

**Investigating State Rumination as a Moderator for the Relationship of Stressfulness of  
Daily Events and Negative and Positive Affect**

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## Abstract

**Background:** Stressful daily events were repeatedly shown to lead to adverse affective responses, with rumination as a key moderator. Recent studies have urged to consider rumination as a state and to investigate the affective response regarding positive affect (PA), in addition to negative affect (NA). This study investigates state rumination as a moderator for the relationship between the stressfulness of daily events and both NA and PA.

**Method:** The current study utilized Ecological Momentary Assessment (EMA) with four daily measures over a 14-day period. Linear Mixed Models (LMMs) were employed to analyze the data of a retained sample of 61 participants (mean age 23.48, 63.49% female).

**Results:** Results indicated a significant positive moderation effect of state rumination on the relationship between the stressfulness of daily events and NA ( $b = .03$ ,  $SE = .01$ ,  $p < .001$ ). Conversely, the moderation effect of state rumination on PA was not statistically significant ( $b = -.01$ ,  $SE = .01$ ,  $p = .19$ ). State rumination and the stressfulness of daily events alone, were associated with a decrease in PA.

**Conclusion:** The findings suggest that state rumination significantly enhances NA responses to more stressful daily events but that it does not significantly alter the relationship between stressfulness of daily events and PA. Stressfulness of daily events and state rumination independently contributed to a decrease in PA, suggesting different pathways of influence that may need separate intervention strategies. Despite limitations like convenience sampling and potentially underpowered moderation analyses, the results offer valuable insights into how state rumination affects responses to daily stressors.

## **Investigating State Rumination as a Moderator for the Relationship of Stressfulness of Daily Events and Negative and Positive Affect**

Investigating how the stressfulness of daily events impact affective responses of individuals has been an important aspect of psychological research (Chahraoui, 1999; Charles et al., 2013; Ryff & Dunn, 1985). One important factor that has been shown to influence this relationship is rumination (Nolen-Hoeksema, 1991; Watkins & Roberts, 2020). Rumination can be considered a putatively maladaptive factor for psychological well-being (Kraiss et al., 2020) and is characterized by repetitive and persistent thoughts about one's distress (Nolen-Hoeksema, 1991; Watkins & Roberts, 2020). Through this focus on distress, rumination may intensify negative experiences in response to stressful daily events by preventing the natural decline of distress (Lyubomirsky & Nolen-Hoeksema, 1995). Moreover, rumination can consume cognitive resources, reducing the ability to shift focus away from the stressful daily life event towards more positive aspects of life (Dhinakaran et al., 2013; van Vugt & van der Velde, 2018). Conclusively, rumination might intensify how the stressfulness of daily events impacts affective responses.

As rumination is defined by the dwelling on negative emotions, its impact on the relationship between the stressfulness of daily events and the affective response is mostly investigated in regard to negative affect (NA) (Nolen-Hoeksema, 1991; Watkins, 2008). However, recent insights suggest broadening this research scope to include positive affect (PA). Layous et al. (2023) and Wong et al. (2023) argue that understanding the impact of rumination on PA in context of stressful daily events is important for a more holistic view of its impact on psychological well-being. This broader perspective aligns with the view that psychological well-being includes, not just the absence of negative symptoms, but also the presence of positive elements (Feldman et al., 2008; Mason Stephens et al., 2023; Vázquez et al., 2009). It emphasizes the need for a comprehensive understanding of psychological well-being, including both NA and PA.

Research has traditionally viewed rumination as a stable trait (Jose, 2015; Kirkegaard Thomsen, 2006), consistently linking it to NA across different clinical and non-clinical populations (Grierson et al., 2016; Joormann, 2005; Nolen-Hoeksema et al., 2008). However, this approach fails to capture the spontaneous nature of rumination in real-life situations, potentially overlooking the context-specific effects of rumination on individuals (Connolly & Alloy, 2017; Moberly & Watkins, 2008; Schwarz, 2012). Thus, it is increasingly recognized that rumination might be more accurately conceptualized as a dynamic state construct, taking into account situational factors such as social and physical contexts or daily events. (Genet &

Siemer, 2012; Kalisch et al., 2019; Moberly & Watkins, 2008). Specifically, LeMoult et al. (2013) demonstrated an association between rumination and stress reactivity, indicating that rumination can fluctuate in response to situational factors, such as stress. Shaw et al. (2019) extend this by suggesting that rumination may initially emerge as a state in response to developmental risk factors such as stressful environments, and only later develops into a trait. Collectively, these findings suggest considering rumination as a state in context of its environment, as it might more accurately reflect real life experiences.

To measure state rumination, Ecological Momentary Assessment (EMA), also known as Experience Sampling Methods, can be used to obtain multiple measures a day asking about momentary states. EMA is a research method designed to capture real-time data on individuals' emotions, thoughts, and behaviours as they occur in their natural environments (Myin-Germeys & Kuppens, 2022). By asking participants to report their immediate experiences multiple times a day, EMA aims to minimize retrospective biases associated with traditional survey methods, providing a potentially more accurate and dynamic measurement of state rumination (Csikszentmihalyi, 2014; Myin-Germeys & Kuppens, 2022; Versluis et al., 2021).

Prior research using EMA reveals the important impact of state rumination on NA and PA in the context of the stressfulness of daily events. One of the foundational studies was conducted by Moberly and Watkins (2008) with a university sample completing eight daily measures over one week. They found that occasions when participants reported a stressful event, they would also report higher levels of NA and that this relationship could be partially explained by rumination.

While this study establishes a strong link between state rumination and affect, it does not explicitly explore whether rumination moderates the relationship between the stressfulness of daily events and affect. Investigating state rumination as a moderator in this relationship is crucial due to its dynamic and context-specific nature. State rumination might amplify the stressfulness of daily events, making them feel more overwhelming and prolonging emotional responses (Genet & Siemer, 2012). Its situational variability suggests that its influence fluctuates based on context and specific stressors (Kalisch et al., 2019; LeMoult et al., 2013). Therefore, examining how state rumination affects the relationship between the stressfulness of daily events and affect will provide valuable insights into its role in everyday life.

Genet and Siemer (2012) were the first to provide insight into the moderating effect of rumination on the relationship between the level of stressfulness of daily events and NA. By

asking students to document their daily events and emotional states through end-of-day diaries over a week. They identified a positive moderation effect of state rumination on the relationship between stressful events and NA. Nonetheless, it can be speculated that asking about daily events at the end of the day might be prone to retrospective biases, potentially impairing the examination of concurrent state rumination (Van den Bergh & Walentynowicz, 2016). Later, in an EMA study with four daily measures, Connolly and Alloy (2017) also found a moderation effect of state rumination on the relationship between the level of stressfulness of daily events and depressive symptoms, which are related to NA (Koval et al., 2013).

While state rumination has been identified as a moderator for the relationship between the stressfulness of daily events and NA, its role in moderating the impact of the stressfulness of daily events for PA has not yet been researched explicitly. However, Brans et al. (2013) found that an increase in state rumination correlated not only with an increase in NA but also a decrease in PA, using an EMA research design. Supporting this in a series of classic quasi-experiments, Layous et al. (2023) also found that ruminating was associated with both an increased intensity of NA and decreased intensity of PA. Additionally, EMA studies have demonstrated concurrent and lagged associations between the stressfulness of daily events and a decrease in PA (Eldahan et al., 2016; Rackoff & Newman, 2020; van Eck et al., 1998).

### **Current Study**

This study aims to extend the scientific knowledge base by examining how state rumination moderates the relationship between the stressfulness of daily events and not only NA but also investigate its potential moderation on the relationship with PA. It is hypothesized that in moments where individuals experience a more stressful daily event, they will report greater intensity of NA (Hypothesis 1) and lower intensity of PA (Hypothesis 2). Importantly, these relationships are anticipated to be stronger in moments of higher intensity of state rumination.

### **Methods**

This study uses secondary data of research that was approved by the Ethics Committee of Behavioural, Management and Social Sciences of the University of Twente (request number: 220285).

## **Participants**

Participants were recruited using a convenience sampling technique. This approach is not only quick and economical but also frequently employed in ESM research to gather participants (Conner & Lehman, 2012; Etikan, 2016; Stratton, 2021). Specifically, participants were sourced via two ways: Firstly, the researcher's personal contacts were consulted. Secondly, participants were recruited from the University of Twente's test subject pool SONA. Here, participants could earn 3.5 points, which would count towards the mandatory quota of 15 points that bachelor's degree students must achieve by the conclusion of their undergraduate studies.

To meet the inclusion criteria, participants were required to be 18 years of age or older, have proficient English language abilities, and have access to a smartphone. Considering that the typical participant count for ESM studies is around 50 (van Berkel et al., 2018), the goal was to recruit a sample significantly larger than 50 participants, to account for the expected high non-compliance rates due to the demanding nature of data collection. Consequently, 96 participants were recruited.

## **Materials**

This study involved two types of questionnaires: a one-time baseline questionnaire (Appendix A) and a multiple times per day EMA questionnaire (Appendix B). The baseline questionnaire administered prior to the EMA study gathered demographic information and assessed emotion regulation strategies. However, only the responses from EMA questionnaire were relevant for this study. The EMA questionnaires included measures of momentary affect, stressfulness of daily events, and state rumination. Although other constructs were also assessed, only the responses relevant for this study will be reported. For further information on the project see: <https://osf.io/gvebm/>.

### ***Negative Affect***

To measure NA, a composite score of four items that were used in previous EMA research (Helmich et al., 2021) was calculated. Specifically, participants were asked "how anxious/irritable/depressed/sad do you feel right now?" and could respond on a 7-point Likert scale ranging from 1 (not at all) to 7 (very much). The items showed internal consistency with a split half reliability of  $r = 0.89$ .

### ***Positive Affect***

For PA, a composite score was calculated of four items that were used in previous EMA research (Helmich et al., 2021). Participants could respond on a 7-point Likert scale

ranging from 1 (not at all) to 7 (very much) to the following items: "how anxious/irritable/depressed/sad do you feel right now?". The items showed internal consistency with a split half reliability of  $r = 0.85$ .

### ***State Rumination***

To measure state rumination, the composite score of two items developed in the context of this project (see <https://osf.io/gvebm/>), was calculated. Specifically, the items were: "In the last hour, I have been thinking about my problems" and "In the last hour, I had repetitive thoughts about my problems". Participants could respond on a 7-point Likert scale ranging from 1 (not at all) to 7 (very much). Here, internal consistency was shown with a split-half reliability of  $r = 0.91$ .

### ***Stressfulness of Daily Events***

The level of stressfulness of a daily event was examined using only one item from this project (see <https://osf.io/gvebm/>): "Think of the most striking event or activity in the last hour. How stressful was this event or activity?". The participants could respond on a 7-point Likert scale ranging from 1 (not at all) to 7 (very much).

### **Procedure**

For the collection of the EMA data, the Ethica app was utilized (Ethica Data Services Inc., 2023). Prior to the main study, a two-day pilot was carried out to assess practicality and to identify and resolve any technical difficulties or glitches. The baseline questionnaire was available on the second day of the study, which took approximately 10 to 15 minutes to complete. It did not have an expiration time. However, reminders were sent after 8, 24, and 72 hours.

EMA data collection commenced on April 13, 2022, all participants were sent a study link via email detailing the registration process, which required downloading the Ethica app onto their smartphones. Upon registration in the Ethica app, participants were briefed on the confidentiality of the data collected, their right to exit the study at any point, and the procedure for providing consent (see Appendix C). Data collection concluded on April 27, 2022, spanning a total of 14 days. The 14-day duration with four daily measurements for this study follows established EMA protocols (van Berkel et al., 2018) and attempts to minimize participant burden while capturing a variety of real-life experiences (Eisele et al., 2022; Larson & Csikszentmihalyi, 2014; Napa Scollon et al., 2009).

Each of the responses in the EMA measurement took about 2 to 3 minutes. These questionnaires were prompted by notifications on their smartphones. Employing signal-contingent sampling, participants received these prompts at semi-random times within four

predetermined windows each day (see Table 1). The random timing within these slots ensured unpredictability, thereby reducing the likelihood of participants avoiding or planning around the questionnaires (Larson & Csikszentmihalyi, 2014; Myin-Germeys & Kuppens, 2022; Thomas & Azmitia, 2016). If a questionnaire was not answered, reminders were sent and after one hour it expired.

### **Data Analysis**

All data cleaning and analyses were performed in the Statistical Software R (R Core Team, 2018). To clean the data consistent with established EMA research, participants who had a response rate of less than 50% were removed from the dataset. It can be assumed that responding less than 50% of the time is unlikely to be representative of the whole duration of the study and thus not comparable to other participants (Conner & Lehman, 2012; van Berkel et al., 2018).

Linear Mixed Models (LMMs), fitted by restricted maximum likelihood (REML), were deemed appropriate for the analysis as they effectively handle the hierarchical structure of the data, allowing for the inclusion of both fixed and random effects, and an autocorrelation structure to account for the fact that observations closer together in time are more highly correlated than those further apart. To test the moderation of stressfulness of daily events and state rumination on NA, the first LMM included the independent variables stressfulness of daily events, state rumination, and their interaction term (stressfulness \* state rumination) and the dependent variable of NA. A second LMM, to test the moderation of stressfulness of daily events and state rumination on PA, included the independent variables stressfulness of daily events, state rumination, and their interaction term (stressfulness \* state rumination) and PA as the dependent variable. Additional LMMs were set up to investigate the main effects of the stressfulness of daily events on NA and PA and state rumination on NA and PA. For all models, Participant ID was included as a random effect to account for observations nested within participants, using a random intercept model. Furthermore, for all models, the variance-covariance structure was set to autoregressive (1). The LMMs, were set up using the r-package *nlme* (Pinheiro et al., 2023). For all analyses, findings with a p-value less than .05 were considered statistically significant. Additionally, sensitivity analyses were conducted to investigate the impact of including participants with a response rate below 50%. This was done by repeating the analyses with all participants.



**Table 1***Schedule of the Questionnaires*

Day	Questionnaire	Interval	Expire
2	Baseline Questionnaire	-	No
Every day (14 days)	EMA Questionnaire	10:00 – 11:00	Yes, after 30 minutes
		13:30 – 14:30	
		17:00 – 18:00	
		20:30 – 21:30	

**Results**

A total number of 96 participants were recruited. During the data analysis, 35 participants were excluded from the study because they had completed less than 50% of the questionnaires. The remaining 61 participants showed a compliance rate of 74.1% (95% CI [70.81%, 77.39%]) to the EMA protocol. The average age was 23.48 years (SD = 7.96). The gender distribution was predominantly female, constituting 55.7% of the sample, while male participants made up 42.6%. In terms of nationality, 70.5% were German, 16.4% Dutch, and the remaining 13.1% included individuals from various countries including Albania, Italy, Finland, Ecuador, Poland, Turkey, and Russia.

Figure 1 shows a positive relationship of the stressfulness of daily events and NA, while in Figure 2 a negative relationship can be observed for the stressfulness of daily events and PA. Additionally, the combination of high stressfulness of daily events and high NA seems to be more frequent in the presence of higher levels of state rumination. Similarly, the combination of high stressfulness of daily events and low PA seems to be more frequent in the present in presence of higher levels of state rumination. Figure 3 shows that the slopes of NA and stressfulness of daily events were steeper at higher intensities of state rumination. Figure 4 shows that for PA and level of stressfulness of daily events, slopes at different intensities of state rumination were more heterogenous, not indicating clear trends.

**Figure 1**

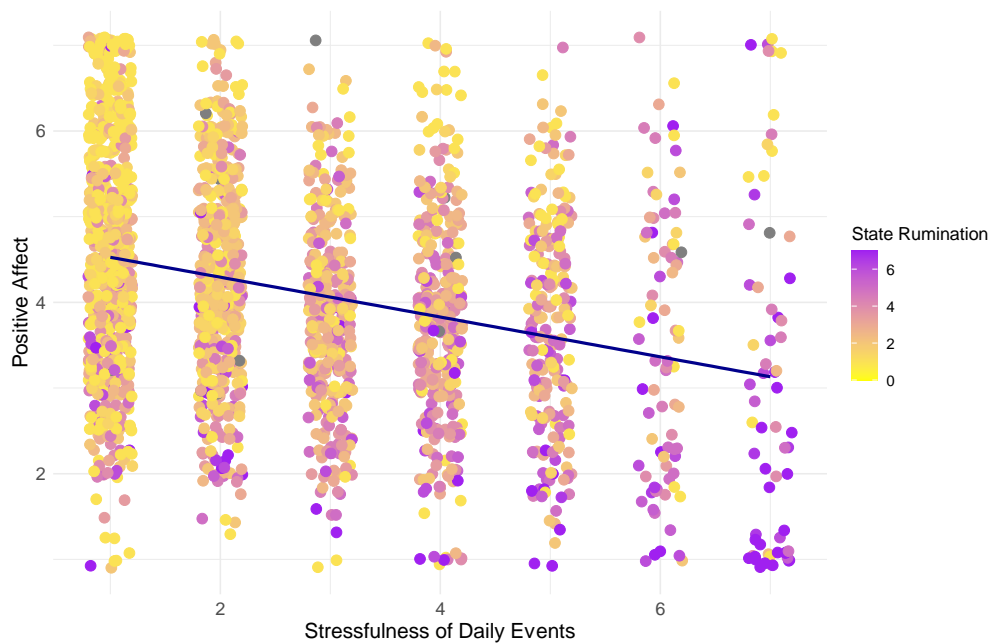
*The Relationship between Negative Affect and the Level of Stressfulness of a Daily Event in Context of State Rumination*



*Note.* Level 1  $n = 2401$

**Figure 2**

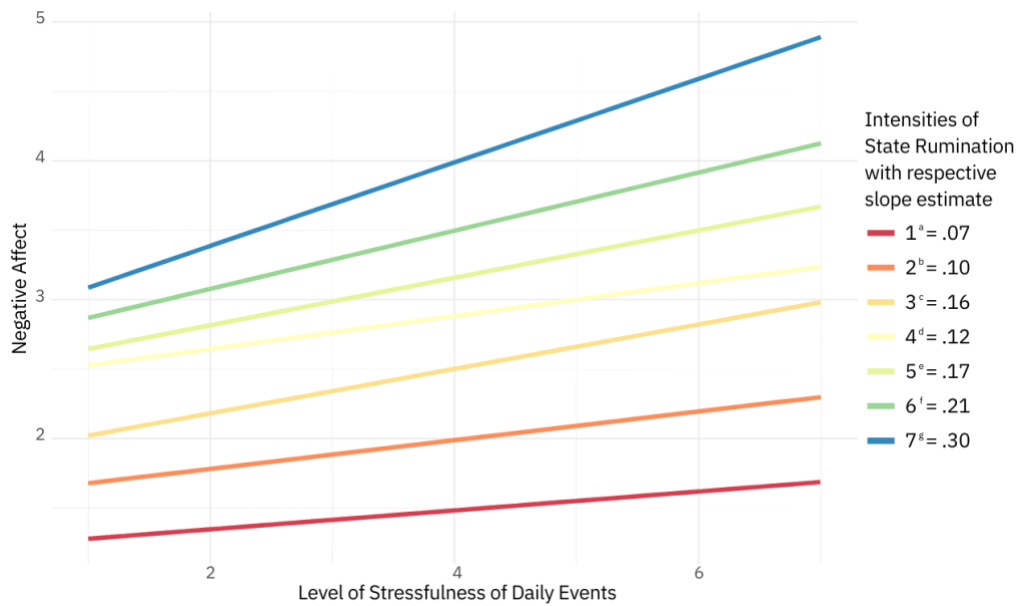
*The Relationship between Positive Affect and the Level of Stressfulness of a Daily Event in Context of State Rumination*



*Note.* Level 1  $n = 2401$

**Figure 3**

*The Slopes at Different Intensities of State Rumination for the Relationship between the Stressfulness of Daily Events and Negative Affect*

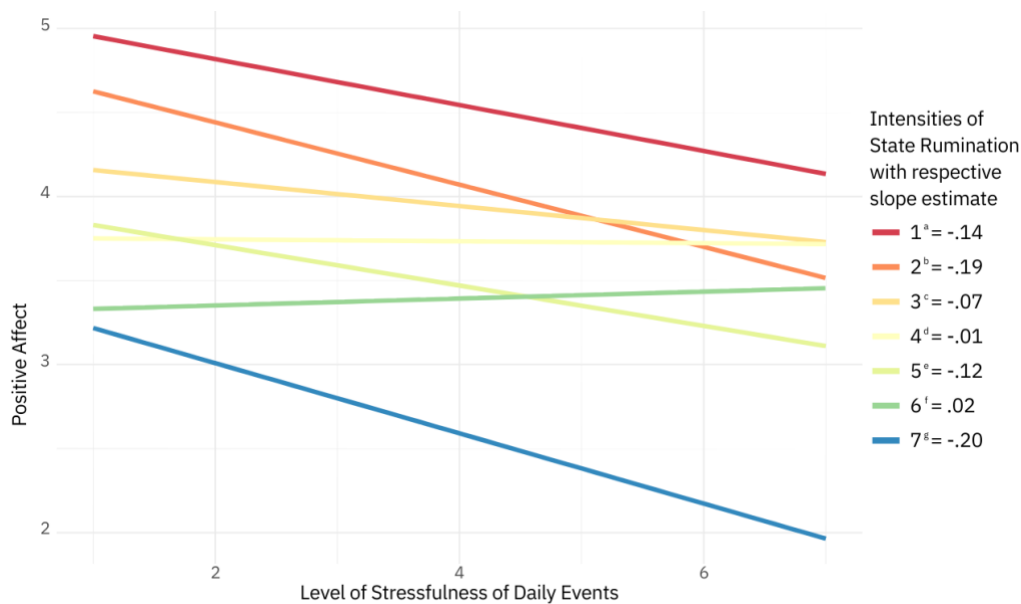


*Note.* Slope at State Rumination Intensity 1-7. Level 1  $n = 2401$ , Level 2  $N = 61$ .

<sup>a</sup>  $n = 529$ . <sup>b</sup>  $n = 823$ . <sup>c</sup>  $n = 270$ . <sup>d</sup>  $n = 437$ . <sup>e</sup>  $n = 127$ . <sup>f</sup>  $n = 142$ . <sup>g</sup>  $n = 73$ .

**Figure 4**

*The Slopes at Different Intensities of State Rumination for the Relationship between the Stressfulness of Daily Events and Positive Affect*



*Note.* Slope at State Rumination Intensity 1-7. Level 1  $n = 2401$ , Level 2  $N = 61$ .

<sup>a</sup>  $n = 529$ . <sup>b</sup>  $n = 823$ . <sup>c</sup>  $n = 270$ . <sup>d</sup>  $n = 437$ . <sup>e</sup>  $n = 127$ . <sup>f</sup>  $n = 142$ . <sup>g</sup>  $n = 73$ .

The interaction between the stressfulness of daily events and state rumination on NA was significant,  $b = 0.03$ ,  $SE = 0.01$ ,  $p < .001$  (see Table 2). Surprisingly, the interaction of the level of stressfulness of daily events and state rumination on PA was not significant,  $b = -0.01$ ,  $SE = 0.01$ ,  $p = .19$  (see Table 3). The analyses of the main effects showed that state rumination alone was significantly associated with NA,  $b = 0.35$ ,  $SE = 0.01$ ,  $p < .001$ . Stressfulness of daily events and NA also showed a significant association,  $b = 0.18$ ,  $SE = 0.01$ ,  $p < .001$ . Furthermore, state rumination alone was significantly associated with a decrease in PA,  $b = -0.34$ ,  $SE = 0.02$ ,  $p < .001$ . Stressfulness of daily events and PA also showed a significant and negative association,  $b = -0.19$ ,  $SE = 0.01$ ,  $p < .001$ . Additionally, the sensitivity analyses conducted, including participants regardless of individual response rate, did not yield any difference in significance compared to the primary analyses using 50% compliance rate as a threshold for inclusion.

**Table 2**

*Linear Mixed Model for the interaction between Stressfulness of Daily Event and State Rumination on Negative Affect*

Effect	$b$	$SE$	$df$	$t$	95% CI		$p$
					$LL$	$UL$	
(Intercept)	1.27	.09	2312	14.39	1.1	1.44	< .001
Stressful event	.02	.02	2312	1.27	-.01	.06	.20
Rumination	.22	.02	2312	10.53	.18	.26	< .001
Stressfulness* Rumination	.03	.01	2312	5.41	.02	.04	< .001

*Note.* Level 1  $n = 2401$ , Level 2  $N = 61$ . CI = confidence interval;  $LL$  = lower limit;  $UL$  = upper limit.

**Table 3**

*Linear Mixed Model for the interaction between Stressfulness of Daily Event and State Rumination on Positive Affect*

Effect	<i>b</i>	<i>SE</i>	<i>df</i>	<i>t</i>	95% CI		<i>p</i>
					<i>LL</i>	<i>UL</i>	
(Intercept)	5.18	.12	2313	42.13	1.1	1.44	< .001
Stressful event	-.08	.03	2313	-3.36	-.1	.06	< .001
Rumination	-.27	.03	2313	-10.26	.18	.26	< .001
Stressfulness* Rumination	-.01	.01	2313	-1.31	.02	.04	.19

*Note.* Level 1  $n = 2401$ , Level 2  $N = 61$ . CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

### Discussion

This study aimed to investigate whether state rumination moderates the relationship between the stressfulness of daily events and NA and PA. The results support the first hypothesis. In moments where individuals experienced a more stressful daily event, they reported greater levels of NA with this relationship being stronger with higher levels of state rumination. However, the results did not support the second hypothesis. Participants levels of state rumination did not significantly alter the relationship between the level of stressfulness of daily events and PA. However, higher levels of stressfulness of daily events and state rumination alone were both significantly associated with lower levels of PA.

### Main Findings

Results of the first hypothesis align with previous EMA research by Genet and Siemer (2012) and Connolly and Alloy (2017) that state rumination positively moderates the relationship between the stressfulness of daily events and NA. The findings of this study also reflect the theoretical framework proposed by Nolen-Hoeksema (2000) which posits that rumination exacerbates negative emotional responses to stress by maintaining focus on distressing aspects of events, thereby intensifying NA. These findings highlight the importance of state rumination in context of the relationship between the stressfulness of daily events and NA. Consequently, interventions aimed to mitigate the negative consequences of stress in daily life would be advised to tackle state rumination due to its possible impact on negative affective consequences of the stressfulness of daily events. In a

systematic review, Querstret and Cropley (2013) identified mindfulness-based and cognitive behavioural interventions to effectively target rumination, decreasing NA and increasing psychological well-being.

The findings do not support the second hypothesis that state rumination moderates the relationship between the stressfulness of daily events and PA. Nonetheless, the stressfulness of daily events and state rumination alone were both associated with a decrease in PA, which aligns with previous research (Moberly & Watkins, 2008; Rackoff & Newman, 2020; Ruscio et al., 2015). These findings would suggest that the stressfulness of daily events and state rumination both are independently associated with a decrease in PA but that this impact is not due to the hypothesized influence of state rumination on the relationship between the stressfulness of daily events and PA. Consequently, interventions aiming to increase PA or protect against a decrease of PA might benefit from separately addressing both the stressfulness of daily events and state rumination and not focus on their interaction.

One possible explanation for the lack of significant interaction is that the cognitive and physiological pathways through which state rumination and the stressfulness of daily events influence PA could be inherently different. On the one hand, state rumination, involving persistent, repetitive thoughts about one's distress (Nolen-Hoeksema, 1991), was found to deplete cognitive resources (Dhinakaran et al., 2013; van Vugt & van der Velde, 2018). This cognitive drain could have led to a decreased capacity to shift focus away from NA to possibly engage in thoughts related to PA. On the other hand, the direct impact of higher levels of stressfulness of daily events on PA might have been more immediate and physical, similar to the effect of stress on energy levels: Papousek et al. (2010) found that physiological responses to stress, such as increased cortisol levels and heightened sympathetic nervous system activity, can result in fatigue and a lack of energy. Further research could investigate how both stress and rumination affect PA.

The differential findings of hypotheses 1 and 2 show the inherent differences between NA and PA. The results suggest that state rumination increases NA and decreases PA, but that state rumination only significantly alters the relationship between the stressfulness of daily events and NA but not PA. This suggests that NA and PA are influenced by different mechanisms and can be independently affected by stress. This aligns with the perspective that PA and NA are not merely opposite ends of a single spectrum (Feldman et al., 2008; Gratz & Roemer, 2004; Vázquez et al., 2009). Nonetheless, previous research has demonstrated NA and PA to be correlated and interactive (Crawford & Henry, 2004; Oren-Yagoda et al., 2018). Therefore, further research could not only investigate how state rumination and stressfulness

of daily events impact NA and PA distinctively, but also how changes in NA and PA respectively influence each other.

The results of the current study also highlight the putatively maladaptive nature of state rumination for psychological well-being. State rumination was found to reinforce the association between the stressfulness of daily events and NA and to correlate with a decrease in PA and increase in NA. However, the maladaptivity of state rumination is up to debate regardless (Gratz & Roemer, 2004). For example, Watkins and Teasdale (2001) suggest that when individuals ruminate, they might be better able to tolerate highly emotional events. Additionally, rumination can serve as a coping mechanism to reflect on past experiences, to reassess and reframe meanings or beliefs (Platte et al., 2022). Therefore, rumination might also include adaptive aspects that focus on problem solving, while the maladaptivity of rumination might lie in excessive rumination that is not focused on solving the problem (Olatunji et al., 2013). Consequently, further research could investigate multiples subtypes of rumination, such as brooding or reflecting, as moderators for the relationship between the level of stressfulness of daily events and affect to achieve more nuanced insight into rumination in this context.

### **Strengths and Limitations**

The major strength of this study lies in its research design. With an EMA research design, this study was able to capture responses up to 56 times for one participant over a timespan of 14 days. This allowed measurement of the relevant constructs in a great variety of contexts and thereby, might have captured them with greater ecological validity compared to studies with traditional one-time cross-sectional measurements (Rabasco & Andover, 2022; Trull & Ebner-Priemer, 2009). Moreover, only asking participant about the last hour at most, likely decreased retrospective biases compared to traditional studies asking about the past week or further back (Hufford, 2007; Trull & Ebner-Priemer, 2009). Additionally, investigating rumination as a state captured the spontaneous nature of rumination, which might more closely resemble individuals understanding of rumination compared to investigating it as a trait (Genet & Siemer, 2012; Kalisch et al., 2019; Moberly & Watkins, 2008).

Despite its strengths, the study's limitations must also be acknowledged. First, the use of convenience sampling limits the generalizability of the findings. Participants were mainly recruited from the University of Twente and the researcher's contacts, failing to represent the broader population. Second, this study only used a single item to measure the level of stressfulness of daily events. This is a commonly used strategy in EMA research as it

simplifies data collection and reduces participant burden (Chan et al., 2019; Kraiss et al., 2024; Kwasnicka et al., 2021). However, it may not adequately capture the complexity and variability inherent in stress experiences (Houdmont et al., 2019; Sarason et al., 1980). Third, while the current study achieved its target of 50 retained participants, it still might have been underpowered for a moderation analyses, as this study failed to address the recommendation of using a significantly larger sample for moderation analyses compared to investigating main effects (Leon & Heo, 2009; Pan et al., 2018). Fourth, the study did not include lagged variables to investigate time effects, thus failed to gain insights into the temporal dynamics the investigated variables. Fifth, within-subject variations were not investigated, potentially missing individual variability that might be masked by the group-level analysis.

### **Conclusion**

This study was the first to investigate the moderating role of state rumination on the relationship between the level of stressfulness of daily events and PA, while also simultaneously examining its effects on NA. The findings confirmed previous research in showing that at higher levels of state rumination, the relationship between the stressfulness of daily events and NA was stronger. Surprisingly, higher levels of state rumination did not significantly alter the relationship between the stressfulness of daily events and PA, while state rumination and the stressfulness of daily events alone were associated with a decrease in PA. This suggests that state rumination and the stressfulness of daily events influence PA through different pathways, indicating that interventions aiming to maintain and increase PA should address them separately. Despite limitations like convenience sampling and a potentially underpowered moderation analysis, the results offer valuable insights into how state rumination affects emotional responses to daily stressors.



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## Appendix A: Baseline Questions

### Demographics

- Age: How old are you?
- Gender: What gender do you identify as? Male, female, other –
- Nationality: What is your nationality? Dutch German Other
- Occupation: What is your current occupation? Student, Working, Self-employed, studying and working, not working, other
- Highest degree obtained: Middle school (such as MBO, MTS, MEAO or Haupt- oder Realschule), High school (such as HAVO, VWO, HBS or Gymnasium/ Berufsschule/ Berufskolleg), High school, Bachelor, Master, PhD, Other

### Mental well-being (MHC-SF)

During the past month, how often did you feel...

1. Happy
  2. Interested in life
  3. Satisfied with life
  4. That you had something important to contribute to society
  5. That you belonged to a community
  6. That our society is a good place or is becoming a better place, for all people
  7. That people are basically good
  8. That the way our society works makes sense to you
  9. That you liked most parts of your personality
  10. Good at managing the responsibilities of your daily life
  11. That you had warm and trusting relationships with others
  12. That you had experiences that challenged you to grow and become a better person
  13. Confident to think or express your own ideas and opinions
  14. That your life has a sense of direction or meaning to it
1. Never
  2. Once or twice
  3. About once a week
  4. About 2 or 3 times a week
  5. Almost every day
  6. Every day



### **Anxiety (GAD-7)**

Over the last two weeks, how often have you been bothered by the following problems?

1. Feeling nervous, anxious, or on edge
2. Not being able to stop or control worrying
3. Worrying too much about different things
4. Trouble relaxing
5. Being so restless that it is hard to sit still
6. Becoming easily annoyed or irritable
7. Feeling afraid, as if something awful might happen
  - a. Not at all
  - b. Several days
  - c. More than half the days
  - d. Nearly every day

### **Depression (PHQ-9)**

Over the last 2 weeks, how often have you been bothered by any of the following problems?

1. Little interest or pleasure in doing things
2. Feeling down, depressed, or hopeless
3. Trouble falling or staying asleep, or sleeping too much
4. Feeling tired or having little energy
5. Poor appetite or overeating
6. Feeling bad about yourself or that you are a failure or have let yourself or your family down
7. Trouble concentrating on things, such as reading the newspaper or watching television
8. Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual
9. Thoughts that you would be better off dead, or of hurting yourself
  - a. Not at all
  - b. Several days
  - c. More than half the days
  - d. Nearly every day

### **Rumination (CERQ)**

State how often you think in the following manner when experiencing strong threatening or stressful life events.

1. I often think about how I feel about what I have experienced
2. I am preoccupied with what I think and feel about what I have experienced
3. I want to understand why I feel the way I do about what I have experienced
4. I dwell upon the feelings the situation has evoked in me
  - a. Almost never
  - b. Occasionally
  - c. Frequently
  - d. Almost always

## **Appendix B: Daily Questionnaire**

### **Positive and Negative Affect**

Below you can find several questions about your current feelings. Please try to indicate how you felt right before you started to answer the questionnaire!

1. How cheerful do you feel right now?
2. How enthusiastic do you feel right now?
3. How satisfied do you feel right now?
4. How relaxed do you feel right now?
5. How anxious do you feel right now?
6. How irritable do you feel right now?
7. How down do you feel right now?
8. How sad do you feel right now?

- 1 (not at all) to 7 (very much)

### **Stressful Event**

1. Think of the most striking event or activity in last hour. How (un)pleasant was this event or activity?

- 3 (very unpleasant) to +3 (very pleasant)

2. Think of the most striking event or activity in the last hour. How stressful was this event or activity?

- 1 (not at all) to 7 (very much)

### **Rumination**

1. In the last hour, I have been thinking about my problems
2. In the last hour, I had repetitive thoughts about my problems

- 1 (not at all) to 7 (very much)

## **Appendix C: Informed Consent**

Dear participant,

Thank you for your participation in this study. Before you participate, it is important that you understand the goal of this research and what the study will ask from you. The purpose of this study is to find out how mental health is related to emotion regulation. To explore this relationship, we want to measure fluctuations in emotions in daily life.

For this study, we will ask you to fill in several questionnaires on your mobile phone. All questionnaires will be completed in the Ethica app. The study will start with a questionnaire concerning your demographics and general mental health. This initial questionnaire will take about 10 minutes to complete. Afterwards, you will receive four questionnaires per day for a period of two weeks. Notifications will remind you about the next questionnaire. One daily questionnaire takes approximately 3 minutes to complete. It is important that you answer the questionnaires as soon as possible. *Please make sure that you turn on the notifications for the Ethica app on your mobile device.*

The information that we collect from this research project will be kept confidential. This means that only the researchers have insight into your answers. All personal data (such as age, gender etc.) will be anonymized and will not be published and/or given to a third party. Your participation in this study is voluntary. You are free to withdraw from this study at any time and without giving a reason.

### **Contact Information**

If you have any questions regarding this study, you can contact the researchers of this research project: Jasmin Wallner (j.wallner@student.utwente.nl), Paula Oberle (p.v.oberle@student.utwente.nl), Natalie Koop (n.koop@student.utwente.nl), Caroline Dauer (v.c.dauer@student.utwente.nl), Kia Lemmen (k.r.lemmen@student.utwente.nl) and Jenny Schwabe (j.schwabe@student.utwente.nl).

### **Consent**

I have read and understood the information provided and had the opportunity to ask 38 questions. I understand that my participation is voluntary and that I am able to withdraw at any time, without a reason or cost. I hereby voluntarily agree to take part in this study.