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ORIGINAL ARTICLE

The Impact of Emotion Regulation on the Relationship Between Momentary Negative Affect and End-of-Day Worry and Rumination

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Abstract

Background Negative self-referential processing (NSRP), including worry and rumination, is a hallmark feature of generalized anxiety disorder (GAD). Negative affect relates to NSRP, and emotion regulation skills (e.g., reappraisal and acceptance) may attenuate this relationship. This ecological momentary assessment study explored whether increased emotion regulation skills use would alter associations between daily fluctuations of negative affect and end-of-day NSRP.

Methods Participants were 99 young adults ($M_{age} = 19.94$; $SD = 1.81$), diagnosed with GAD (n = 48) and healthy controls (n = 51). They provided twice daily ratings of negative affect, reappraisal, and acceptance over 14 days, and end-of-day ratings of NSRP. Mixed linear models adjusted for covariates, including state-level worry and rumination.

Results Individuals with GAD reported higher levels of negative than controls, and high negative affect corresponded to greater end-of-day NSRP across all participants. Increased emotion regulation skills altered the relationship between increased negative affect and higher NSRP, though this did not differ by group. Acceptance and reappraisal differentially affected associations between negative affect and NSRP.

Conclusions Findings suggest that emotion regulation skills moderate the relationship between negative affect and end-of-day NSRP, highlighting the utility of using reappraisal and acceptance in daily life. This could eventually lead to improvements in treating GAD.

Keywords Emotional regulation · Negative affect · Generalized anxiety disorder · Rumination · Worry · Ecological momentary assessment

Introduction

Negative self-referential processing (NSRP) (Jones et al., 2008; Olatunji et al., 2013; Watkins, 2008) represents a transdiagnostic feature of many forms of psychopathology, including the impairing and difficult to treat "distress disorders," such as major depressive disorder (MDD) and generalized anxiety disorder (GAD) (Clark & Watson, 2006). Two forms of NSRP have received notable empirical investigation: worry, or repetitive negative thinking about the future aimed at reducing perceived future threats (Borkovec et al., 2004; Mennin & Fresco, 2013; Newman & Llera, 2011), and rumination, or repetitive negative thinking about the past aimed at reducing perceived loss (Nolen-Hoeksema et al., 2008). Evidence suggests that these processes relate to decreased cognitive and emotion regulation (ER) capacities (Brewer et al., 2011; Whitfield-Gabrieli & Ford, 2012) and subsequent deficits in threat (Lissek, 2012; Whitmer et al., 2012) and reward processing (e.g., Bogdan & Pizzagalli, 2006), which lead to maladaptive behavioral responding to manage emotional/motivational experiences (e.g., Ferster, 1973; Mennin & Fresco, 2013).

NSRP has often been explored in relation to negative affect (NA) as both a global, trait-like tendency (e.g.,

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Fresco et al., 2002; Koval et al., 2012) and as a time-varying, state-like process that covaries with NA over time (Brose et al, 2014). Worry and rumination are now commonly conceptualized and investigated as both an antecedent and a consequence of NA (Colombo et al., 2020; Pavani et al., 2016). Prior findings highlighted this reciprocal relationship, with rumination predicting NA at the following assessment and vice versa (Moberly & Watkins, 2008). Consistent with the habit-goal framework of depressive rumination (Watkins & Nolen-Hoeksema, 2014), daily fluctuations in NA also predicted later rumination and a stronger temporal pairing of NA and rumination was associated with more persistent negative mood states (Hjartarson et al., 2021). Worry may also increase and sustain negative emotions to avoid an upward negative emotional shift from a neutral or positive state to a negative state (Newman & Llera, 2011; Newman et al., 2019).

Adaptive ER strategies, such as acceptance, conceptualized as openness to internal experience without control or avoidance attempts (Hayes et al., 1999; Kohl et al., 2012), and reappraisal, or the process by which situations are reinterpreted to change their emotional salience (Gross, 1998), impact this relationship between NSRP and NA. Mindfulness-based regulation skills, including acceptance, are hypothesized to decrease NA by shifting momentary attention to and facilitating nonjudgement towards emotional experiences (e.g., Blanke et al., 2018), and have shown negative associations with rumination and subsequent reductions in depression (Jain et al., 2007; Svendsen et al., 2017). Acceptance is related to less concurrent rumination and may attenuate the relationship between rumination and NA. For example, when individuals were in a more mindful state, rumination was less strongly associated with increases in NA compared to when they were less mindful (Blanke et al., 2020). Furthermore, the utility of acceptance to down-regulate negative emotions in daily life is likely subject to contextual factors, including negative intensity (Lennarz et al., 2019), and the implementation and variability of acceptance use across levels of emotional intensity negatively predicted symptoms of psychopathology (Aldao & Nolen-Hoeksema, 2012). Evidence also suggests that individuals with GAD less successfully implement acceptance regulatory efforts than healthy controls (Aldao & Mennin, 2012).

Deficits in reappraisal are linked to various forms of psychopathology (Cludius et al., 2020), including GAD (Aldao & Mennin, 2012). Multiple studies draw associations between reappraisal and positive outcomes across different domains (e.g., affective, cognitive, social; see Gross, 2014; O'Toole, et al., 2019). Individuals with GAD report decreased use of reappraisal in daily life versus healthy controls (Ball et al., 2013) and demonstrate downregulation of neural responses during reappraisal from pre- to post-cognitive behavioral therapy (CBT) (Bomyea et al., 2020). CBTs improve reappraisal abilities for individuals with GAD (Draheim & Anderson, 2021) and cognitive reappraisal training effectively attenuates NA (Denny, 2020).

Acceptance and reappraisal are differentiated, in part, by cognitive elaboration, or the degree of linguistic or symbolic processing utilized to enhance or diminish emotional experiences (Badre & D'Esposito, 2007; Renna et al., 2017). Building on Gross' (2015) temporal model of ER, optimal ER may begin by first engaging less elaborative strategies, such as acceptance, followed by more elaborative strategies, such as reappraisal. Individuals with distress disorders, by contrast, utilize elaborative and perseverative processes (e.g., NSRP) more diffusely than is contextually appropriate (Renna et al., 2017). Indeed, increases in these ER capacities mediated symptom change for individuals with GAD in emotion regulation therapy (ERT; O'Toole et al., 2019).

Sheppes et al. (2011) propose negative emotional intensity as a key situational factor influencing the contexts in which individuals prefer differentially elaborative ER strategies (Sheppes et al., 2011). Specifically, less elaborative, attentional deployment strategies (e.g., distraction) are more effective than semantic-based, cognitive strategies (e.g., reappraisal) at high levels of emotional intensity (Sheppes & Levin, 2013). Indeed, Moodie et al. (2020) found that brain regions associated with attention were preferentially engaged by distraction over reappraisal at high intensities (Moodie et al., 2020). Such findings support the notion that attentional strategies are less effortful and more effective than metacognitive strategies in high intensity situations. Taken together, the existing literature provides a theoretical basis for predicting that the relationship between NA on NSRP may vary depending on whether individuals use high or low levels of ER skills (e.g., acceptance and reappraisal).

Investigating ER in the context of daily life is increasingly possible with the use of ecological momentary assessment (EMA) methods (Colombo et al., 2020). This approach allows for assessing ER strategy use within a real-world context to better capture antecedents to and consequences of regulation. Trait measures of ER common to research and clinical settings likely reflect broad tendencies towards strategy utilization in daily life and are not strongly or consistently related to adaptive strategy use measured via EMA (McMahon & Naragon-Gainey, 2020; McRae & Gross, 2020). For instance, McRae and Gross (2020) suggest that while individuals with psychopathology successfully use reappraisal when cued in a laboratory setting, they can fail to appropriately identify everyday moments to utilize this ER strategy. In addition, researchers have encountered discrepancies between trait and momentary experiences of NSRP (e.g., Huffziger et al., 2013; Verkuil et al., 2007), highlighting the necessity of measuring relationships among these constructs in daily life (Rosenkranz et al., 2020). The

Table 1 Participant characteristics, NSRP, ER skills use, and emotionality

	GAD ($n=48$)			Controls ($n=51$)		
	M (SD)	*n*	%	*M* (SD)	*n*	%
Age	20.02 (1.80)			19.86 (1.83)		
WVAS	44.40 (25.22)			29.67 (22.59)		
RVAS	31.91 (24.14)			19.44 (18.88)		
Gender (% Female)		30	62.5		29	56.9
Race						
White		10	20.8		16	31.4
African American		13	27.1		10	19.6
Asian/Pacific Islander		16	33.3		13	21.6
Hispanic/Latino		8	16.7		9	17.6
American Indian		0	0		1	2.0
Other/Mixed Race		1	2.1		0	0
Worry	12.88 (4.94)			9.28 (4.07)		
Rumination	9.37 (3.75)			7.56 (3.24)		
Acceptance	2.25 (1.00)			2.24 (0.91)		
Reappraisal	2.75 (1.05)			2.94 (1.00)		
Negative affect	17.94 (7.17)			14.61 (4.85)		
Positive affect	21.47 (7.73)			24.35 (7.84)		

M mean, *SD* standard deviation, % percentage of participants, WVAS/RVAS Worry and Rumination Visual Analog Scales. The following data was missing per group: GAD (Age: 4; Gender: 2); Control (Age: 2; Gender: 2; Race: 4). Worry was measured using the Penn State Worry Questionnaire. Rumination was measured using the brooding subscale of the Rumination Scale. Negative affect was measured using the negative affect subscale of the Positive and Negative Affect Schedule. All values reported reflect aggregated means across momentary and end-of-day assessments

use several ER strategies at once is also ubiquitous (Bahlinger et al., 2022; Folkman & Lazarus, 1980), and thus EMA may be used to better understand how different strategies are associated in real-world contexts.

The Current Study

This study tested how momentary NA and ER, measured in an EMA design, predicted end of day ratings of worry and rumination among young adults diagnosed with GAD and psychologically healthy controls. We hypothesized (1) that individuals with GAD would have higher levels of NA, and that higher NA would correspond to higher daily ratings of worry and rumination. We also tested how NA and ER interacted in relation to NSRP, hypothesizing that (2) increased ER skills use would alter the relationship between high NA and increased worry and rumination, and that this effect would be weaker for people with GAD relative to controls. Finally, we hypothesized (3) that the relationship between the level of NA and NSRP would vary depending on ER skill use (i.e., acceptance vs. reappraisal). Specifically, we expected that acceptance would be more effective at reducing worry and rumination when NA was high (vs. low). In contrast, we predicted that acceptance and reappraisal would be equally effective at reducing worry and rumination when NA was low (vs. high).

Methods

Participants

Participants were 99 young adults ($M_{age}=19.94$; $SD=1.81$) diagnosed with GAD ($n=48$) and healthy controls ($n=51$). Demographics are presented in Table 1. Participants were required to be over 18 years old and able to read and understand English. A random sample of college undergraduates, taken from the University's undergraduate email directory, were approached via email. Interested students completed a screening questionnaire, which included demographic and contact information, as well as a brief assessment of GAD-related symptoms (Generalized Anxiety Disorder Questionnaire–IV; GAD-Q-IV; Newman et al., 2002). A sub-sample of participants with high and low scores on the GAD-Q-IV were randomly selected (ensuring appropriate distribution of GAD symptom severity) to participate in a semi-structured diagnostic interview confirming eligibility (e.g., primary

diagnosis of GAD or no psychological disorders for healthy controls). Following the eligibility interview, 55 individuals with confirmed GAD diagnoses and 59 healthy controls with no history of past or current psychopathology were invited to participate in the full study. Of these 114 individuals, 15 were excluded from the current analyses due to missing momentary data (7 individuals with GAD, 8 healthy controls).

Aggregated across participants with at least one momentary observation (N = 99), there were a total of 2772 possible observations across all time points. Overall, 1610 observations were completed (58%) and participants completed an average of 16.26 observations (*SD* = 7.64) out of a possible 28 observations. Percentage of missing data did not differ between groups [$t\,(97) = -1.50$, $p < 0.14$].

Overall, 54% of the GAD group reported one or more comorbid psychiatric disorder. A total of 8 individuals met diagnostic criteria for comorbid MDD, 5 met criteria for dysthymia, 6 met criteria for social anxiety disorder, 2 met criteria for panic disorder, 4 met criteria for specific phobia, and 2 met criteria for obsessive–compulsive disorder.

Procedures

All participants completed written informed consent and all procedures were approved by the institution's Institutional Review Board (IRB). Following informed consent, participants attended a screening interview where they were assessed for current mood and anxiety disorders via the SCID-IV (Spitzer et al., 2002). Eligible participants then completed an additional study visit to receive training about the strategies individuals typically use to regulate their emotions. During this training, acceptance and reappraisal were clearly operationalized and participants were provided with two examples (one positive valence example and one negative valence example) of skill use. Reappraisal was described as "thinking about a situation differently in order to change your emotions," and accepting was described as "letting yourself feel your emotions without trying to change to them." This training was conducted to increase internal validity by ensuring that participants all shared an understanding of how constructs of interests were defined. Importantly, participants were *not* taught how to use ER skills or informed about associations between ER skill use and lower NSRP. Also included in the training was a step-by-step explanation of all EMA study procedures (i.e., how to complete prompted momentary and end-of-day assessments on SurveyMonkey) to increase compliance (Trull & Ebner-Priemer, 2020). Participants then immediately began the two-week EMA assessment period. During this period, they received text prompts with a link to SurveyMonkey to complete momentary assessments of ER strategies and NA at two random times per day, once in the morning (between 9am and 12 pm) and once in the afternoon (between 1 and 5 pm). Participants were also emailed a SurveyMonkey link between 7 and 10 pm each of the 14 days to complete to end-of-day ratings of worry and rumination.

Measures

Eligibility Measures

The Generalized Anxiety Disorder Questionnaire-IV (GADQ-IV) The GAD-Q-IV (Newman et al., 2002) is a 9-item self-report measure that was developed for use as an initial screening tool to identify individuals with GAD. The measure assesses GAD symptoms using binary (yes = 1, 0 = no), open-ended, and Likert scale (0–8) questions, with possible scores ranging from 0 to 12 and higher scores indicating greater GAD symptom severity. Cutoffs for high and low GADQ-IV scores in this study were based on values that prior research found to maximize the sensitivity and specificity of the questionnaire to DSM-IV diagnoses of GAD in undergraduate students (i.e., 5.7; Newman et al., 2002).

Structured Clinical Interview for DSM-IV (SCID-IV) The SCID-IV (Spitzer et al., 2002) is a semi-structured diagnostic interview used for assessing lifetime and current psychiatric diagnosis based on DSM-IV criteria. All SCID-IV interviewers were advanced clinical psychology graduate students or post-baccalaureate research assistants who were trained by a licensed doctoral-level clinical psychologist with extensive diagnostic interviewing experience. The supervising clinical psychologist confirmed all diagnoses at consensus meetings where contextual and symptom-related information was provided. Any discrepancies between the SCID interviewer and the supervising clinical psychologist were resolved through discussion during this meeting and, for a diagnosis to be given, there must have been complete agreement. This consensus diagnosing procedure has been used in several other published studies (Mennin et al., 2015; Plate et al., 2016; Renna et al., 2018) and previously reported reliability analyses have demonstrated adequate interrater reliability (K's ranging from 0.89 to 1 for GAD and depressive disorders, and K's ranging from 0.70 to 0.85 for all other disorders) (Plate et al., 2016).

Ecological Momentary Assessment Measures

Positive and Negative Affect Schedule (PANAS) The PANAS (Watson et al., 1988) is a 20-item self-report measure that assesses for positive affect (PANAS PA) and negative affect (PANAS NA) in distinct subscales of 10-items each. The current study utilized both subscales to assess the valence (i.e., positive vs. negative) of intense emotional responses

(i.e., emotionality). Internal consistency across twice daily measurement for 14 days was good to excellent for NA (α = 0.81–0.93) and PA (α = 0.88–0.94).

Emotion Regulation Skills Acceptance and reappraisal were evaluated as ER strategies twice daily for 14 days. ER strategy selection was measured by having participants indicate their use of each strategy twice per day as No (1) or Yes (2). Totals across the day therefore ranged from 1 to 4 (score of 1 indicates that someone reported "No" at one time point and did not complete the second time point), with higher numbers indicating more frequent use of the skill.

End-of-Day Assessment Measures

The Penn State Worry Questionnaire—Past Day (PSWQ-PD) The PSWQ (Meyer et al., 1990) is a widely used 16-item self-report measure of trait worry. In the current study, we selected 5 items from the PSWQ to assess worry during the past day at the end of each of the 14 days. This briefer version was chosen to increase tolerability and reduce burden for participants receiving multiple assessments per day. Participants were asked to rate the following items on a scale from 1 ("Not at all Typical") to 5 ("Very Typical"): (1) My worries overwhelm me (2) I didn't tend to worry about things (3) I found it easy to dismiss worrisome thoughts (4) Once I started worrying, I couldn't stop (5) I worried all day. Cronbach's alpha for the PSWQ-PD ranged from good to excellent (α = 0.83–0.92).

The Brooding Subscale of the Rumination Scale (RS) The RS (Armey et al., 2009; Treynor et al., 2003) is a five-item measure of self-reported rumination uncontaminated with depression symptom content. The Brooding subscale was selected for its relevance to individuals with GAD (e.g., Watkins, 2009). For use in the current study, this measure was edited to assess rumination over the past day and was administered at the end of each of the 14 days. Internal consistency for the RS ranged from acceptable to excellent (α = 0.79–0.93).

Covariates

Worry and Rumination Visual Analog Scales (WVAS; RVAS) The Worry and Rumination Visual Analog Scales (Wichelns et al., 2016) were used to assess subjective changes in participant worry and rumination during momentary assessments twice daily. This measure contains an anchor rating scale from 0 to 100 and asks participants to describe five situations, personal to them, that represent differing degrees of worry or rumination. Participants refer to their anchor ratings and give themselves a score according to how much worry or rumination they are experiencing "at the current moment." Previous research has demonstrated that the WVAS and RVAS are reliable measures of state-level worry and have shown acceptable levels of convergent and discriminant validity among unselected undergraduate and clinical samples (Wichelns et al., 2016).

Data Analysis Plan

All analyses were conducted using SPSS version 29. Preliminary analyses examined bivariate correlations between and among the main study variables. Growth models tested whether worry, rumination, and NA changed throughout the 14 days of the study. Mixed linear models tested the primary hypothesis that ER skills interacted with NA[1] in relation to end-of-day worry and rumination. This modeling approach accounted for the non-independence in participants' data (i.e., the correlation between an individual's scores on the same variable over time) and maximized the use of existing data by including all participants in the analyses, regardless of missing data points (Brauer & Curtin, 2018); the mixed models used restricted maximum likelihood estimation, and a subject-specific random intercept captured the within-subject correlation. Separate models were run for each skill (acceptance or reappraisal) and their interactions with NA as predictors to test whether the relationship between NA and end-of-day NSRP from that same day differed based on skills usage. Independent models were also run for worry and rumination as dependent variables. For all models, momentary data were aggregated by day (Moskowitz & Young, 2006; Shiffman et al., 2008). Significant interactions were probed separately for high and low skills usage (given that total daily scores for skill use ranged from 1 to 4, values of 1 and 2 were considered "low" and 3 and 4 were considered "high"). All models adjusted for multiple comparisons. Given theoretical justification for these models to differ based on group status (GAD or healthy control; e.g., Aldao & Mennin, 2012; Roemer et al., 2009), three-way interactions tested whether effects differed based on group status. All models adjusted for Time (1–14) as a time-varying (level 1) covariate, as well as age, race, gender, state-level worry or rumination, and group (GAD or control) as time-invariant (level 2) covariates. Continuous covariates were grand-mean centered to improve interpretability of the intercepts. To check for the robustness of our results, we performed separate sensitivity analyses. Specifically, we compared findings of the full sample (N = 99) to findings from a subset of the sample that excluded an additional 10 individuals (2 healthy controls, 8 individuals with GAD) with low compliance (i.e.,

[1] Positive affect (PA), though it was not related to major hypotheses, was also examined using the same data analysis procedure. Results have been included as Supplemental Data.

Table 2 Baseline correlations among study variables

	1	2	3	4	5	6	7	8
1. PSWQ	–							
2. RS	0.50**	–						
3. Negative affect	0.65**	0.70**	–					
4. Acceptance	0.22*	0.09	0.23**	–				
5. Reappraisal	−0.02	−0.18	−0.05	0.54**	–			
6. WVAS	0.59**	0.38**	0.62**	0.03	−0.19	–		
7. RVAS	0.48**	0.33**	0.44**	0.18	−0.06	0.32**	–	
8. Age	0.08	−0.06	−0.04	0.16	0.02	−0.02	−0.11	–

*$p < 0.05$, **$p < 0.01$. End-of-day worry was measured using the Penn State Worry Questionnaire (PSWQ). End-of-day rumination was measured using the brooding subscale of the Rumination Scale (RS). Negative affect was measured using the negative affect subscale of the Positive and Negative Affect Schedule. Reappraisal and acceptance were treated as continuous variables in these correlations. Momentary worry and rumination were measured using the Worry and Rumination Visual Analog Scales (WVAS/RVAS), respectively

percentage of missing data was greater than 1.5 SDs above the mean percentage of missing data).

Results

Descriptive Statistics

Table 1 provides descriptive statistics and frequencies of all control variables. There were no differences between those with and without GAD on age ($p = 0.66$), race ($p = 0.45$), or gender ($p = 0.55$). Table 1 presents the means and standard deviations of ER skill use (i.e., acceptance and reappraisal), emotionality (i.e., PA and NA subscales of the PANAS), and end-of-day NSRP (i.e., PSWQ and RS). Growth models revealed that PANAS PA ($b = -0.19$, $SE = 0.06$, $p < 0.01$) decreased over the 14-day study period. No other variables of interest changed significantly over time during the study ($ps > 0.05$). Table 2 provides bivariate correlations among momentary NA, end-of-day NSRP, ER skills use, and covariates of interest at baseline. Independent *t*-tests revealed a significant difference between groups on NA [$t(781.80) = -8.37$, $p < 0.001$], indicating that individuals with GAD experienced significantly more NA than healthy controls. Individuals with GAD also reported experiencing significantly greater end-of-day worry [$t(672.31) = -11.05$, $p < 0.001$] and rumination [$t(689.41) = -7.15$, $p < 0.001$] than healthy controls. Participants with GAD also indicated using significantly less reappraisal than healthy controls [$t(944.68) = 2.95$, $p < 0.01$]; the groups did not differ in their use of acceptance ($p = 0.76$).

Covariates were explored in relation to end-of-day NSRP. Higher WVAS ratings related to higher end-of-day worry ($b = 0.12$, $SE = 0.01$, $p < 0.001$). Group ($b = -3.65$, $SE = 0.31$, $p < 0.001$), gender ($b = 1.75$, $SE = 0.35$, $p < 0.001$), ethnicity ($bs = -3.66$ to 2.83, $SEs = 1.37$–2.01, $p < 0.001$), and age ($b = -0.32$, $SE = 0.09$, $p < 0.001$) were also significantly related to worry at the end of the day. Higher RVAS ratings related to higher end-of-day rumination ($b = 0.08$, $SE = 0.01$, $p < 0.001$). Group ($b = -1.85$, $SE = 0.25$, $p < 0.001$), gender ($b = 1.06$, $SE = 0.27$, $p < 0.001$), ethnicity ($bs = -1.67$ to 1.50, $SEs = 1.03$–1.54, $p = 0.01$), and age ($b = -0.36$, $SE = 0.07$, $p < 0.001$) were also significantly associated with rumination at the end of the day. Time did not relate to end-of-day worry or rumination ($ps > 0.05$).

Sensitivity Analyses

Sensitivity analyses regarding the relationships among momentary ER skill use, NA, and end-of-day NSRP, are reported as Supplemental Data (Table S1). Specifically, results remained stable after removing 10 individuals due to low compliance, resulting in a sample of 89 participants (40 individuals diagnosed with GAD and 49 healthy controls) with 64% overall compliance.

Associations Between Momentary Negative Affect and End-of-Day NSRP

Worry

NA was related to higher end-of-day worry ($b = 0.20$, $SE = 0.03$, $p < 0.001$), indicating that highly negative emotional moments during the day corresponded to higher end-of-day worry.

Rumination

NA was also related to higher end-of-day rumination ($b = 0.27$, $SE = 0.02$, $p < 0.001$), such that higher

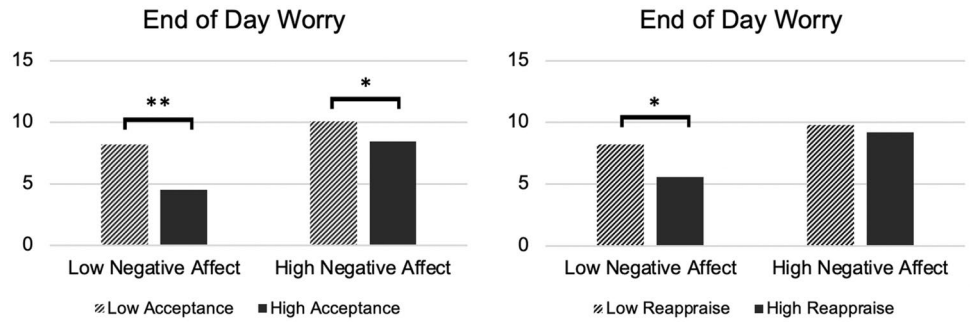

Fig. 1 The effect of high and low ER skills use on worry at different levels of negative affect. *$p < 0.05$, **$p < 0.01$. Negative affect was probed at 1 standard deviation above and below the mean. The left panel represents associations between acceptance and end-of-day worry. Higher use of acceptance corresponded to lower worry when negative affect was both low and high. The right panel represents associations between reappraisal and end-of-day worry. Reappraisal corresponded to lower worry when negative affect was low, but not high

negative emotionality corresponded to increased end-of-day rumination.

Associations Between Emotion Regulation Skills and End-of-Day NSRP

Worry

Acceptance was not associated with end-of-day worry ($b = -0.14$, $SE = 0.32$, $p = 0.67$). In contrast, higher reappraisal use corresponded to lower end-of-day worry ($b = -0.88$, $SE = 0.31$, $p < 0.01$).

Rumination

There were neither main effects of acceptance ($b = -0.44$, $SE = 0.27$, $p = 0.10$), nor reappraisal ($b = -0.17$, $SE = 0.26$, $p = 0.50$) in relation to end-of-day rumination.

Moderating Effect of Emotion Regulation Skills

Worry

Interactions between NA and skill use on end-of-day worry are presented in Fig. 1. Interactions with group were not significant (acceptance: $p = 0.99$; reappraisal: $p = 0.67$) and were therefore removed from the final models. Final models are presented in Table 3. Use of acceptance to regulate emotion throughout the day interacted with NA ($b = -0.16$, $SE = 0.06$, $p < 0.01$). Bonferroni-corrected pairwise comparisons indicated a significant difference between low and high levels of acceptance when NA was both low [$F(1, 547.74) = 8.28$, $p < 0.01$] and high [$F(1, 546.65) = 6.58$, $p = 0.01$]. Specifically, greater use of acceptance was associated with lower worry regardless of the level of NA. Likewise, momentary use of reappraisal significantly interacted with NA to predict end-of-day worry ($b = -0.16$, $SE = 0.05$, $p < 0.01$). Bonferroni-corrected pairwise comparisons indicated that high and low use of reappraisal differentially related to worry when NA was low [$F(1, 566.84) = 5.02$, $p = 0.03$], but not high [$F(1, 574.23) = 1.11$, $p = 0.29$], indicating that increased reappraisal corresponded to lower worry only in low-intensity NA contexts.

Rumination

Interactions between NA and skill use on end-of-day rumination are presented in Fig. 2. Interactions with group were not significant (acceptance: $p = 0.61$; reappraisal: $p = 0.84$) and were thus removed from the final models. Final models are presented in Table 3. Acceptance did not interact with NA ($b = -0.06$, $SE = 0.04$, $p = 0.14$) in relation to rumination. However, there was a significant interaction between the use of reappraisal and NA relating to end-of-day rumination ($b = -0.15$, $SE = 0.04$, $p < 0.001$). Bonferroni-corrected pairwise comparisons indicated a significant difference between low and high levels of reappraisal both when NA was low [$F(1, 550.55) = 11.12$, $p < 0.001$] and high [$F(1, 568.31) = 6.07$, $p = 0.01$], such that higher use of reappraisal was associated with lower rumination regardless of the level of NA.

Discussion

This study used EMA methodology to test relationships among acceptance and reappraisal ER skills, NA, and NSRP for participants with and without diagnoses of GAD. Results highlighted ER skill use as an important moderator of the relationship between momentary NA and later worry and rumination in daily life. We predicted that individuals with GAD would experience higher NA than healthy controls,

Table 3 Final models of skills use × Negative affect on end-of-day worry and rumination

	End-of-Day Worry			End-of-Day Rumination		
	b	*SE*	*p*	*b*	*SE*	*p*
Acceptance						
Intercept	14.78	4.90	< 0.01	11.89	3.80	< 0.01
Group	− 1.65	0.32	< 0.001	− 0.55	0.25	0.03
Gender	0.40	0.33	0.23	0.92	0.25	< 0.001
Race	− 3.48	1.91	0.07	− 2.86	1.50	0.06
Age	− 0.40	0.17	0.02	− 0.32	0.13	0.02
Time	− 0.01	0.04	0.72	− 0.01	0.03	0.83
WVAS/RVAS	0.07	0.01	< 0.001	0.04	0.01	< 0.001
Acceptance	2.64	0.94	< 0.01	0.76	0.73	0.30
Negative Affect	0.31	0.05	< 0.001	0.31	0.04	< 0.001
Acceptance * Negative Affect	− 0.16	0.06	< 0.01	− 0.06	0.04	0.14
Reappraisal						
Intercept	15.61	4.85	< 0.01	12.19	3.75	0.001
Group	− 1.60	0.32	< 0.001	− 0.50	0.25	0.04
Gender	0.50	0.33	0.13	0.96	0.24	< 0.001
Race	− 3.85	1.91	0.04	− 3.35	1.50	0.03
Age	− 0.39	0.17	0.02	− 0.35	0.13	0.01
Time	− 0.02	0.04	0.69	− 0.00	0.03	0.89
WVAS/RVAS	0.07	0.01	< 0.001	0.03	0.01	< 0.001
Reappraisal	1.59	0.85	0.06	2.03	0.66	< 0.01
Negative Affect	0.29	0.04	< 0.001	0.35	0.03	< 0.001
Reappraisal * Negative Affect	− 0.16	0.05	< 0.01	− 0.15	0.04	< 0.001

WVAS/RVAS Worry and Rumination Visual Analog Scales. WVAS was used in the End-of-Day Worry model. RVAS was used in the End-of-Day Rumination model. Worry was measured using the Penn State Worry Questionnaire. Rumination was measured using the brooding subscale of the Rumination Scale. Negative affect was measured using the negative affect subscale of the Positive and Negative Affect Schedule

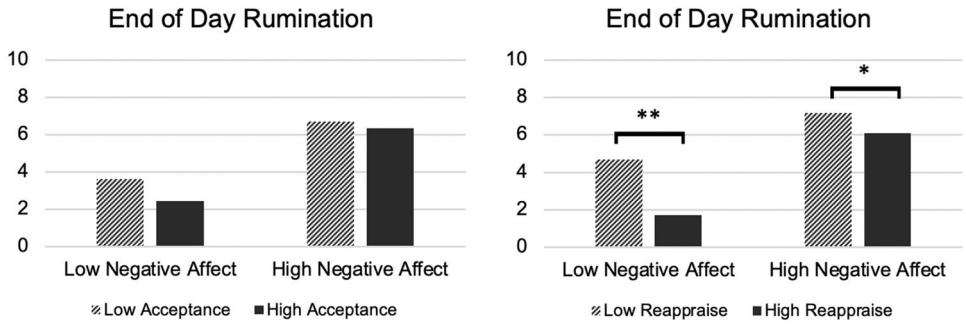

Fig. 2 The effect of high and low ER skills use on rumination at different levels of negative affect. *$p < 0.05$, **$p < 0.01$. Negative affect was probed at 1 standard deviation above and below the mean. The left panel represents associations between acceptance and end-of-day rumination. Acceptance did not interact with negative affect in relation to rumination. The right panel represents associations betweeen reappraisal on end-of-day rumination. Higher use of reappraisal corresponded to lower rumination when negative affect was both low and high

and that higher NA would be associated with greater NSRP at the end of the day. We also hypothesized that greater ER skill use would moderate associations between high NA and increased worry and rumination, and we expected that individuals with GAD would employ ER skills less effectively than healthy controls. Finally, we hypothesized that the relationship between NA and NSRP would vary depending on acceptance and reappraisal skills use. Specifically, consistent with the temporal model of ER (Gross, 2015), we expected that acceptance would be more effective than reappraisal at

reducing NSRP at high levels of NA, while both ER skills would effectively reduce NSRP when NA levels were low.

Consistent with hypotheses, individuals with GAD experienced higher levels of NA than healthy controls, and this high negative emotionality corresponded to greater end-of-day worry and rumination across all participants. Individuals with GAD in our sample experiencing higher levels of NA than healthy controls is aligned with literature suggesting that NA is a primary comorbidity factor among distress disorders, including GAD, MDD, and PTSD (Mennin et al., 2002; Price et al., 2018). Moreover, our findings suggest that NA indeed relates to later NSRP even when controlling for momentary worry or rumination, which suggests that the relationship between momentary NA and end-of-day NSRP is not simply due to a "build-up" of momentary worry and rumination. While most prior literature has explored worry and rumination as generators of subsequent negative mood states (e.g.,McLaughlin et al., 2007), the present findings suggest that higher NA also leads to later engagement with perseverative processes.

Our second hypothesis was partially supported through an interaction between ER skills use and NA on worry and rumination, though the nature of this relationship did not differ between the GAD and healthy control groups. This finding supports the notion that the relationship between NA and NSRP can be attenuated through ER skills at both high (e.g., reappraisal) and low (e.g., acceptance) levels of cognitive elaboration. Indeed, CBTs and mindfulness meditation-based interventions teach ER skills at various levels of cognitive elaboration to treat psychopathology, including refractory conditions characterized by NSRP (Fresco & Mennin, 2019). The results of the present study highlight the importance not only of building ER strategies at various levels of cognitive elaboration, but also of recognizing how such strategies effectively reduce transdiagnostic NSRP throughout daily life. Future research might consider using EMA at multiple timepoints during treatment to better understand how these interventions change one's ability to choose the most effective ER strategy in contexts of varying emotional intensity. Further, in addition to emotional intensity, other contextual factors, including emotion type and daily life events, would be important to explore when considering which ER skills individuals deploy and when (Dixon-Gordon et al., 2015a; Kircanski et al., 2018).

The interaction between momentary ER skills use and NA on later NSRP not differing between individuals with GAD and healthy controls in this study was unexpected. Although several models of GAD highlight the possibility of differences in ER skill deployment between healthy individuals and individuals with mood and anxiety disorders (Fernandez et al., 2016; Picó-Pérez et al., 2017), including GAD (e.g., Mennin et al., 2007; see Newman & Llera, 2011), this study supports the idea that momentary NA and ER skill use are associated with later NSRP both in individuals with and without GAD. This is consistent with research in non-clinical samples suggesting that ER strategies influence the effect of momentary NA on affective experience over time (e.g., Pavani et al., 2016). Moreover, another EMA study found that worry and negative thought valence predict anxious arousal across individuals with GAD and healthy controls, irrespective of group status (Newman et al., 2019).

Importantly, many studies investigating group differences in ER skill use have used experimental paradigms in a laboratory setting, which may not reflect real-world use of ER skills. Indeed, Gruber et al. (under review) emphasize the need for further research exploring differences between regulatory *ability* in laboratory settings versus regulatory *achievement* in daily life for individuals with various forms of psychopathology. Thus, regulatory differences between individuals with GAD and healthy controls may be sensitive to methodological variation and are likely more nuanced than originally hypothesized. For example, Newman et al. (2013) posited that individuals with GAD symptoms fear negative emotional *contrast*, rather than negative emotionality itself, and thus utilize worry to blunt the effects of emotion contrast on future negative emotion (Crouch et al., 2017). Another possibility is that *conflicting* emotional moments (i.e., those with both high NA and high PA) distinguish individuals with GAD from healthy controls. Specifically, individuals with GAD (vs. controls) struggle to effectively regulate emotional conflict (e.g., Etkin & Schatzberg, 2011; Etkin et al., 2010), and demonstrate nonspecific amygdala reactivity to both negative and neutral stimuli (Nitschke et al., 2009). In our study, momentary observations characterized by both high PA and high NA were limited, and we were thus unable to differentiate between moments with conflicting versus congruent levels of NA and PA. Additionally, it may be that frequent occurrence of intense NA—more so than reduced engagement or efficacy of ER—contributes to the NSRP that characterizes GAD (e.g., Decker et al., 2008). Long-term reliance on interpersonal ER (e.g., reassurance-seeking; Hofmann, 2014) could also help explain regulatory differences between groups (Dixon-Gordon et al., 2015b). Taken together, these nuances highlight important avenues for future EMA research. There are also methodological post-hoc explanations for the lack of group differences between individuals with GAD and healthy controls, including that we were likely underpowered for three-way interactions. Non-significant group differences in the overall use of acceptance could also help explain this, at least for interactions that included acceptance as a moderator. Overall, these findings underscore the association between increased ER skills use and lower NSRP regardless of clinical anxiety levels.

Finally, Hypothesis 3, which predicted that the relationship between NA level and NSRP would vary depending on

ER skills use, was supported for end-of-day worry. Specifically, when NA was low, both acceptance and reappraisal related to lower worry at the end of the day; however, when NA was high, only acceptance related to lower worry. This finding supports the framework put forth by Sheppes et al. (2011), which highlights emotional intensity as a moderator of ER choice. Importantly, the theoretical approach of treating NA as a moderator (e.g., Sheppes et al., 2011) is congruent with the present study's interest in ER skills use as a moderator because interactions between NA and ER skills use are of primary interest in both conceptualizations. While originally developed using healthy controls, the ER choice framework has been increasingly used in clinical populations with varied results. Studies using samples of individuals with bipolar disorder, borderline personality disorder, and MDD indicated no between-group behavioral differences in use of distraction and reappraisal at different levels of emotional intensity (Hay et al., 2015; Sauer et al., 2016), though increased distraction use as emotional intensity rises was magnified for individuals with higher levels of fear symptoms (Argyriou & Lee, 2020) and individuals with (vs. without) probable PTSD were less likely to use reappraisal in low intensity contexts (Hannan & Orcutt, 2020). Though findings from our study address ER skill *effectiveness*, rather than *choice*, the results contribute to this larger literature on differential ER skills use in a sample of individuals diagnosed with GAD and healthy controls.

Importantly, the current study utilized in-vivo self-report of acceptance and reappraisal ER skills via EMA, rather than comparing distraction and reappraisal through experimental measurement in a laboratory setting (Sheppes et al., 2011). Previous investigations of ER choice have consistently demonstrated that distraction is preferable to reappraisal at low emotional intensities (e.g., Sheppes et al., 2014), but other ER strategies also fall along this continuum of cognitive elaboration (e.g., acceptance, decentering; Moodie et al., 2020). In the current study, acceptance effectively reduced worry at both high and low levels of NA. Interestingly, while acceptance was not significantly associated with end-of-day worry in the main effect model, there was a significant interaction between acceptance and NA on end-of-day worry. This differential finding could suggest that momentary acceptance without concurrent NA is not meaningfully related to worry at the end of the day, which aligns with literature suggesting that the adaptiveness of mindfulness ER strategies (e.g., acceptance) differs contextually. For example, Mankus et al. (2013) found evidence for mindfulness as an adaptive ER strategy to increase heart rate variability (HRV), but only for individuals with high levels of generalized anxiety symptoms. Specifically, mindfulness was positively associated with HRV for individuals with high (versus low) levels of generalized anxiety symptoms, suggesting that the utilization of adaptive ER strategies is more predictive of improvement in psychopathology outcomes for individuals who use high levels of maladaptive strategies (i.e., compensatory hypothesis; Aldao & Nolen-Hoeksema, 2012). Relatedly, the present findings suggest that acceptance may be most adaptive for reducing worry when considered in the context of NA.

Unexpectedly, the pattern of moderation findings was different for rumination, such that only reappraisal, but not acceptance, reduced rumination in both low and high NA contexts. Both worry and rumination are increasingly recognized as transdiagnostic mechanisms (e.g., Mennin & Fresco, 2013) related to a higher order factor (Samtani et al., 2022), and there have been intervention trials for individuals with primary GAD and elevated levels of rumination that have reliably decreased rumination (e.g., Mennin et al., 2018). Worry and rumination are regularly investigated separately in the context of EMA research on ER and NA, though the more limited number of studies analyzing relations between worry and NA make comparisons with rumination findings difficult (Boemo et al., 2022). This study contributes to the literature by analyzing worry and rumination separately and findings suggests that there may be differences in the way ER processes and NA interact in association with these two forms of NSRP. To this end, there is evidence that momentary worry and rumination impact subsequent NA differently in the context of everyday events (e.g., Kircanski et al., 2018). Moreover, research suggests that worry and rumination are differentially associated with cortisol activity (Lewis et al., 2017), which may interfere with reappraisal generation processes (Tsumura et al., 2015). Thus, it is possible that rumination is less physiologically arousing than worry, making reappraisal easier at both high and low levels of NA. Additionally, while higher acceptance, a non-elaborative ER process, alters the relationship between high-intensity NA and increased worry, a greater degree of elaboration may be required to affect the relationship between NA and rumination at both high and low levels of NA. These findings also suggest a need for future research on emotion-specific effects on the efficacy of various regulatory strategies.

Limitations and Future Directions

These analyses were correlational in nature and causality could not be assessed. We also did not include every variable of interest at both momentary and end-of-day assessment points, and thus we are unable to meaningfully test other effects between and among these variables, including the impact of momentary NSRP on end-of-day NA and ER skill use.[2] Interestingly, in an EMA study of emotional intensity

[2] Although not related to study hypotheses about momentary ER skill use moderating the relationship between momentary NA and end-of-day NSRP, questions about the reverse relationship between end-of-day NSRP and momentary NA and ER skills were also examined. Bidirectional analyses indicated significant associations

and worry in individuals with GAD and healthy controls, Pawluk et al. (2021) found that higher worry was associated with subsequent increased negative emotion, and that this association was more pronounced for the GAD group; however, the authors did not find a bidirectional relationship between emotional intensity and subsequent changes in worry (Pawluk et al., 2021). In support of multiple conceptualizations of NSRP in relation to NA (Newman et al., 2016), researchers use EMA methods to explore worry and rumination as both predictors and outcomes of negative emotionality (Colombo et al., 2019, 2020). Future research should further tease apart the differential impact of skills use in the moment on end-of-day NSRP and vice versa.

Further, given the high rates of comorbidity among the sample of people with GAD in this study, it is possible that observed differences are due to co-occurring mental disorders rather than, or in addition to, the presence of GAD. On the other hand, GAD is a heterogenous disorder (Unick et al., 2009) that is often comorbid with other forms of psychopathology (Kessler et al., 2005), and thus the findings may be more construct- and ecologically valid (Pawluk et al., 2021). Regardless, it likely that some of the rumination findings in this study are due to comorbidity between GAD and MDD, and future research should utilize a larger sample to examine group differences between various forms of "pure" and comorbid psychopathology.

Finally, there are several limitations related to the EMA methodology used in this study that warrant discussion. First, although the use of 2 prompts per day for 14 days falls within the range of past EMA studies investigating mood and anxiety symptomology and related processes, there remains significant methodological variation across EMA studies, which limits generalizability (Hall et al., 2021; Walz et al., 2014). In addition, our compliance rate (58%) was lower than the average for EMA studies, which is closer to 80% (Wrzus & Neubauer, 2022), despite efforts to increase compliance through study procedures training (Trull & Ebner-Priemer, 2020). It is possible that other factors may have reduced compliance for this study, including our use of a student sample and lack of tiered compensation, though findings on the impact of these factors on compliance are mixed (Wrzus & Neubauer, 2022). Future research should reference recent guidelines, systematic reviews and meta-analytic studies when designing EMA studies to maximize compliance rates and increase the potential for comparison across studies (e.g., Hall et al., 2021; Trull & Ebner-Priemer, 2020; Wrzus & Neubauer, 2022).

Footnote 2 (continued)

between increased end-of-day worry ($b = 0.25$, $SE = 0.04$, $p < 0.001$) and rumination ($b = 0.69$, $SE = 0.06$, $p < 0.001$) and higher momentary NA. Results from models testing the relationships between end-of-day NSRP and momentary ER skills were non-significant ($ps > 0.05$), except for increased end-of-day worry significantly corresponding to higher momentary reappraisal ($b = 0.01$, $SE = 0.01$, $p < 0.01$).

Conclusion

Despite limitations, the current study lends valuable information about the use of acceptance and reappraisal across varying levels of NA in daily life. Specifically, this study investigated ER skill use as an important moderator of the relationship between momentary NA and NSRP at the end of the day for those with and without clinical levels of GAD. Less elaborative, attentional ER skills (e.g., acceptance) benefitted individuals in high NA moments, while a broader range of skills, including reappraisal, corresponded to lower NSRP when NA was low. Elucidating the daily, real-world contexts in which ER effectively alters the relationship between NA and later worry and rumination could eventually lead to improvements in treating distress disorders.

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Declarations

Conflict of interest Michal Clayton, Megan E. Renna, David H. Klemanski, Caroline Kerns, Katie A. McLaughlin and Douglas S. Mennin have no known conflicts of interest to disclose.

Informed consent Informed consent was obtained from all individual participants included in the study.

Animal Rights No animal studies were carried out by the authors for this article.

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