Journal of Affective Disorders 372 (2025) 27–36

Contents lists available at ScienceDirect

Journal of Affective Disorders

journal homepage: www.elsevier.com/locate/jad

Research paper

Anhedonia in flux: Understanding the associations of emotion regulation and anxiety with anhedonia dynamics in a sample with major depressive disorder☆

Michael R. Gallagher [a,b,*], Amanda C. Collins [c,d], Damien Lekkas [c,e], Matthew D. Nemesure [f], Tess Z. Griffin [c], George D. Price [c,e], Michael V. Heinz [c,g], Arvind Pillai [h], Subigya Nepal [h], Daniel M. Mackin [c,d], Andrew T. Campbell [c,h], E. Samuel Winer [i], Nicholas C. Jacobson [c,d,g,h]

[a] Department of Psychology, Mississippi State University, Mississippi State, MS, United States
[b] Department of Psychiatry and Behavioral Health, The Ohio State University Wexner Medical Center, Columbus, OH, United States
[c] Center for Technology and Behavioral Health, Geisel School of Medicine, Dartmouth College, Lebanon, NH, United States
[d] Department of Biomedical Data Science, Geisel School of Medicine, Dartmouth College, Lebanon, NH, United States
[e] Quantitative Biomedical Sciences Program, Dartmouth College, Hanover, NH, United States
[f] Digital Data Design Institute, Harvard Business School, Boston, MA, United States
[g] Department of Psychiatry, Geisel School of Medicine, Dartmouth College, Hanover, NH, United States
[h] Department of Computer Science, Dartmouth College, Hanover, NH, United States
[i] Department of Psychology, The New School for Social Research, New York, NY, United States

ARTICLE INFO

Keywords:
Dampening
Anhedonia
Depression
Ecological momentary assessment
Positivity

ABSTRACT

Negative rumination and emotion regulation difficulties have been consistently linked with depression. Despite anhedonia—the lack of interest in pleasurable experiences—being a cardinal symptom of depression, emotion regulation of positive emotions, including dampening, are considered far less in the literature. Given that anhedonia may manifest through blunted responses to previously positive or enjoyable experiences, it is vital to understand how different positive emotion regulation strategies impact anhedonia symptom severity and how it can vary or change over time. Moreover, understanding the detrimental or protective nature of positive emotion regulation on anhedonia can aid with future anhedonia-focused treatments. Therefore, the current study examined the temporal association between anhedonia dynamics and two different emotion rumination strategies in response to positive emotions: dampening and positive rumination. Depressed persons (N = 137) completed baseline measures of positive emotion regulation, difficulties regulating negative emotions, and anxiety, and completed ecological momentary assessments three times per day for 90 days regarding their depressive symptoms, including anhedonia. We assessed baseline dampening and amplifying scores to predict anhedonia dynamics through four linear models with interactions. Providing partial support for our hypotheses, results indicate that amplifying positivity is positively associated with fluctuations, instability, and acute changes in anhedonia over the course of 90 days; however, neither dampening, difficulties regulating negative emotions, nor anxiety were related to anhedonia dynamics. The current findings suggest that amplifying positivity may be able to predict changes in anhedonia over time and should further be examined as a potential protective factor of anhedonia.

An extensive body of literature suggests that depressed persons display a vigilance of negative information or view the world in a negative light (Beck and Bredemeier, 2016; Gotlib and Joormann, 2010). Negative rumination and emotion regulation difficulties, or engaging in maladaptive responses to negative emotions, have consistently been linked to higher depression scores (Joormann and Stanton,

☆ Author NotePrior to running data analyses, but after data collection ended, we pre-registered our hypotheses and analytic plan on the Open Science Framework (OSF; https://osf.io/58x2n). Relevant data and R code is also publicly available on the OSF page.

* Corresponding author at: Mississippi State University, P.O. Box 6161, Mississippi State, MS, 39762, United States.
E-mail address: mrg463@msstate.edu (M.R. Gallagher).

https://doi.org/10.1016/j.jad.2024.11.059
Received 9 August 2024; Received in revised form 24 October 2024; Accepted 17 November 2024
Available online 25 November 2024

2016; Lyubomirsky and Nolen-Hoeksema, 1993; Nolen-Hoeksema and Morrow, 1991). However, less literature has focused on the tendency for depressed persons to avoid positive information or emotions, including through maladaptive responses, such as dampening (Feldman et al., 2008). Avoidance of positivity may result in, or be a consequence of, anhedonia, which is a core symptom of depression characterized by a lack of interest in or inability to enjoy previously pleasurable activities (Calafiore et al., 2024; Winer and Salem, 2016). Despite prior work outlining the importance of positive emotionality on psychopathology, including depression and anhedonia, positive emotion regulation strategies typically have not received the same amount of attention as negative rumination.

1. Positive emotion regulation strategies in depression

The Responses to Positive Affect questionnaire (RPA; Feldman et al., 2008) is a quintessential measure of positive emotion regulation strategies. Dampening is a unique response pattern that involves reducing the frequency and intensity of positive emotions (Feldman et al., 2008). Diminishing positive emotionality may be done intentionally or reflexively through a pattern of learned behaviors, due to uncomfortability with positive emotions or to avoid potential negative outcomes typically associated with positive emotions (Feldman et al., 2008; Gallagher et al., 2023, 2024). Dampening has been shown to predict future depression severity (Raes et al., 2014) and has a unique association with anhedonia (Werner-Seidler et al., 2013). Whereas the dampening subscale involves diminishing positive emotions, the other two subscales (i.e., emotion-focused and self-focused rumination) involve positive rumination, which involves amplifying positive emotions (i.e., responding to positive emotional states with recurrent positive thoughts and experiences), and positive rumination has been found to be negatively associated with depression severity (Feldman et al., 2008; Li et al., 2017; Werner-Seidler et al., 2013).

Research has established an association between the subscales of the RPA and anhedonia. One subscale, dampening, has demonstrated a unique connection with anhedonia (Joormann and Stanton, 2016; Nelis et al., 2015), which appears to be independent and unique from other depression symptoms (Werner-Seidler et al., 2013). Moreover, anhedonia has been associated with high dampening and low positive rumination concurrently (Nelis et al., 2018). The connection between the responses to positivity and anhedonia has also been examined longitudinally: both high levels of dampening and low levels of positive rumination have predicted greater anhedonia scores longitudinally (Nelis et al., 2018; Yilmaz et al., 2021).

The exact longitudinal association between anhedonia and positive rumination strategies, however, remains unclear with several studies evidencing contrasting findings. In a longitudinal study, dampening was not predictive of anhedonia at a one-year follow up, but was at a two-year follow up, indicating that the stability of anhedonia may influence the predictive power of dampening, depending on the timeframe (Nelis et al., 2018). Additionally, other work has demonstrated no significant association between dampening or positive rumination and depression (Johnson et al., 2008). Furthermore, the potential inverse association between positive rumination and depression symptoms remains even more uncertain, as evidenced by a study showing that positive rumination was associated with higher depression scores in children at high risk for depression (Gilbert et al., 2017).

Given the accumulation of evidence for the potential roles of dampening and positive rumination on depression (Bean et al., 2022), it is vital to examine these associations to better understand how dampening influences daily symptom dynamics in anhedonia, both over time and through ecologically-valid measurements. Research has shown that individuals display substantial changes in depression symptoms over time, with changes happening within and across days (Nemesure et al., 2024; Thompson et al., 2012). This is also shown in the affect literature as well: dynamic indices for positive and negative affect are related to the development, maintenance, severity, and remission of MDD (Funkhouser et al., 2021; Houben et al., 2015; Kuppens et al., 2012; Schoevers et al., 2021). Thus, investigating changes in affect and individual MDD symptoms, rather than the mean level across time, may provide more detailed information into the course of psychopathology. Indeed, further investigation into how symptoms, including anhedonia, change across time could prove useful for identifying times at which interventions should be delivered when a maladaptive change in symptoms is detected. Moreover, identifying how individual differences in behaviors, including dampening, relate to symptom dynamics could provide information into the specific active ingredients to include (i.e., strategies focused on upregulating positive affect when changes in anhedonia are detected).

Indeed, prior work has examined the influence of daily dampening and positive rumination on depression over a two-week period through daily diary entries (Li et al., 2017), with findings showing that dampening and positive rumination were related to higher and lower depression severity, respectively. This suggests that dampening and enhancing positive affect can have a daily impact on mood. However, additional research regarding the unique impact that dampening and positive rumination may have on depression dynamics or stability over time, as well as the assessment of symptom level dynamics, will be invaluable.

2. Dynamic change metrics

Studying dynamic changes in anhedonia severity over time may aid in a better understanding of the role of dampening and amplifying positive affect as potential risk and protective factors, respectively. A clearer picture of moment-to-moment changes in anhedonia will provide a more nuanced understanding of its course, which can be more sensitive and clinically relevant than solely examining mean levels. Changes in anhedonia symptoms over time can be measured through a variety of related, yet unique change metrics. Past studies have used dynamic metrics to examine changes in depression and affect (Bos et al., 2019; Kline et al., 2024; Koval et al., 2013).

In particular, Kline et al. (2024) used four change metrics to accurately capture changes in depression. For example, standard deviation provides an overall level of variability or average deviation from the mean. Similar to variability but unique due to its temporal nature, root mean square of successive differences (i.e., RMSSD) provides a measure of instability, as it takes into account momentary temporal changes in symptoms (Bos et al., 2019). Inertia is another dynamic change metric that is commonly used in affective research. Inertia provides a measurement of inflexibility based on how well a measurement at one time point can predict that measurement at the next time point (Bos et al., 2019; Koval et al., 2013). Finally, probability of acute change (i.e., PAC) also measures symptom changes, but measures extreme shifts in symptom severity over time. Each of these four dynamic metrics examines symptom changes, but provides unique measurements of symptom dynamics that can aid in overall conceptualization. Therefore, examining anhedonia symptom dynamics through each of these four change variables will provide fine grained data regarding the different ways anhedonia symptoms dynamically change.

3. Anxiety and depression

Another construct that appears to be vital in the development and maintenance of depression is anxiety. Depression and anxiety are highly comorbid and share similar symptoms (Beard et al., 2016; Kalin, 2020; Park and Kim, 2020). Anxiety has been shown to be associated with vigilance to negative information (Winer and Salem, 2016), but recent research has specifically investigated the connection between anxiety and anhedonia. In a longitudinal investigation of the association between anhedonia, anxiety, and depression, anhedonia temporally mediated the association between anxiety and depression (Winer et al.,

2017). Moreover, when these associations were investigated in a different manner, anxiety mediated the connection between anhedonia and depression. These associations are further supported by prior work suggesting that anxiety and anhedonia may both diminish reward-seeking behaviors (Taylor et al., 2022). For example, avoidance of situations due to anxiety may persist if reward is blunted (possibly due to anhedonia).

There is clear symptom overlap and connection between depression and anxiety, but the exact nature of the relationship of anxiety and anhedonia in particular, is not fully understood. For example, prior work has shown that anhedonia mediates the relationship between anxiety and depression (Winer et al., 2017). Expanding these findings, Calafiore et al. (2024) found that anhedonia symptoms serve as a vital connection between anxiety and depression, and proposed a pathway in which anxiety may lead to the development of anhedonic tendencies. Although anxiety may indeed lead to anhedonia, it remains unclear how anxiety is associated with dynamic indices in anhedonia symptoms over time. Therefore, it will be valuable to examine whether anxiety significantly influences anhedonia symptom changes over time, separate from what is captured with the positive emotion regulation strategies commonly seen in depression. Understanding the unique impact of anxiety on anhedonia, independent from that of depression, will help disentangle the interplay and overlapping effects of depression and anxiety. This can aid in the development of more targeted and tailored interventions for individuals that experience comorbid anxiety and depression, which is needed given the prevalence of these comorbid symptoms (Kalin, 2020).

4. Rationale

Prior work has indicated that depressive symptoms can vary dramatically across time, including within hours (Nemesure et al., 2024). Moreover, the temporal association of anhedonia and depression on emotion regulation strategies and emotions has also been explored (van Roekel et al., 2024). However, how emotion regulation, specifically in response to positive emotions, relates to anhedonia dynamics over time has not yet been looked at. This is an important area of investigation and may help us better understand how trait-level behaviors relate to future symptom changes. Thus, the current study sought to investigate whether dampening relates to change indices in anhedonia over time in individuals with elevated depression levels. In addition, we evaluated the impact of other constructs that may also impact anhedonia dynamics, including positive rumination, difficulties with regulating negative emotions, and anxiety. The unique effect of each of these variables on anhedonia was investigated through symptom dynamics over the course of 270 depression EMA measurements (3 measurements per day for 90 days). Our pre-registered hypotheses focus on the unique associations of dampening, amplifying, difficulties with emotion regulation, and anxiety.

Dampening: The current sample consists of participants that began the study with elevated depression symptoms and prior work has indicated that depressed individuals may experience fewer changes in anhedonia and positive emotions given their general tendency to use dampening strategies more (van Roekel et al., 2024). Therefore, we hypothesized that *dampening would have a negative association with variability, instability, and acute changes in anhedonia and a positive association with inflexibility of anhedonia.*

Amplifying: Past work has found a negative relationship between positive rumination and depression (Feldman et al., 2008; Li et al., 2017). Therefore, we also hypothesized that *positive rumination (e.g., amplifying positivity) would have a positive association with variability, instability, and acute changes in anhedonia and a negative association with inflexibility of anhedonia,* such that positive rumination may be associated with decreases in depression due to the ability to effectively prolong the intensity of positive emotions and thus buffering against anhedonia.

Emotion Regulation Difficulties and Anxiety: Emotion regulation difficulties and anxiety appear to be tied to anhedonia (Joormann and Stanton, 2016; Winer et al., 2017), although they do not necessarily encompass an explicit positivity component as do the positive emotion regulation strategies. Thus, we hypothesized that *emotion regulation difficulties and anxiety would have an association with variability in anhedonia (no directionality specified), negative associations with instability of anhedonia, positive associations with inflexibility of anhedonia, and either negative or no associations with acute changes in anhedonia.*

In addition to the primary pre-registered hypotheses, we included exploratory analyses to examine the possible interaction of dampening and positive rumination. While dampening reflects a suppression of positivity and positive rumination represents an amplification of positivity, it may be that the tendency to avoid positivity needs to be present across both response strategies in order to observe anhedonia symptom stability. For example, given that dampening and positivity enhancement have both been previously established in relation to anhedonia, it may require an elevation in dampening and reduction in positive rumination in order to observe anhedonia stability. Depression appears to be partially driven not only by a mere lack of positive emotionality, but a reverse calibration in how positivity is processed (Winer and Salem, 2016). Low positive rumination scores may only exhibit a relation with anhedonia symptom changes when dampening is high, signaling an active suppression of positivity rather than low positive emotionality. Therefore, we also examined the interaction of dampening and positive rumination in relation to anhedonia symptom changes.

5. Method

The current study was approved by the Committee for the Protection of Human Subjects at Dartmouth College (STUDY00032081) and participants provided both written and verbal consent prior to taking part in study procedures.

5.1. Participants

Participants aged 18 or older were recruited online across the United States using a targeted ad for depression on Google and Meta Ads from February 17, 2021 to December 1, 2023. Upon clicking on the ad, participants were redirected to the screening website where they read through the informed consent and completed self-report measures to confirm that they (1) were 18 years of age or older, (2) used an Android as their primary mobile device, and (3) met criteria for current MDD. We implemented several verification checks throughout our initial data collection steps to ensure data quality and to limit the number of fraudulent responses: (1) CAPTCHA verification, (2) IP address restriction to allow only one-time screener access, (3) phone verification via text, (4) physical address verification to confirm residence within the United States, and (5) use of Qualtrics fraudulent checks, including bot detection.

Individuals who completed the screener steps, met initial eligibility requirements, and did not have their responses flagged as fraudulent, were deemed eligible based on their PHQ-9 scores ($\geq$ 10). Eligible individuals were then invited to complete a 20-min screener via Zoom with a research assistant to assess their current depressive symptoms and possible exclusion symptoms (e.g., mania symptoms, psychotic symptoms, or suicidal thoughts and behaviors). Participants who remained eligible following this screener were next invited to complete the final screener: the clinician-administered Structured Clinical Interview for DSM-5 (SCID-5) with a trained study clinician (e.g., a board-certified psychiatrist or clinical psychology fellow) via Zoom. Participants who met criteria for current MDD (i.e., in the past 30 days) via SCID-5 were eligible to participate in the main study. Participants who endorsed a history of (1) mania symptoms, (2) psychotic symptoms, or (3) active suicidal thoughts and behaviors at any time during the screening process (i.e., from the initial screener through the SCID-5) were excluded from participating in the main study.

6. Measures

6.1. Patient health questionnaire-9

The Patient Health Questionnaire-9 (PHQ-9) is a 9-item self-report measure that assesses the frequency and severity of the nine MDD symptoms (Kroenke and Spitzer, 2002). In the current study, participants completed a mobile-friendly PHQ-9 developed and validated to assess for momentary changes in MDD symptoms (i.e., from prompt to prompt; Torous et al., 2015). Each PHQ-9 item begins with the prompt "In the past 4 hours, I have …" and is scored on a sliding scale ranging from 0 (not at all) to 100 (constantly). Prior to starting the EMA portion of the study, participants met with the study coordinator to receive a study orientation, including instructions to respond to each EMA item with the following range in mind: the least (i.e., 0 or "not at all") to the most (i.e., 100 or "constantly") they had ever experienced that symptom in their life. Participants were given these instructions to provide the same reference point for all participants and to minimize artificial floor and ceiling effects (Nemesure et al., 2024).

The PHQ-9 was administered as an EMA, and participants completed 3 EMAs per day. Only the anhedonia item of the PHQ-9 (i.e., item 1) was included in the current set of analyses, given the primary focus on assessing changes in anhedonia: "In the past 4 hours, I have had little interest or pleasure in doing things" using the sliding scale described above. This item demonstrated strong construct validity with a high correlation ($r = 0.698$, $p < 0.001$) with the anhedonia item on the traditional PHQ-9, which participants completed at the end of the study. The PHQ-9 EMA also demonstrated good internal consistency ($\alpha = 0.906$; Haddox et al., 2024).

6.2. Responses to positive affect

The Responses to Positive Affect (RPA) questionnaire is a 17-item self-report measure that assesses how participants respond to the experience of positive emotions. Although there are three subscales to the RPA, dampening, self-focused positive rumination, and emotion-focused positive rumination, prior work has combined the two positive rumination subscales into a larger amplifying subscale due to subscale overlap (Bijttebier et al., 2012; Gilbert et al., 2017; Li et al., 2017; Nelis et al., 2016). The dampening subscale represents a tendency to decrease the intensity or frequency of positive emotions and contains 8 items. The amplifying subscale is opposite and represents a tendency to increase the intensity or frequency of positive emotions and contains 9 items. Items are scored on a 4-point Likert scale from 1 (almost never) to 4 (almost always). The RPA has demonstrated good internal consistency, with a meta-analysis demonstrating an average Cronbach's alpha of 0.80 across over 40 different studies (Bean et al., 2022). In the current study, the RPA also demonstrated good internal consistency ($\alpha_{Total} = 0.81$; $\alpha_{Dampening} = 0.89$; $\alpha_{Amplifying} = 0.91$).

6.3. Generalized anxiety disorder questionnaire-IV

The Generalized Anxiety Disorder Questionnaire-IV (GAD-Q-IV) is a 14-item self-report measure that assesses the DSM-5 criteria for generalized anxiety disorder (GAD; Newman et al., 2002). Eleven items are scored on a dichotomous scale (i.e., "yes" or "no") to assess for the presence of GAD symptoms (e.g., "Do you experience excessive worry?"). Two items are scored on a 9-point Likert scale ranging from 0 (not at all/no distress) to 8 (very severely/very severe distress) to assess for the extent that the GAD symptoms interfere with their life or are distressing. One item is open-response and participants write up to 6 topics that they worry about excessively and uncontrollably, and a score is derived from this item by counting the number of topics that they provide. In the current study, we scored the GAD-Q-IV using a dimensional scoring system to create a continuous score of anxiety, rather than utilizing a cutoff score to detect a diagnosis of anxiety. The GAD-Q-IV demonstrated good internal consistency in the current study ($\alpha = 0.83$).

6.4. Difficulties with emotion regulation scale

The Difficulties with Emotion Regulation Scale (DERS) is a 36-item self-report measure that assesses the extent to which someone has difficulties regulating their emotions (Gratz and Roemer, 2004). Items are scored on a 5-point Likert scale ranging from 1 (almost never) to 5 (almost always), with 11 items being reverse scored. There are 6 subscales to the DERS, but we opted to score the DERS as a total score to limit multicollinearity in our regression models. A total score was calculated by summing all items after reverse scoring the 11 items, and total scores range from 0 to 180. The DERS has demonstrated good internal consistency in prior work ($\alpha = 0.94$), and the average DERS score of 102.3 in the current study is within prior ranges for moderately-depressed samples (Burton et al., 2022). The DERS demonstrated good internal consistency in the current study ($\alpha = 0.93$), and the subscales also demonstrated good internal consistency ($\alpha = 0.87$–0.91), similar to prior work.

7. Procedure

During the screening process, participants completed a battery of self-report measures, including the RPA, GAD-Q-IV, and DERS. Participants who were eligible for the main study and enrolled completed an onboarding meeting to receive more information on the study procedures, including how to download and use MLife, the mobile application used to collect EMAs. Self-reported wake times provided by participants during the screening process were confirmed at the onboarding meeting, ensuring EMAs were delivered in personalized time frames for each participant. After the screening and onboarding process, participants moved on to completing the main study. This included submitting three, 60–90 s EMAs per day for the study length period of 90 days. Participants were prompted to complete their first EMA of the day 4 h after their self-reported wake time (e.g., if they woke up at 8 am, they would receive their morning prompt at 12 pm). They then received two more prompts during the day, also spaced four hours apart from one another (e.g., afternoon EMA prompt at 4 pm and evening EMA prompt at 8 pm). Participants had 4 h to complete each EMA and were compensated $1 for each EMA that they completed throughout the 90-day study.

7.1. Planned data analysis

The current sample includes 146 persons who met criteria for a current major depressive episode (i.e., in the past 30 days). Using an a priori and pre-registered cutoff decision, we excluded participants from analyses if they had fewer than 30 instances of paired consecutive EMAs (e.g., completing a morning and afternoon EMA in the same day constituted a "paired consecutive EMA" whereas completing a morning and evening EMA, but skipping the afternoon EMA, was not considered a "paired consecutive EMA"). Nine participants did not meet this criteria and were excluded (6.2 %), resulting in data for 137 participants (Table 1). The average EMA compliance across the sample was 87.48 %.

Dynamic changes in anhedonia severity were assessed via four variables: (1) standard deviation (SD), or the dispersion of symptom fluctuations from the mean and their magnitude, (2) root mean square of successive differences (RMSSD), which measures instability (Bos et al., 2019), or the magnitude and temporal association of moment-to-moment symptom fluctuations, (3) inertia, or first-order autoregressions over time, which measures how anhedonia at one time point can predict anhedonia at the next time point and provides a measure of inflexibility or resistance to change without providing a metric of magnitude (Bos et al., 2019; Koval et al., 2013), and (4) probability of acute change (PAC), which measures acute changes in symptom severity over time (Berner et al., 2017).

The four dynamic variables were derived from prior work investi-

Table 1
Cohort demographics.

Attribute	Value	Mean / Count	SD / %
Age	–	41.09	12.35
Gender	Women	110	80.29 %
	Men	17	12.41 %
	Non-Binary	8	5.84 %
	Other (Prefer to Self-Describe)	2	1.46 %
Transgender	No	131	95.62 %
	Yes	6	4.38 %
Race	White	100	72.99 %
	Black or African American	12	8.76 %
	Asian	10	7.30 %
	More than One Race	10	7.30 %
	Other	4	2.92 %
	American Indian or Alaska Native	1	0.73 %
Ethnicity	Non-Hispanic	116	84.67 %
	Hispanic or Latino	21	15.33 %
Employment	Working–Paid Employee	65	47.45 %
	Not working–Looking for work	23	16.79 %
	Not working–Disabled	17	12.41 %
	Other (Prefer to Self-Describe)	13	9.49 %
	Working–Self-Employed	12	8.76 %
	Not working–Retired	5	3.65 %
	Not working (Temporary Layoff)	1	0.73 %
	Not working–Due to COVID-19	1	0.73 %
Income	Less than $10,000	18	13.14 %
	$10,000 to $19,999	9	6.57 %
	$20,000 to $29,999	12	8.76 %
	$30,000 to $39,999	9	6.57 %
	$40,000 to $49,999	20	14.60 %
	$50,000 to $59,999	8	5.84 %
	$60,000 to $69,999	13	9.49 %
	$70,000 to $79,999	5	3.65 %
	$80,000 to $89,999	9	6.57 %
	$90,000 to $99,999	6	6.57 %
	$100,000 to $149,999	14	10.22 %
	$150,000 or more	14	10.22 %
Education	Less than High School Degree	1	0.73 %
	Trade/Technical School Degree	2	1.46 %
	Associate's Degree	9	6.57 %
	Bachelor's Degree	42	30.66 %
	Master's Degree	19	21.17 %
	Doctoral Degree	5	3.65 %

Note. $N = 137$. Percentages may not sum to 100 % due to rounding error.

gating the role of borderline personality traits in depression dynamics (Kline et al., 2024). Dispersion was calculated for each participant by taking the average SD of each anhedonia EMA response across the 90 days. Instability was derived via RMSSD by calculating a participant's difference scores for the anhedonia item across all consecutive EMA responses. First-order autoregressions (i.e., inflexibility) were calculated by first anhedonia scores in relative time (t), regressing the anhedonia score in a linear fashion on the previous anhedonia score (i.e., the previous EMA), and extracting the coefficient estimate. Lastly, we decided on a predetermined acute change score by examining the absolute value of the difference score between temporally adjacent EMA responses to the anhedonia item (e.g., morning and afternoon EMA in the same day): EMAs at or above the 90th percentile of all temporally adjacent EMA responses for the anhedonia item across all participants indicated an acute change. Equations for each of these four variables are as followed:

$$SD_{anhedonia} = \sqrt{\frac{\sum_{i=1}^{N} (EMA_i - \mu)^2}{N}} \quad (1)$$

$$RMSSD_{anhedonia} = \sqrt{\frac{1}{N-1} \sum_{i=1}^{N-1} (EMA_{i+1} - EMA_i)^2} \quad (2)$$

$$Inertia_{anhedonia} = EMA_{t+1} \sim EMA_t \quad (3)$$

$$PAC_{item} = \frac{1}{N-1} \sum_{i=1}^{N-1} AC_{i+1}, \text{where} AC_{i+1} = 1, \text{if} x_{i+1} - x_i \geq c \quad (4)$$

We stipulated four multiple linear regression models for the primary models with the dependent variables for each model being anhedonia (1) SD (i.e., fluctuations), (2) RMSSD (i.e., instability), (3) inertia (i.e., resistance or inflexibility to change), and (4) PAC (i.e., acute changes). The predictor variables for each of the four models remained the same and included dampening, amplifying, anxiety, and difficulties with emotion regulation. We also stipulated four more multiple linear regression models for the interaction models with the same four dependent variables. The predictor variables for each of these four models diverged from the primary models but remained the same for all interaction models: dampening, amplifying, and the interaction between dampening and amplifying.

7.2. Transparency and openness

Prior to running data analyses, but after data collection ended, we pre-registered our hypotheses and analytic plan on the Open Science Framework (OSF; https://osf.io/58x2n/?view_only=0158ea4daf2648928b513b1ab9b49153). We also conducted a power analysis for multiple linear regression in G*Power and set a medium effect size ($f^2 = 0.15$), similar to past research that found a medium effect size between depression and dampening ($r = 0.34$; Bean et al., 2022), 80 % power, and 4 predictor variables. This power analysis indicated a minimal sample size of 85 being needed with these parameters. Relevant data and R code is publicly available on the OSF page.

8. Results

Data analyses were completed using R (Version 2.2.2) and the *base, dplyr, ggplot2,* and *stats* packages. A correlation matrix and descriptive statistics for all of our predictors and outcomes are available in Fig. S1 and Table S1, respectively.

8.1. Primary models

In our four primary models, we included anhedonia 1) SD, 2) RMSSD, 3) inertia, and 4) PAC as the four outcome variables. The four predictor variables for each model were dampening (RPA), amplifying (RPA), emotion regulation (DERS), and anxiety (GAD-Q-IV). Using the *stats* package in R, we used the following specifications:

$$\text{lm}(\text{outcome} \sim \text{Dampening} + \text{Amplifying} + \text{DERS} + \text{GAD} - \text{Q} - \text{IV})$$

Across three of the models (SD, RMSSD, and PAC), the only significant predictor of anhedonia dynamics was amplifying, or the extent to which someone engages in strategies to increase the frequency or intensity of positive emotions (p-values: 0.001–0.015). There were no significant predictors in the inertia model (p-values $\geq$0.315). Neither dampening, emotion regulation, nor anxiety emerged as significant predictors in any of the models (Table 2).[1] Although prior research has found a medium effect size between dampening and depression (Bean et al., 2022), results from our primary models indicated small effect sizes

[1] We also investigated how each variable, when entered alone in the models, was associated with the outcomes. In doing so, we found that none of the variables were significantly associated with the outcomes in any of the models, except for amplifying in the SD, RMSSD, and PAC models. However, dampening did demonstrate an association with anhedonia SD when it was the only variable in the model, albeit non-significant ($\beta = -0.189$, $p = 0.061$). Thus, the current findings in our primary models remain consistent: only amplifying is associated with anhedonia dynamics and dampening, ER difficulties, and anxiety are not associated with anhedonia dynamics when each variable is included as the sole predictor in the models.

Table 2
Primary model outcomes.

Outcome	Variable	Adjusted R^2	Estimate	*p-value*	95 % CI
Anhedonia SD	Dampening	0.044	−0.150	0.217	[−0.389, 0.089]
	Amplifying		**0.248**	**0.015**	**[0.048, 0.448]**
	Emotion Regulation Difficulties		0.018	0.555	[−0.042, 0.077]
	Anxiety		−0.193	0.319	[−0.574, 0.189]
Anhedonia RMSSD	Dampening	0.058	−0.200	0.136	[−0.463, 0.063]
	Amplifying		**0.332**	**0.003**	**[0.112, 0.552]**
	Emotion Regulation		0.034	0.303	[−0.031, 0.100]
	Anxiety		−0.056	0.792	[−0.476, 0.364]
Anhedonia Inertia	Dampening	0.003	−0.001	0.688	[−0.007, 0.005]
	Amplifying		−0.002	0.336	[−0.007, 0.002]
	Emotion Regulation Difficulties		−0.001	0.407	[−0.002, 0.001]
	Anxiety		−0.005	0.315	[−0.014, 0.004]
Anhedonia PAC	Dampening	0.069	−0.002	0.161	[−0.005, 0.001]
	Amplifying		**0.004**	**0.001**	**[0.002, 0.007]**
	Emotion Regulation Difficulties		0.000	0.252	[−0.000, 0.001]
	Anxiety		0.000	0.884	[−0.005, 0.005]

Note. $N = 137$. SD = standard deviation; RMSSD = root mean square of successive differences; PAC = probability of acute change. Significant values ($p < 0.05$) are bolded.

(ranging from 0.003 to 0.075); thus, we used the *pwr* package in R to conduct post-hoc power analyses for all of our primary models by stipulating the adjusted R^2 values (Table 2), a sample size of 137, and 4 predictors. Contrary to our a priori power analysis mentioned above, which stipulated a minimum sample size of 85 participants, the post-hoc power analyses indicated that all models, except for the PAC model, were underpowered to accurately detect significant effects.

8.2. Interaction models

While dampening reflects a suppression of positivity and positive rumination represents an amplification of positive emotionality, it may be that the tendency to avoid positivity needs to be present across both response strategies in order to observe anhedonia symptom stability. Thus, as stated in our pre-registration, we conducted four additional models to investigate the effects of dampening and amplifying, as well as their interactive effect, on our four anhedonia variables. We again included anhedonia 1) SD, 2) RMSSD, 3) inertia, and 4) PAC as the four outcome variables. However, the three predictor variables for each of these models were dampening (RPA), amplifying (RPA), and the dampening x amplifying interaction. Using the *stats* package in R, we used the following specifications:

lm(outcome ~ Dampening * Amplifying)

The interaction of dampening and amplifying was not significant in any of the four models. Unlike in our primary models, within the interaction models, amplifying only emerged as a significant predictor in the RMSSD ($p = 0.035$), and PAC models ($p = 0.013$), and dampening emerged as a significant predictor in the inertia model ($p = 0.045$). There were no other significant predictors in the RMSSD, PAC, and inertia models besides the aforementioned, and there were no significant predictors in the SD model (Table 3). As with our primary models, we conducted post-hoc power analyses using the *pwr* package and stipulated the adjusted R^2 values (Table 3), a sample size of 137, and 3 predictors. These post-hoc power analyses indicated that our SD and inertia models were underpowered to accurately detect significant effects.

9. Discussion

The current study aimed to investigate the influence of emotion regulation strategies in response to positive emotions, namely dampening and positive rumination (i.e., amplifying), on anhedonia symptom dynamics over time in a clinically-depressed sample. Unique and robust change metrics were used to operationalize anhedonia symptom dynamics, providing detailed insight into how anhedonia varies across a 90-day period. Anhedonia scores were measured via ecological momentary assessments (EMAs) completed three times a day for 90 days, resulting in up to 270 anhedonia measurements per participant. The models examined baseline scores of dampening and amplifying in relation to fluctuations, instability, resistance to change, and acute changes in the anhedonia EMAs.

Contrary to our pre-registered hypotheses, dampening, or the tendency to decrease the intensity or frequency of positive emotions, was not significantly associated with anhedonia dynamics in any of the four models; however, this may have been affected by insufficient power in some of our models. Prior work has established an association between dampening and anhedonia (Li et al., 2017; Werner-Seidler et al., 2013) and thus we hypothesized that dampening would be associated with anhedonia stability (i.e., less symptom variability). However, the current null findings may be due to the design and sample used in the current study. Specifically, many past studies that examine these associations utilize either cross-sectional methods, or rather longitudinal measures that obtain measurements of anhedonia after large periods of time (Nelis et al., 2018), and none of these existing studies have investigated anhedonia *dynamics*. Therefore, in an effort to capture fine-

Table 3
Interaction model outcomes.

Outcome	Variable	Adjusted R^2	Estimate	*p-value*	95 % CI
Anhedonia SD	Dampening	0.048	0.098	0.753	[−0.514, 0.709]
	Amplifying		0.489	0.116	[−0.122, 1.100]
	Dampening x Amplifying		−0.014	0.378	[−0.047, 0.018]
Anhedonia RMSSD	Dampening	0.068	0.256	0.451	[−0.414, 0.927]
	Amplifying		**0.722**	**0.035**	**[0.052, 1.391]**
	Dampening x Amplifying		−0.023	0.208	[−0.058, 0.013]
Anhedonia Inertia	**Dampening**	0.018	**−0.015**	**0.045**	**[−0.030, 0]**
	Amplifying		−0.014	0.061	[−0.029, 0.001]
	Dampening x Amplifying		0.001	0.100	[0, 0.001]
Anhedonia PAC	Dampening	0.083	0.004	0.261	[−0.003, 0.012]
	Amplifying		**0.010**	**0.013**	**[0.002, 0.017]**
	Dampening x Amplifying		0.000	0.127	[−0.001, 0.001]

Note. $N = 137$. SD = standard deviation; RMSSD = root mean square of successive differences; PAC = probability of acute change. Significant values ($p < 0.05$) are bolded.

grained symptom dynamics of anhedonia in the current study, anhedonia was measured three times per day for 90 days and used to create change variables. Thus, the current study may build off of prior work and indicate that dampening may not predict moment-to-moment changes in anhedonia severity.

Another potential explanation for the lack of association between dampening and anhedonia is the elevated depression sample used in the current study. All participants in the current sample were screened for a diagnosis of MDD and had elevated depression scores, and thus, most likely, also elevated anhedonia scores. A recent study found that, while individuals with elevated depression symptoms dampen their positive emotions more frequently, this diminishment strategy does not lead to significant decreases in moment-to-moment emotionality (van Roekel et al., 2024). Therefore, individuals with MDD may indeed utilize dampening as an emotion regulation strategy more often than healthy controls, but dampening may not specifically lead to future moment-to-moment decreases in emotionality, possibly due to the elevated levels of negative affect.

9.1. Amplifying positivity

We found that positive rumination, or the tendency to increase the intensity or frequency of positive emotions (i.e., amplifying), was consistently associated with higher levels of anhedonia dynamics. As hypothesized, positive rumination exhibited a positive association with anhedonia SD, RMSSD, and PAC: higher levels of baseline positive rumination predicted dynamic changes in anhedonia severity over time, including extreme shifts in anhedonia. These findings provide clarity to the association between positive rumination and depressive symptoms. Whereas some past studies found evidence for a negative association between amplifying and anhedonia or depression symptoms (Li et al., 2017; Nelis et al., 2018; Yilmaz et al., 2021), other studies did not find such an association emerged (Gilbert et al., 2017; Johnson et al., 2008). Thus, the utilization of anhedonia *dynamics* may add to the inconsistent literature to provide clarity regarding the potential role of positive rumination as a protective factor for anhedonia. Whereas the directionality of change was not examined in the current study, the current findings indicate that positive rumination may play a central role in understanding anhedonia dynamics, and future research would benefit from further examining amplifying as a protective factor. Another area for future research is to examine the impact of daily dampening and amplifying on anhedonia dynamics. The current study assessed the predictive abilities of baseline measures of positive emotion regulation strategies; thus, going forward it will be valuable to better understand how daily dampening and amplifying impact anhedonia symptom dynamics in that same day.

9.2. Anxiety and difficulties regulating negative emotions

Across the four models, neither anxiety nor difficulties regulating negative emotions were associated with dynamic changes in anhedonia; however, some of the models were not adequately powered to detect a true effect and may have been prone to Type II error. This contradicts past findings that have shown a connection between anxiety and anhedonia (Calafiore et al., 2024; Winer et al., 2017), as well as emotion regulation difficulties and depression (Joormann and Stanton, 2016). Again, as noted with dampening, these findings may be due to the dynamic nature of the anhedonia change variables (rather than just overall anhedonia severity). Specifically, anxiety and emotion regulation difficulties may be associated with higher anhedonia scores, but may not be signals of dynamic moment-to-moment changes in anhedonia. Prior research has established a theoretical connection between positive rumination strategies and anhedonia (Werner-Seidler et al., 2013), as positivity avoidance appears to be a transdiagnostic mechanism in both positive rumination and anhedonia. Therefore, the lack of significant association between negative emotion regulation difficulties and anxiety with anhedonia dynamics could partly be due to the nature of the models employed. Specifically, within the context of the linear models, negative emotion regulation difficulties and anxiety may not add significant predictive power in regard to anhedonia dynamics that is above and beyond the positive rumination strategies. Future research can investigate whether anxiety or difficulties regulating negative emotions are associated with dynamics in overall depressive symptoms or the cardinal symptom of depressed mood, rather than anhedonia. Additionally, the current sample was composed solely of participants with a diagnosis of MDD. Therefore, it is possible there was less variability in anhedonia scores given the elevated baseline scores, and future work should investigate these potential associations with anhedonia variability in samples with a wide-range of MDD symptoms, including persons without MDD and those with MDD.

A limitation of the primary models is that we only used linear models to investigate the predictive association of emotion regulation and anxiety with anhedonia dynamics, and it is possible that the nature of these associations may not be best captured through linear modeling, but through other models (e.g., multilevel modeling). However, the goal of the study was to understand how these clinically-relevant constructs related specifically to anhedonia dynamics over time. Given the quantity of anhedonia measurements per participant (i.e., 270 measurements over 90 days), we used robust change metrics to reliably operationalize anhedonia dynamics. Thus, linear models appeared most appropriate to investigate the impact of baseline emotion regulation and anxiety scores on anhedonia dynamics.

9.3. Dampening and amplifying interaction models

The exploratory analyses revealed that the interaction between dampening and amplifying was not a significant predictor of anhedonia dynamics in any of the four interaction models. These findings indicate that the combined effect of dampening and positive rumination is not able to predict changes in anhedonia, although some main effects did emerge. Similar to the main models, positive rumination demonstrated an association with anhedonia RMSSD and PAC (but not with SD, as in the main model): greater positive rumination was associated with greater temporal changes in anhedonia and extreme shifts in anhedonia over time. Interestingly, dampening emerged as a significant predictor in the model with inertia of anhedonia as the outcome, although not in the expected direction. In this model, dampening was *negatively* related to anhedonia inertia, indicating that persons with greater dampening strategies demonstrate a lower resistance to anhedonia change (i.e., anhedonia can vary more). It is important to note that the main effects may be influenced by the presence of an interaction term in these exploratory models and thus, should be interpreted within that context.

9.4. Clinical implications

The current study provides important insight into how behaviors representative of psychopathology, including emotion regulation or rumination strategies, are associated with dynamic changes in anhedonia in a clinical sample. In particular, the current findings suggest that positive rumination is associated with higher levels of anhedonia symptom dynamics, including moment-to-moment fluctuations, instability, and extreme changes. Thus, further upregulating positive emotions may be a protective factor in the consideration of improving anhedonia. There are several existing treatments that focus on upregulating the positive valence systems through savoring or other techniques (Craske et al., 2016; Dunn et al., 2019a; Taylor et al., 2017). These types of treatments have shown promising evidence in their ability to improve anhedonia symptoms over time (Craske et al., 2019; Dunn et al., 2019b; Dunn et al., 2023). In particular, Amplification of Positivity (AMP) has an entire module devoted to capitalizing on the experience of positive emotions, including savoring, telling someone about the positive event, writing, revisiting, and re-experiencing the positive event (Taylor et al.,

2017). These strategies are all related to positive rumination and aim to increase the frequency and intensity of positive emotions. Although treatments focused on upregulating the positive valence systems demonstrate efficacy for anhedonia and depressive symptoms, no known work has investigated moment-to-moment changes in symptoms, including variability, during the course of these treatments.

9.5. Limitations

The target population of the current study included adults with a diagnosis of MDD via the SCID-5. Given that anhedonia is one of the two cardinal symptoms of MDD, this clinical sample was of interest to better understand anhedonia dynamics over time. However, we did not include a control sample (i.e., individuals who did not meet criteria for MDD), and thus the current findings may be specific to those with an MDD diagnosis and may not expand to a general sample. Future research regarding the impact of dampening and amplifying on anhedonia dynamic indices in a community sample and those with co-occurring conditions are needed to further generalize the current findings.

Although our a priori power analysis indicated that we would be adequately powered to detect a medium effect size, the actual effect sizes in our primary and interaction models were smaller, thus impacting the power in our models. Although some of the primary and interaction models were underpowered, we were still able to detect significant associations between amplifying and the different dynamic indices of anhedonia. However, the null findings for some of our predictors (e.g., dampening in most of our models), were contrary to our hypotheses and could be due to Type II error given the low power to detect an effect. Thus, the current study provides a preliminary investigation into how emotion regulation and anxiety relate to dynamic indices of anhedonia, but future research with larger sample sizes is needed to better understand whether these are true null effects or if significant effects between these predictors and the dynamic indices emerge in adequately-powered models.

The current study aimed to recruit a sample that was nationally-representative of the demographic estimates of MDD in the United States. Given that individuals with MDD are primarily women (61 %) and White (65 %; Substance Abuse and Mental Health Services Administrations, 2023), the current sample consisted of a sample of persons only in the United States, and most participants in our sample identified as White, non-Hispanic women. Additionally, over half of the sample reported having a Bachelor's level of education or higher, including a Master's or Doctoral degree. Thus, the findings in the current sample may not generalize to other samples representing other cultures (i.e., Eastern) or demographic characteristics. Moreover, prior work has indicated that individuals from collectivist cultures hold different values regarding positivity (Senft et al., 2021), thus, future work should examine whether these findings replicate in a more diverse sample. Lastly, participants were required to own and use an Android as their primary device due to software constraints of the MLife app. Thus, individuals who used other phones as their primary device (e.g., iPhones) were excluded from the current study. Given that Androids only represent 44.27 % of the market share in mobile operating systems in the United States, it is unclear whether these findings would generalize to other samples in the United States with persons who use an iPhone, which represents 55.42 % of the market share (GlobalStats, 2024).

10. Conclusion

In the current study, we investigated the associations between emotion regulation strategies, particularly dampening and positive rumination, with anhedonia dynamics over time in a clinically depressed sample. We found that, although dampening was not associated with anhedonia dynamics via four models, higher positive rumination was associated with greater dynamic changes in anhedonia in three of the models. These findings suggest that positive rumination may act as a protective factor and may aid in decreases in anhedonia over time. Future research should further investigate the associations between dampening, positive rumination, and anhedonia dynamics in larger, fully-powered samples using both clinical and nonclinical participants and repeated measures of positive emotion regulation strategies over time.

CRediT authorship contribution statement

Michael R. Gallagher: Writing – review & editing, Writing – original draft, Conceptualization. **Amanda C. Collins:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Damien Lekkas:** Writing – review & editing, Investigation, Data curation. **Matthew D. Nemesure:** Writing – review & editing, Investigation. **Tess Z. Griffin:** Writing – review & editing, Project administration, Investigation. **George D. Price:** Writing – review & editing, Investigation. **Michael V. Heinz:** Writing – review & editing, Investigation. **Arvind Pillai:** Writing – review & editing, Software, Investigation. **Subigya Nepal:** Writing – review & editing, Software, Investigation. **Daniel M. Mackin:** Writing – review & editing, Investigation. **Andrew T. Campbell:** Writing – review & editing, Supervision, Software, Investigation. **E. Samuel Winer:** Writing – review & editing, Supervision, Conceptualization. **Nicholas C. Jacobson:** Writing – review & editing, Supervision, Resources, Investigation, Funding acquisition.

Funding

This research was supported by the National Institute of Mental Health (NIMH) and the National Institute of General Medical Sciences (NIGMS) grant R01MH123482 and by the National Institute on Drug Abuse grant T32DA037202.

Declaration of competing interest

NCJ has received a research grant from Boehringer Ingelheim as PI (though there is no salary support or direct payments to NCJ, the grant funds his personnel and his ability to collect data). Additionally, NCJ receives speaking fees and royalties related to publishing a book through the Academic Press.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jad.2024.11.059.

References

Bean, C.A.L., Summers, C.B., Ciesla, J.A., 2022. Dampening of positive affect and depression: a meta-analysis of cross-sectional and longitudinal relationships. Behav. Res. Ther. 156, 104153. https://doi.org/10.1016/j.brat.2022.104153.

Beard, C., Millner, A.J., Forgeard, M.J.C., Fried, E.I., Hsu, K.J., Treadway, M.T., Leonard, C.V., Kertz, S.J., Björgvinsson, T., 2016. Network analysis of depression and anxiety symptom relationships in a psychiatric sample. Psychol. Med. 46 (16), 3359–3369. https://doi.org/10.1017/s0033291716002300.

Beck, A.T., Bredemeier, K., 2016. A unified model of depression. Clin. Psychol. Sci. 4 (4), 596–619. https://doi.org/10.1177/2167702616628523.

Berner, L.A., Crosby, R.D., Cao, L., Engel, S.G., Lavender, J.M., Mitchell, J.E., Wonderlich, S.A., 2017. Temporal associations between affective instability and dysregulated eating behavior in bulimia nervosa. J. Psychiatr. Res. 92, 183–190. https://doi.org/10.1016/j.jpsychires.2017.04.009.

Bijttebier, P., Raes, F., Vasey, M.W., Feldman, G.C., 2012. Responses to positive affect predict mood symptoms in children under conditions of stress: a prospective study. J. Abnorm. Child Psychol. 40 (3), 381–389. https://doi.org/10.1007/s10802-011-9579-2.

Bos, E.H., De Jonge, P., Cox, R.F.A., 2019. Affective variability in depression: revisiting the inertia–instability paradox. Br. J. Psychol. 110 (4), 814–827. https://doi.org/10.1111/bjop.12372.

Burton, A.L., Brown, R., Abbott, M.J., 2022. Overcoming difficulties in measuring emotional regulation: assessing and comparing the psychometric properties of the DERS long and short forms. Cogent Psychology 9 (1), 2060629. https://doi.org/10.1080/23311908.2022.2060629.

Calafiore, C., Collins, A.C., Miller, J.A.M., Watson, J.C., Winer, E.S., 2024. Examining the unique and interactive impacts of anhedonia and fear of happiness on depressive symptoms. Journal of Affective Disorders Reports 15, 100702. https://doi.org/10.1016/j.jadr.2023.100702.

Craske, M.G., Meuret, A.E., Ritz, T., Treanor, M., Dour, H.J., 2016. Treatment for anhedonia: a neuroscience driven approach. Depress. Anxiety 33 (10), 927–938. https://doi.org/10.1002/da.22490.

Craske, M.G., Meuret, A.E., Ritz, T., Treanor, M., Dour, H., Rosenfield, D., 2019. Positive affect treatment for depression and anxiety: a randomized clinical trial for a core feature of anhedonia. J. Consult. Clin. Psychol. 87 (5), 457–471. https://doi.org/10.1037/ccp0000396.

Dunn, B.D., Widnall, E., Reed, N., Owens, C., Campbell, J., Kuyken, W., 2019a. Bringing light into darkness: a multiple baseline mixed methods case series evaluation of augmented depression therapy (ADepT). Behav. Res. Ther. 120, 103418. https://doi.org/10.1016/j.brat.2019.103418.

Dunn, B.D., Widnall, E., Reed, N., Taylor, R., Owens, C., Spencer, A., Kraag, G., Kok, G., Geschwind, N., Wright, K., Moberly, N.J., Moulds, M.L., MacLeod, A.K., Handley, R., Richards, D., Campbell, J., Kuyken, W., 2019b. Evaluating augmented depression therapy (ADepT): study protocol for a pilot randomised controlled trial. Pilot and Feasibility Studies 5 (1). https://doi.org/10.1186/s40814-019-0438-1.

Dunn, B.D., Widnall, E., Warbrick, L., Warner, F., Reed, N., Price, A., Kock, M., Courboin, C., Stevens, R., Wright, K., Moberly, N.J., Geschwind, N., Owens, C., Spencer, A., Campbell, J., Kuyken, W., 2023. Preliminary clinical and cost effectiveness of augmented depression therapy versus cognitive behavioural therapy for the treatment of anhedonic depression (ADepT): a single-Centre, open-label, parallel-group, pilot, randomised, controlled trial. EClinicalMedicine 61, 102084. https://doi.org/10.1016/j.eclinm.2023.102084.

Feldman, G.C., Joormann, J., Johnson, S.L., 2008. Responses to positive affect: a self-report measure of rumination and dampening. Cognitive Therapy and Research 32 (4), 507–525. https://doi.org/10.1007/s10608-006-9083-0.

Funkhouser, C.J., Kaiser, A.J.E., Alqueza, K.L., Carrillo, V.L., Hoffman, L.M.K., Nabb, C. B., Auerbach, R.P., Shankman, S.A., 2021. Depression risk factors and affect dynamics: an experience sampling study. J. Psychiatr. Res. 135, 68–75. https://doi.org/10.1016/j.jpsychires.2021.01.007.

Gallagher, M.R., Collins, A.C., Winer, E.S., 2023. A network analytic investigation of avoidance, dampening, and devaluation of positivity. J. Behav. Ther. Exp. Psychiatry 81, 101870. https://doi.org/10.1016/j.jbtep.2023.101870.

Gallagher, M.R., Salem, T., Winer, E.S., 2024. When hope springs a leak: aversion to positivity as a key to understanding depressed persons. Curr. Psychol. 43 (8), 7564–7577. https://doi.org/10.1007/s12144-023-04917-2.

Gilbert, K., Luking, K., Pagliaccio, D., Luby, J., Barch, D., 2017. Dampening, positive rumination, and positive life events: associations with depressive symptoms in children at risk for depression. Cognitive Therapy and Research 41 (1), 31–42. https://doi.org/10.1007/s10608-016-9798-5.

GlobalStats StatCounter. (2024). Mobile Operating System Market Share United States of America. Retrieved June 28, 2024 from https://gs.statcounter.com/os-market-share/mobile/united-states-of-america.

Gotlib, I.H., Joormann, J., 2010. Cognition and depression: current status and future directions. Annu. Rev. Clin. Psychol. 6 (1), 285–312. https://doi.org/10.1146/annurev.clinpsy.121208.131305.

Gratz, K.L., Roemer, L., 2004. Multidimensional assessment of emotion regulation and dysregulation: development, factor structure, and initial validation of the difficulties in emotion regulation scale. Journal of Psychopathology and Behavioral Assessment 26 (1), 41–54. https://doi.org/10.1023/b:joba.0000007455.08539.94.

Haddox, D., Mackin, D., Griffin, T., Heinz, M.V., Nemesure, M.D., Collins, A.C., Price, G., Lekkas, D., Pillai, A., Nepal, S., Campbell, A.T., Jacobson, N.C. 2024. Psychometric Properties and Validity of a Mobile Patient Health Questionnaire-9 (MPHQ-9) for Ecological Momentary Assessment in Depressed Adults. Preprints. https://doi.org/10.31234/osf.io/rfvy5.

Houben, M., Van Den Noortgate, W., Kuppens, P., 2015. The relation between short-term emotion dynamics and psychological well-being: a meta-analysis. Psychol. Bull. 141 (4), 901–930. https://doi.org/10.1037/a0038822.

Johnson, S.L., McKenzie, G., McMurrich, S., 2008. Ruminative responses to negative and positive affect among students diagnosed with bipolar disorder and major depressive disorder. Cognitive Therapy and Research 32 (5), 702–713. https://doi.org/10.1007/s10608-007-9158-6.

Joormann, J., Stanton, C.H., 2016. Examining emotion regulation in depression: a review and future directions. Behav. Res. Ther. 86, 35–49. https://doi.org/10.1016/j.brat.2016.07.007.

Kalin, N.H., 2020. The critical relationship between anxiety and depression. Am. J. Psychiatry 177 (5), 365–367. https://doi.org/10.1176/appi.ajp.2020.20030305.

Kline, E.A., Lekkas, D., Bryan, A., Nemesure, M.D., Griffin, T.Z., Collins, A.C., Price, G.D., Heinz, M.V., Nepal, S., Pillai, A., Campbell, A.T., Jacobson, N.C., 2024. The role of borderline personality disorder traits in predicting longitudinal variability of major depressive symptoms among a sample of depressed adults. J. Affect. Disord. https://doi.org/10.1016/j.jad.2024.07.104.

Koval, P., Pe, M.L., Meers, K., Kuppens, P., 2013. Affect dynamics in relation to depressive symptoms: variable, unstable or inert? Emotion 13 (6), 1132–1141. https://doi.org/10.1037/a0033579.

Kroenke, K., Spitzer, R.L., 2002. The PHQ-9: a new depression diagnostic and severity measure. Psychiatr. Ann. 32 (9), 509–515. https://doi.org/10.3928/0048-5713-20020901-06.

Kuppens, P., Sheeber, L.B., Yap, M.B.H., Whittle, S., Simmons, J.G., Allen, N.B., 2012. Emotional inertia prospectively predicts the onset of depressive disorder in adolescence. Emotion 12 (2), 283–289. https://doi.org/10.1037/a0025046.

Li, Y.I., Starr, L.R., Hershenberg, R., 2017. Responses to positive affect in daily life: positive rumination and dampening moderate the association between daily events and depressive symptoms. J. Psychopathol. Behav. Assess. 39 (3), 412–425. https://doi.org/10.1007/s10862-017-9593-y.

Lyubomirsky, S., Nolen-Hoeksema, S., 1993. Self-perpetuating properties of dysphoric rumination. J. Pers. Soc. Psychol. 65 (2), 339–349. https://doi.org/10.1037/0022-3514.65.2.339.

Nelis, S., Holmes, E.A., Raes, F., 2015. Response styles to positive affect and depression: concurrent and prospective associations in a community sample. Cogn. Ther. Res. 39 (4), 480–491. https://doi.org/10.1007/s10608-015-9671-y.

Nelis, S., Luyckx, K., Feldman, G., Bastin, M., Raes, F., Bijttebier, P., 2016. Assessing response styles to positive affect: one or two dimensions of positive rumination in the responses to positive affect questionnaire? Personal. Individ. Differ. 89, 40–46. https://doi.org/10.1016/j.paid.2015.09.031.

Nelis, S., Bastin, M., Raes, F., Bijttebier, P., 2018. When do good things lift you up? Dampening, enhancing, and uplifts in relation to depressive and anhedonic symptoms in early adolescence. J. Youth Adolesc. 47 (8), 1712–1730. https://doi.org/10.1007/s10964-018-0880-z.

Nemesure, M.D., Collins, A.C., Price, G.D., Griffin, T.Z., Pillai, A., Nepal, S., Heinz, M.V., Lekkas, D., Campbell, A.T., Jacobson, N.C., 2024. Depressive symptoms as a heterogeneous and constantly evolving dynamical system: idiographic depressive symptom networks of rapid symptom changes among persons with major depressive disorder. Journal of Psychopathology and Clinical Science 133 (2), 155–166. https://doi.org/10.1037/abn0000884.

Newman, M.G., Zuellig, A.R., Kachin, K.E., Constantino, M.J., Przeworski, A., Erickson, T., Cashman-McGrath, L., 2002. Preliminary reliability and validity of the generalized anxiety disorder questionnaire-IV: a revised self-report diagnostic measure of generalized anxiety disorder. Behav. Ther. 33 (2), 215–233. https://doi.org/10.1016/S0005-7894(02)80026-0.

Nolen-Hoeksema, S., Morrow, J., 1991. A prospective study of depression and posttraumatic stress symptoms after a natural disaster: the 1989 Loma Prieta earthquake. J. Pers. Soc. Psychol. 61 (1), 115–121. https://doi.org/10.1037/0022-3514.61.1.115.

Park, S.-C., Kim, D., 2020. The centrality of depression and anxiety symptoms in major depressive disorder determined using a network analysis. J. Affect. Disord. 271, 19–26. https://doi.org/10.1016/j.jad.2020.03.078.

Raes, F., Smets, J., Wessel, I., Van Den Eede, F., Nelis, S., Franck, E., Jacquemyn, Y., Hanssens, M., 2014. Turning the pink cloud grey: dampening of positive affect predicts postpartum depressive symptoms. J. Psychosom. Res. 77 (1), 64–69. https://doi.org/10.1016/j.jpsychores.2014.04.003.

Schoevers, R.A., van Borkulo, C.D., Lamers, F., Servaas, M.N., Bastiaansen, J.A., Beekman, A.T.F., van Hemert, A.M., Smit, J.H., Penninx, B.W.J.H., Riese, H., 2021. Affect fluctuations examined with ecological momentary assessment in patients with current or remitted depression and anxiety disorders. Psychol. Med. 51 (11), 1906–1915. https://doi.org/10.1017/S0033291720000689.

Senft, N., Campos, B., Shiota, M.N., Chentsova-Dutton, Y.E., 2021. Who emphasizes positivity? An exploration of emotion values in people of Latino, Asian, and European heritage living in the United States. Emotion 21 (4), 707–719. https://doi.org/10.1037/emo0000737.

Substance Abuse and Mental Health Services Administrations, 2023. 2022 National Survey on drug use and health. https://www.samhsa.gov/data/sites/default/files/reports/rpt42728/NSDUHDetailedTabs2022/NSDUHDetailedTabs2022/NSDUHDetTabsSect6pe2022.htm.

Taylor, C.T., Lyubomirsky, S., Stein, M.B., 2017. Upregulating the positive affect system in anxiety and depression: outcomes of a positive activity intervention. Depress. Anxiety 34 (3), 267–280. https://doi.org/10.1002/da.22593.

Taylor, C.T., Hoffman, S.N., Khan, A.J., 2022. Anhedonia in anxiety disorders. In: Pizzagalli, D.A. (Ed.), Anhedonia: Preclinical, Translational, and Clinical Integration. Springer International Publishing, pp. 201–218. https://doi.org/10.1007/7854_2022_319.

Thompson, R.J., Mata, J., Jaeggi, S.M., Buschkuehl, M., Jonides, J., Gotlib, I.H., 2012. The everyday emotional experience of adults with major depressive disorder: examining emotional instability, inertia, and reactivity. J. Abnorm. Psychol. 121 (4), 819–829. https://doi.org/10.1037/a0027978.

Torous, J., Staples, P., Shanahan, M., Lin, C., Peck, P., Keshavan, M., Onnela, J.P., 2015. Utilizing a personal smartphone custom app to assess the patient health Questionnaire-9 (PHQ-9) depressive symptoms in patients with major depressive disorder. JMIR Mental Health 2 (1), e8. https://doi.org/10.2196/mental.3889.

van Roekel, E., Erbas, Y., Everaert, J., D'ejonckheere, E., Maciejewski, D., 2024. Understanding Daily Positive Emotion Regulation: Examining Associations with Momentary Emotions and Anhedonia [Preprint].

Werner-Seidler, A., Banks, R., Dunn, B.D., Moulds, M.L., 2013. An investigation of the relationship between positive affect regulation and depression. Behav. Res. Ther. 51 (1), 46–56. https://doi.org/10.1016/j.brat.2012.11.001.

Winer, E.S., Salem, T., 2016. Reward devaluation: dot-probe meta-analytic evidence of avoidance of positive information in depressed persons. Psychol. Bull. 142 (1), 18–78. https://doi.org/10.1037/bul0000022.

Winer, E.S., Bryant, J., Bartoszek, G., Rojas, E., Nadorff, M.R., Kilgore, J., 2017. Mapping the relationship between anxiety, anhedonia, and depression. J. Affect. Disord. 221, 289–296. https://doi.org/10.1016/j.jad.2017.06.006.

Yilmaz, M., Psychogiou, L., Ford, T., Dunn, B.D., 2021. Examining the relationship between anhedonia symptoms and trait positive appraisal style in adolescents: a longitudinal survey study. J. Adolesc. 91, 71–81. https://doi.org/10.1016/j.adolescence.2021.07.007.