioral repertoires with more adaptive responses, consistent with the goals of third-wave treatments that are being increasingly applied (Dialectical Behavior Therapy: Ritschel et al., 2015). Finally, assessment of cognitive-emotion regulatory abilities may also be a consideration in assessment protocols for new patients, to help build better predictive models of treatment response.

In summary, although preliminary, the results of this investigation suggest that the interplay of cognitive control and trait negative affectivity play a role in the endorsement of maladaptive regulatory behaviors in daily life in both impaired and psychologically healthy adults. These associations were maintained when considering momentary deviations in negative emotion, immediate prior use of those behaviors, trait rumination, and treatment status. Our findings are consistent with dominant models of self-regulation, including models of emotion regulation that suggest that top-down cognitive control processes in concert with bottom up reactivity to negative emotional content drive regulatory action. In addition, findings are consistent with other research suggesting that these behaviors should be considered a transdiagnostic class with common correlates and maintaining processes. These results suggest important avenues for future research, and the further development of treatments for patients relying on these behaviors.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10608-021-10284-8.

Funding This study was supported by a Farris Family Foundation Innovation Award to Dr. Coifman.

Declarations

Ethical Approval These data were collected with approval of the Kent State University Institutional Research Board and in accordance with national and international conventions regarding the ethical treatment of human subjects in research.

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