An Experience Sampling Study into Daily-Life Stress Recovery, Depressive Symptoms, and Emotion Regulation

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Abstract

Background: Experience Sampling Method (ESM) studies showed associations between depressive symptomatology and daily-life stress (DLS) recovery. However, in naturalistic settings, it is unclear how this association is influenced in moments of emotion regulation (ER). This ESM study investigates the role of momentary rumination and momentary cognitive reappraisal on the relationship between DLS recovery and depressive symptom severity in naturalistic settings.
Methods: 51 healthy volunteers (44 female and seven male) aged 19 to 35 filled out baseline measurements including demographic data and depressive symptom severity. ESM questionnaires then assessed event-related stress, negative affect (NA), rumination, and cognitive reappraisal ten times over eight consecutive days. DLS recovery was assessed with the extent of NA after event-related stress.
Results: Linear Mixed Models showed a significant effect of rumination and depressive symptom severity on DLS recovery ($p < .01$). Further, cognitive reappraisal and depressive symptom severity had a significant effect on DLS recovery ($p < .01$).
Discussion: Conclusively, momentary rumination did improve the relationship between the severity of depressive symptoms and DLS recovery. Further, momentary cognitive reappraisal improved the relationship between more severe depressive symptoms and DLS recovery yet worsened the relationship between less severe depressive symptoms and DLS recovery. These findings contribute to a better understanding of DLS recovery and have the potential of enhancing ER interventions to reduce (daily-life) stress and depressive symptoms in the long run. Future research should replicate this study, potentially including multiple reports (e.g.: psychological and physiological reports) or alternative ER strategies.
Keywords: Stress, Recovery, Depressive Symptoms, Experience Sampling Method

Globally, stress is a common phenomenon. In Europe alone, between 33% – 52% reported experiencing stress, with tendencies increasing (Stewart, 2022). Stress is defined as the mental, physical, or emotional strain experienced when environmental demands exceed the personal resources (Daily Life - The American Institute of Stress, n.d.; Fink, 2016). Concerningly, stress is shown to have a profound negative impact on health. Several studies depicted stress as a possible cause of illness both physically (cardiovascular diseases) and mentally (mood disorders; Kasl, 1984; Avison & Gotlib, 1994). Specifically, daily-life stress

(DLS) is shown to have long-term implications on health, including physical and mental disorders (Charles et al., 2013; Leger et al., 2018). DLS's impact on health can be even more extensive with unsuccessful affective recovery (Leger et. al., 2018; Waugh et al., 2010). Affective recovery of DLS is seen as the most important factor to prevent stress from adversely affecting health (Waugh et al., 2010). Therefore, it is of great importance to investigate and understand the affective recovery from DLS.

Daily-life stress and daily-life stress recovery

DLS is defined as frustrating, irritating, and distressing interruptions or difficulties which occur in daily interaction with the environment (Crosswell & Lockwood, 2020; Kanner et al., 1981). This includes annoying practical problems (lost items) or fortuitous occurrences (harsh weather) (Kanner et al., 1981). These stressors result in heightened activation levels which can primarily induce higher and prolonged levels of negative affect (NA; de Calheiros Velozo et al., 2022; Richardsen, 2017; Schilling & Diehl, 2014). Therefore, NA can play a role in the influence of DLS on mental health. DLS' influence on mental health varies from short-term problems to long-term implications, up to mental disorders (Avison & Gotlib, 1994; Charles et al., 2013; Leger et al., 2018). It can be investigated in a naturalistic setting with the experience sampling method (ESM). ESM "tracks experiences in the real world and in real-time, using self-reports to capture these momentary experiences as well as their context" (Myin-Germeys et al., 2022, p. 9). With ESM the study of mental health can be fundamentally strengthened by tailoring interventions to specific moments and situations (Heron & Smyth, 2010; Myin-Germeys et al., 2018). Thus, DLS can play a serious role in mental health, and these stressors and their impact can be investigated with ESM.

Important for the DLS' impact on mental health is the affective recovery. Stress recovery is defined as the return to baseline level from previous heightened activation level. Successful DLS recovery implies a quick and/ or complete return to baseline (Leger et al., 2018; Waugh et al., 2010). Here successful DLS recovery is the return to baseline levels of NA from previous heightened NA levels (Schilling & Diehl, 2014). Unsuccessful stress and DLS recovery, especially prolonged or incomplete affective recovery, is a common predictor of poor long-term mental health and psychopathology (Epel et al., 2018; Kuranova et al., 2020; Piazza et al., 2013). Thus, unsuccessful affective recovery from DLS can be detrimental to mental health and psychopathology.

Depressive Symptomatology

Depressive symptomatology is one area of the DLS' impact on mental health and psychopathology. Whereas the present study focusses on subclinical depressive symptoms, it

is thought that existing literature on clinical depressive symptoms/ clinical depression can still provide valuable insights into the relationship of DLS and subclinical depressive symptoms (see Ruscio et al., 2015; Shapero et al., 2019). Clinical depression is mainly characterized by depressed mood and/ or loss of pleasure or interest (American Psychiatric Association, 2013). Typical for depression are low positive affect and high NA (Peeters et al., 2003). Subclinical depression refers to clinically relevant depressive symptoms which do not yet meet diagnostic criteria for a depression due to their severity and/ or persistency (Cuijpers et al., 2014; Ji, 2012). An association between DLS and depressive symptomatology is long shown (O'Neill et al., 2004; Parrish et al., 2011; Wichers et al., 2009). Accordingly, poor DLS responses, which also include DLS recovery, play a key role in the development and prediction of depressive symptoms and are, over time, a risk factor for depression (O'Neill et al., 2004; Parrish et al., 2011). Thus, the association between DLS and depressive symptomatology is widely accepted.

Further, DLS recovery and depressive symptomatology is shown to be associated. Several laboratory studies have demonstrated the association between depressive symptomatology and DLS recovery (Charles et al., 2013; Peeters et al., 2003). Clinically depressed individuals are found to have poorer DLS recovery as it takes more time and effort (Charles et al., 2013; Peeters et al., 2003). A recent ESM study by de Calheiros Velozo et al. (2022) supported these laboratory findings in a naturalistic setting. Compared to healthy controls, individuals at risk for a depression (including subclinical depressive symptoms and residual clinical depressive symptoms) showed a delayed DLS recovery. Thus, there is an association between delayed DLS recovery and depressive symptomatology.

Emotion Regulation

One crucial factor in the relationship between DLS recovery and depressive symptomatology is emotion regulation (ER). ER consists of extrinsic and intrinsic processes which are responsible for the monitoring, evaluation, and modification of emotional reactions and is divided into adaptive and maladaptive ER strategies (Aldao & Nolen-Hoeksema, 2012; Thompson, 1994). Within the context of stress, ER enables individuals to influence emotions to maintain emotional balance which can influence the DLS recovery (Aldao et al., 2015; Krkovic et al., 2018). An impaired ER may also predict depressive symptoms, the severity of depressive symptoms, and can even develop and maintain depression (Aldao & Nolen-Hoeksema, 2010; Berking et al., 2014; Ehring et al., 2010). Further, ER plays a role in the relationship between DLS recovery and depressive symptoms. Laboratory studies showed that clinically depressed individuals display a dysfunctional ER more frequently, which influences

DLS recovery (Ehring et al., 2010; Joormann & Stanton, 2016). However, in naturalistic settings little is known about the influence of ER on the relationship between depressive symptoms and DLS recovery.

Rumination

ER strategies can be differentiated in maladaptive and adaptive ER strategies (Aldao & Nolen-Hoeksema, 2012). Maladaptive ER strategies are less effective in reducing NA and are shown to be a risk in the development of mental disorders (Aldao & Nolen-Hoeksema, 2012; Wante et al., 2017). One maladaptive ER strategy is rumination. Rumination is defined as repetitive thinking about the thoughts and feelings associated with a negative event (Omran, 2011). It has one of the strongest positive associations with depressive symptoms, depression, and symptom severity (Aldao et al., 2010; Joorman & Stanton, 2016). Additionally, laboratory studies showed an association between stress recovery, depressive symptoms, and rumination (Abela et al.,2012; Michl et al., 2013). Namely, Abela et al. (2012) found that higher levels of rumination, after a stressful event, are associated with an increase in clinical depressive symptoms. Michl et al. (2013) showed rumination mediated the relationship between self-reported stressful life events and clinical depressive symptoms. Investigating this relationship in a naturalistic setting, different studies used ESM (Connolly & Alloy, 2017; Fang et al., 2019; Ruscio et al., 2015). Specifically, Ruscio et al. (2015) showed an association between stress recovery and depressive symptoms with rumination mediating this association, meaning after daily stressful event, rumination levels were higher in clinical depressed individuals. Thus, rumination plays a vital role in the relationship between DLS stress, stress recovery, and depressive symptoms.

Cognitive Reappraisal

Next to the maladaptive ER strategies there are also adaptive ER strategies. These reduce NA and may be a protective factor in the development of psychopathology (Aldao & Nolen-Hoeksema, 2012; Wante et al., 2017). One adaptive ER strategy is cognitive reappraisal. Cognitive reappraisal is defined as a cognitive change in which the emotional impact of a possible emotion-eliciting situation is altered (Gross & John, 2003). It commonly has one of the strongest negative associations with depressive symptoms, depression, and symptom severity (Aldao et al., 2010; Joorman & Stanton, 2016). Additionally, a laboratory study showed a link between DLS and depressive symptoms with cognitive reappraisal being a moderator of this link (Troy et al., 2010). Self-report studies also showed subclinical depressed individuals who used more cognitive reappraisal recover better from DLS (Shapero

et al., 2019). Thus, cognitive reappraisal plays a vital role in the relationship between stress recovery and depressive symptoms.

The present study

To understand the affective recovery from DLS, this present study aims to provide knowledge on the role of momentary ER on the relationship between DLS recovery and depressive symptoms in a naturalistic setting. This research uses ESM to ensure this goal and investigates the following research question: What is the role of momentary rumination and momentary cognitive reappraisal in the relationship between DLS recovery and depressive symptom severity? Based on the literature, it is hypothesized that i) the severity of depressive symptoms is associated with the DLS recovery, meaning the more severe the depressive symptoms the poorer the DLS recovery, ii) momentary rumination worsens this relationship, meaning individuals with more severe depressive symptoms show the poorest DLS recovery in moments of reported high rumination, and iii) momentary cognitive reappraisal improves this relationship, meaning individuals with less severe depressive symptoms show the best DLS recovery in moments of reported high cognitive reappraisal.

Methods

Study Design

To implement the present study, the experience sampling method (ESM) was used. ESM employs daily momentary measurements, in form from self report questionnaires, to explore daily life processes over time (Myin-Germeys et al., 2022). This method allows for assessing DLS recovery within individual, multiple times a day over several days (Myin-Germeys et al., 2022). Specifically, these measurements occurred during the day between 7:30 and 22:30 o'clock. Ten measurement occasions were semi-randomly spread over the day, in intervals ranging from 15 to 90 minutes. The measurements took place over eight consecutive days. However, each ESM measurement occasion was seen as a separate measurement.

Participants

Healthy volunteers between the age of 19 and 35 were recruited to take part in this study. The recruitment procedure consisted of flyers spread around key areas of the city Leuven, Belgium (e.g., train stations, supermarkets, libraries, student campuses) and posted on social media. As an inclusion criterion, participants had to be fluent in Dutch. Exclusion criteria included hormonal and/ or cardiovascular disorders, or relevant allergies. As a compensation participants received a gift voucher. Participants gave informed consent and

ethical approval was granted by the Sociaal-Maatschappelijke Etische Commissie (SMEC) of KU Leuven.

Procedure

The study consisted of two parts: the baseline measurements and the ESM measurements. In the first part, participants were presented with an introduction, an information letter, and a consent form. After consent was given, participants could proceed to the baseline measurements. These included the demographic data, such as age, gender, and nationalities, and the depressive symptom severity measured with the short version of the Depression Anxiety Stress Scale (DASS21; Lovibond & Lovibond, 1995).

In the second part of the study, participants took part in the ESM measurements. A research phone with the app 'MobileQ' was provided to fill out the daily diaries electronically. The phone beeped ten times during the day on eight consecutive days. These beeps occurred between 7:30 and 22:30 o'clock and happened semi-randomly between 15 to 90 minutes apart. Each beep was a measurement occasion and triggered a questionnaire in the app to assess momentary levels of affect, and context measures (see Myin-Germeys et al., 2009 for details on ESM). Amongst others, this questionnaire measured event related stress, NA, rumination, and cognitive reappraisal.

Material

The present study obtained the participants' age, gender, and nationality as demographic data.

***Depression Anxiety Stress Scale – short version (DASS21; Lovibond & Lovibond, 1995)*:** The DASS is a self-administered questionnaire with three scales (depression, anxiety, and stress) assessing the magnitude of these three emotional states. The short version of the DASS21 has 21 items. However, for this study only the depression scale will be used. This depression scale consisted of 7 items in form of statements with a 4-point answer scale. One Example is: *I couldn't seem to experience any positive feeling at all*. Participants were asked to rate the extent to which they have experienced this statement over the past week: *0) Did not apply to me at all, 1) Applied to me to some degree, or some of the time, 2) Applied to me to a considerable degree, or a good part of time, 3) Applied to me very much, or most of the time*. The score of depression was then calculated by summing up the scores for this scale with a range between 0 and 21. Hereby, higher scores indicated an increasing severity of depression. The internal consistency of the depression scale was good with Cronbach's α between 0.81 to 0.88 (Coker et al., 2018; Henry & Crawford, 2005).

ESM measure:

Event related stress: Participants were asked to think of the most important event since the last beep and answer how pleasant this event was. The answer possibilities were on a Likert-scale from -3, *very unpleasant*, to 3, *very pleasant*. Events from 0 till 3 were treated as not stressful and were therefor recoded to 0. Events from -1 till -3 were treated as stressful events and were recoded to 1.

Negative Affect: Participants were asked to answer the following question: *At this moment, I feel …?* The participants had to rate the answers *annoyed* and *down* on a 7-point Likert scale with 1 being *not at all* and 7 being *very much*. The average of both answers determined the score of the NA.

Daily-Life Stress Recovery: To be able to measure the change in NA after a stressful event, the variable DLS recovery was created based on event related stress and NA. DLS recovery is the difference in NA between the beep with the stressful event and the beep after the stressful event. To compute the DLS recovery, the NA at the beep of the stressful event got subtracted from the NA at the beep after the stressful event. For example, when the NA at the beep of the stressful event was 4 and the NA at the beep after the stressful event was 1, then the DLS recovery was -3. A negative DLS recovery score, in this case -3, meant the NA has decreased which implies a positive DLS recovery. However, when the NA at the beep of the stressful event was 1 and the NA at the beep after the stressful event was 3, then the DLS recovery was 2. A positive DLS recovery score, in this case 2, meant the NA has increased which implies a negative DLS recovery. When the NA at the beep of the stressful event was 7 and the NA at the beep after the stressful event was also 7, then the DLS recovery was 0. A DLS recovery score of 0 meant the level of NA did not change and no DLS recovery took place. As the highest NA score was a 7 and the NA scores got subtracted from each other, the DLS recovery could potentially range from -7 to 7.

The variable DLS recovery did not get computed when 1) there was no stressful event, 2) the stressful event occurred at the last beep of the day (since the difference in NA can not be calculated over night), or 3) one of the NA scores at the beep of or after the stressful event was missing. The computation of a DLS recovery score was a prerequisite for a measurement point of the other ESM variables (rumination and cognitive reappraisal). Each DLS recovery score was seen as a separate measurement.

Rumination: Participants were asked to answer the following question: *Since the last beep, to what extent have I kept thinking about it?* Participants had to rate the answer on a 7-point Likert scale with 1 being *not at all* and 7 being *very much*. However, a measurement

point of rumination only got included when there was a corresponding DLS recovery score at the same beep. Each rumination score was seen as a separate measurement.

Cognitive Reappraisal: Participants were asked to answer the following question: *Since the last beep, to what extent have I tried to look at it in a different way?* Participants had to rate the answer on a 7-point Likert scale with 1 being *not at all* and 7 being *very much*. However, a measurement point of cognitive reappraisal only got included when there was a corresponding DLS recovery score at the same beep. Each cognitive reappraisal score was seen as a separate measurement.

Data analysis

All Analyses were run in IBM SPSS Statistic Version 27. First, participants with incomplete or non-suitable data were removed. This included participants with no baseline data on the severity of depressive symptoms and no ESM data on unpleasant events, NA, rumination, and cognitive reappraisal. Furthermore, it excluded participants who had less than a 30% response rate on these ESM data such as it was shown in Kuranova et al. (2020). This cut-off point was chosen for including as many data as possible with still getting a good picture of the participants daily-life. Non-suitable data was data in which the answer style did not suit the given style of question. An example of this was when the question required participants to rate the answer on scale from one to seven, but the participants answered with a sentence about what they were doing in that moment (e.g.: 'being on time for the train') and did not rate the answer from one to seven.

In preparation for the analysis, the following clarifications will be used: The beep of the stressful event is described as T0 and the beep after the stressful event is described as T1. Second, based on the stressful event and the NA, the dependent variable DLS recovery was created. This variable showed the difference in NA between T0 and T1. Third, demographic data was obtained with age, gender, and nationality. Fourth, assumptions, such as linearity, homoscedasticity, and normal distribution were checked. Fifth, descriptive statistics, such as mean, standard deviation, and the range were obtained.

Last, the inferential statistics were carried out. To analyse the first hypothesis, the effect of depressive symptom severity on DLS recovery, a Linear Mixed Model (LMM) was performed with the dependent variable DLS recovery (quantitative, -7 to 7) and the independent variable depressive symptom severity (quantitative, 0 to 42). For the second hypothesis, analysing the effect of momentary rumination and depressive symptom severity on DLS recovery, another LMM was carried out. This LMM included the dependent variable DLS recovery (quantitative, -7 to 7), the independent variable depressive symptoms severity

(quantitative, 0 to 42), and momentary rumination (quantitative, 1 to 7) as an independent variable and as an interaction effect between the depressive symptom severity and momentary rumination. To analyse the third hypothesis, the effect of momentary cognitive reappraisal and depressive symptom severity on DLS recovery, a third LMM was performed. This LMM included the dependent variable DLS recovery (quantitative, -7 to 7), the independent variable depressive symptoms severity (quantitative, 0 to 42), and momentary cognitive reappraisal (quantitative, 1 to 7) as an independent variable and as an interaction effect between the depressive symptom severity and momentary cognitive reappraisal. For simplification, in the second and third hypothesis, the severity of depressive symptoms got divided into two group based on the median split. Further, for the first hypothesis it was controlled for two covariates: First, the NA at the beep with the stressful event (at T0) to see whether its intensity influenced the DLS recovery. Second, a stressful event following another stressful event (at T1) to see whether a consecutive stressful event influenced the DLS recovery.

Results

Sample description

A total of 58 volunteers participated in this study. However, 5 participants had to be excluded due to the absence of ESM data, 1 participant had to be excluded due to more than 30% missing ESM values, and 1 participant had to be excluded because no stressful event was reported in the ESM period. Therefore, the sample size consisted of 51 healthy volunteers between the age of 19 to 35 and with a mean age of 23.96 years (*SD* = 3.07). The study included 7 men with a mean age of 23.14 years (*SD* = 2.27), and 44 women with a mean age of 24.09 years (*SD* = 3.18). 3 different nationalities were included. The majority of the participants was Belgium (45 participants), 3 participants were Dutch, and 3 participants had other nationalities.

Assumptions and descriptives

Three assumptions were checked: linearity, homoscedasticity, and normal distribution. Whereas the assumption of linearity was met, the assumption of homoscedasticity and normal distribution were violated. However, the analysis of Linear Mixed Models (LMM) is robust against a violation of these assumptions.

In this study, questionnaires were filled out for 3,529 out of 4,560 beeps, resulting in a compliance rate of 77.39%. This is considered an acceptable compliance rate (Rintala et al., 2019). For the 51 participants, 480 stressful events were recorded, with an average of 9.41 stressful events per participant. This indicates that, on average, each participant experienced slightly over one stressful event per day. However, out of these 480 stressful events, only 370

stressful events were used to create measurement points for the dependent variable DLS recovery. The reason for this was that only the beeps of and after a stressful event (T0, T1) with a present NA could be used for the DLS recovery with the exception of the last beeps of the day. Consequently, the analysis had a total of 370 measurement points.

For these 370 measurement points, the mean NA was 1.87 (sd = 1.17). Participants engaged in rumination 197 out of 370 times following a stressful event. The reported mean was 3.03 (sd = 1.81) for their extent of rumination. Further, participants engaged in cognitive reappraisal 197 out of 370 times following a stressful event. The reported mean was 3.50 (sd = 1.83) for their extent of cognitive reappraisal. For the 51 participants, the mean of the depressive symptoms was 2.78 (sd = 2.74).

Hypothesis testing

Three linear mixed models were conducted to test the three hypothesis stated above. Results for the first hypothesis showed that the severity of depressive symptoms did not have a significant effect on DLS recovery: $B = 0.01$, $SE = 0.03$, $t(95.20) = 0.22$, $p > .83$ (*Figure 1*). However, this result was affected by the first covariate, the intensity of NA at the beep with the stressful event (T0): $B = -0.06$, $SE = 0.01$, $t(364.16) = -3.54$, $p < .01$. Results for the second hypothesis showed that there is a significant interaction effect of momentary rumination and the severity of depressive symptoms on DLS recovery; $B = -0.07$, $SE = 0.02$, $t(187.28) = -3.46$, $p < .01$. Opposite to expectations, in moments of reported high rumination individuals with more severe depressive symptoms showed the best DLS recovery, and in moments of reported low rumination individuals with more severe depressive symptoms showed the poorest DLS recovery (*Figure 2*). Results for the third hypothesis showed that there is a significant interaction effect of momentary cognitive reappraisal and the severity of depressive symptoms on DLS recovery; $B = -0.07$, $SE = 0.02$, $t(193) = -3.26$, $p < .01$. This is partly in line with expectations. Contrary, in moments of reported high cognitive reappraisal individuals with less severe depressive symptoms showed poorer DLS recovery. Conformingly, in moments of reported high cognitive reappraisal individuals with more severe depressive symptoms showed the best DLS recovery (*Figure 3*).

Figure 1

Hypothesis 1: Independent Variable Severity of Depressive Symptoms on Dependent Variable Daily-Life Stress Recovery

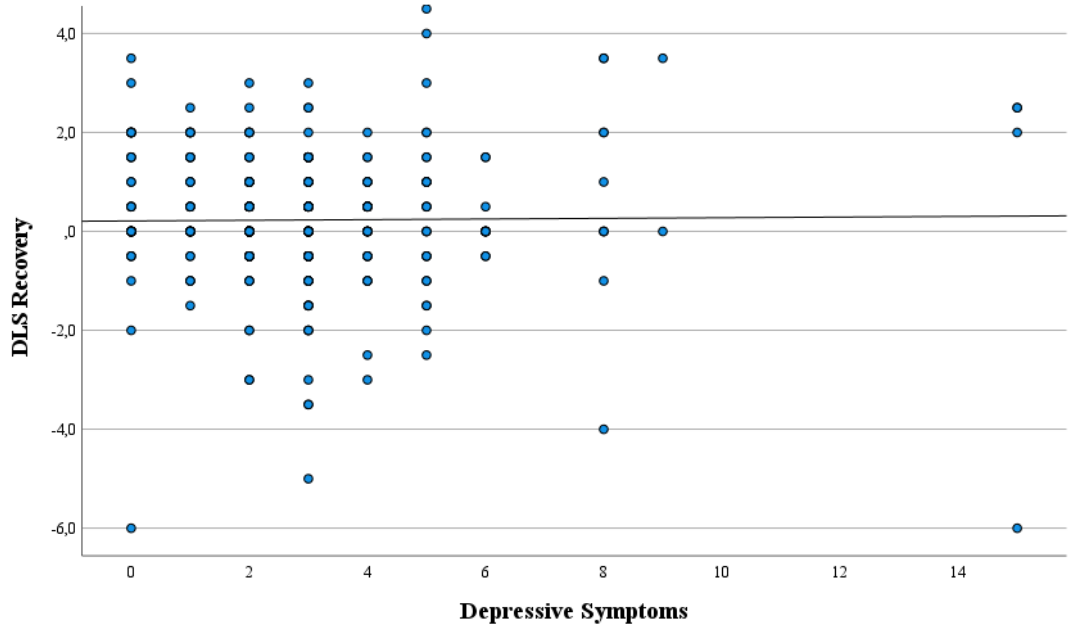
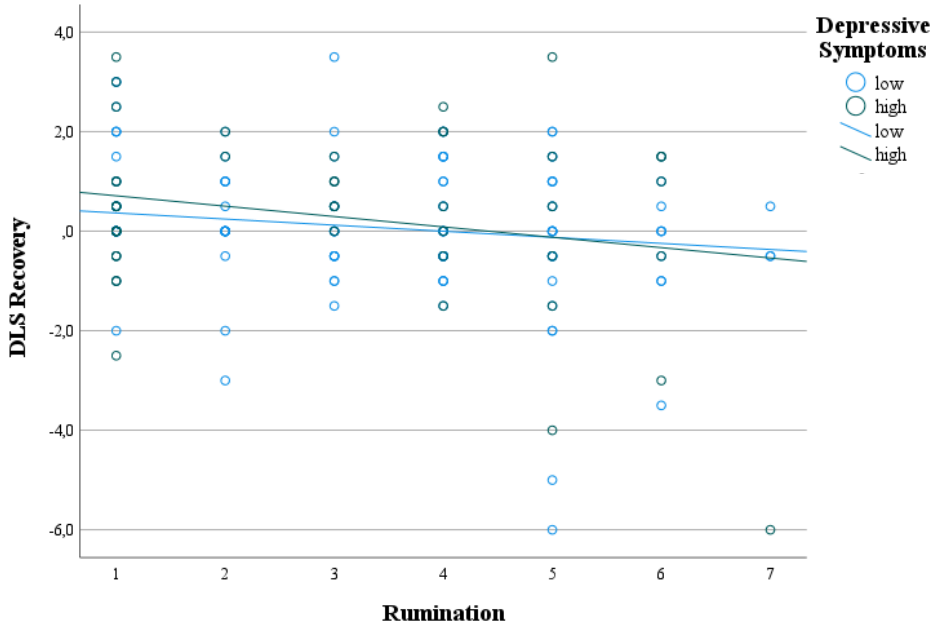


Figure 2

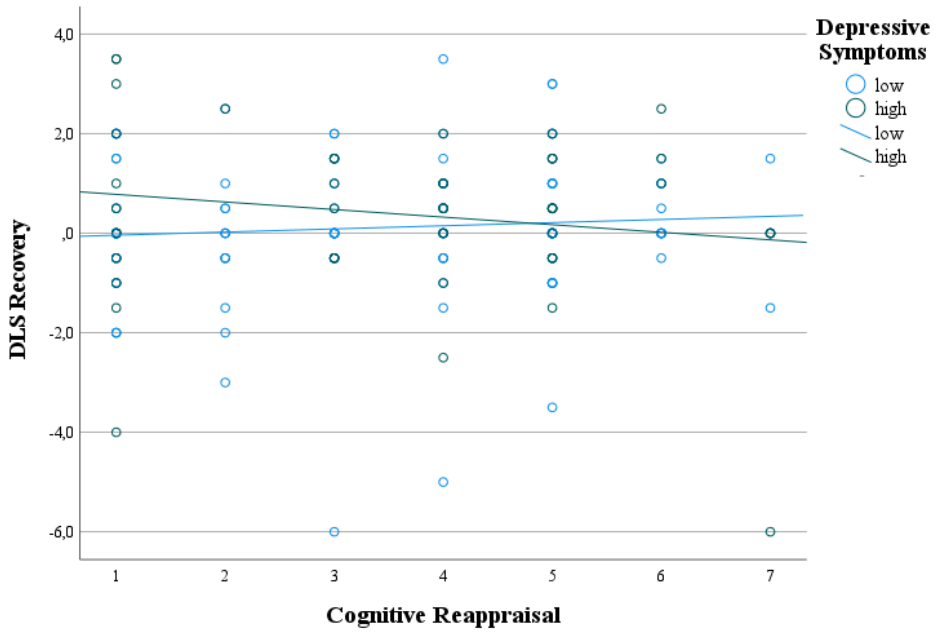
Hypothesis 2: Significant Interaction Effect of Rumination and Severity of Depressive Symptoms on Daily-Life Stress Recovery



Note. *For the purpose of visualization, the median split was used to create the groups low and high severe depressive symptoms.*

Figure 3

Hypothesis 3: Significant Interaction Effect of Cognitive Reappraisal and Severity of Depressive Symptoms on Daily-Life Stress Recovery



Note. *For the purpose of visualization, the median split was used to divide the severity of depressive symptoms into two groups: low and high severe depressive symptoms.*

Discussion

The present study aimed at investigating the role of momentary rumination and momentary cognitive reappraisal in the relationship between DLS recovery and depressive symptom severity in a naturalistic setting. From the results of this study, it can be concluded that there was no relationship between the severity of depressive symptoms and DLS recovery. Momentary rumination did not worsen this relationship, in fact individuals with more severe depressive symptoms showed the best DLS recovery in moments of high rumination. Further, momentary cognitive reappraisal partly improved this relationship. In moments of reported high cognitive reappraisal, individuals with less severe depressive symptoms showed poorer DLS recovery and individuals with more severe depressive symptoms showed the best DLS recovery.

Depressive symptomatology

Contradicting the first hypothesis, there was no association between the severity of depressive symptoms and the DLS recovery. This was surprising, as previous laboratory research showed poorer DLS recovery in depressed individuals (Charles et al., 2013; Peeters et al., 2003). Further, a previous study in a naturalistic setting showed a delayed DLS recovery in individuals at risk for a depression compared to healthy controls (de Calheiros Velozo et al., 2022). The most substantial difference between these studies and the present

study is that, whereas de Calheiros Velozo's study included subclinical depressive symptoms and residual clinical depressive symptoms from a clinical population, the present study solely included individuals with subclinical depressive symptoms from a general population. As this study could not replicate previous outcomes, it seems there is a bigger difference in symptom severity on DLS recovery between clinical and general populations. Specifically, in this study the subclinical depressive symptom severity might be so low that the effects on DLS recovery might be too small to be detected by the sample of a general population. Thus, these findings might suggest that the relationship between depressive symptomatology and DLS recovery might vary between clinical and general populations.

Rumination

Contradicting the second hypothesis, momentary rumination did not worsen the relationship between the severity of depressive symptoms and DLS recovery. This was surprising, as it contradicts prior research, which suggested rumination worsens this relationship (Abela et al., 2012; Michl, et al., 2013; Ruscio et al., 2015). A possible explanation for this contradiction is the ongoing debate regarding rumination being a multidimensional construct with not only maladaptive but also possible adaptive components (Joorman et al., 2006). Whereas the present study viewed rumination as a maladaptive ER strategy, it could have also been the case that individuals used rumination as an adaptive strategy. For example, rumination can help gain insight into problems and emotions, increase self knowledge, and resolve unattained goals (Joorman et al., 2006; Takano & Tanno, 2009; Lyubomirsky & Nolen-Hoeksema, 1993). Important for the adaptive component of rumination is re-thinking in a reflective way, based on the motivation of curiosity or epistemic interest in the self, and not in a ruminative way (Trapnell & Campbell, 1999). The adaptive components of rumination presuppose using the conceptual-evaluative mode of rumination, which is an analytical, conceptual, evaluative, way of thinking about the self (Watkins, 2004). The adaptive components also presuppose responding in reflective pondering way, in which individuals have a self-reflective tendency and a problem-solving orientation to problems (Nolen-Hoeksema et al., 2008). All these adaptive components of rumination are shown to be a helpful in dealing with depressive feelings (Papageorgiou & Wells, 2001; Treynor et al., 2001) and promote affective recovery from upsetting events (Watkins, 2004). Thus, it is possible that the individuals with higher levels of rumination used more adaptive components of rumination which could have helped in recovering from DLS.

Cognitive reappraisal

Partly conforming the third hypothesis, momentary cognitive reappraisal did improve the relationship between more severe depressive symptoms and DLS recovery. This was according to expectations, as it supports Shapero et al. (2019) findings which showed better DLS recovery in depressed individuals who used more cognitive reappraisal. To the researcher's knowledge, this was the first study to show this improving factor of momentary cognitive reappraisal in the relationship between depressive symptoms and DLS recovery in a naturalistic setting. With this finding, momentary cognitive reappraisal can be used to improve interventions and treatments of ER (e.g.: ER training) to decrease depressive and stress symptoms (Jenaabadi, 2017; Training, 2015). However, partly contradicting the third hypothesis, individuals with less severe depressive symptoms did not show the best DLS recovery in moments of reported high cognitive reappraisal. As individuals with less severe depressive symptoms have better DLS recovery and cognitive reappraisal is an improving factor in this relationship, this hypothesis derived (Calheiros Velozo et al., 2022; Shapero et al., 2019). Therefore, it was surprising that momentary cognitive reappraisal did not have the most NA improvement in individuals with less severe depressive symptoms. Up to this point, almost no scientific explanations could be found to account for this outcome. Yet, there are a few studies which showed similar surprising outcomes. For instance, the daily diary study of Brockman et al. (2017) showed that momentary cognitive reappraisal was not generally associated to improvements of NA. Namely, for a subclinical sample with less severe clinical symptoms, momentary cognitive reappraisal was only associated with improving NA in about half of the sample. Thus, the present study suggests that the depressive symptom severity has a bigger impact on the relationship between momentary cognitive reappraisal and DLS recovery than expected.

Strengths and limitations

This study also presents with strengths. Certainly, some of these strengths come from using ESM. First, contingencies in the DLS recovery can be detected more accurately (Napa Scollon et al., 2009). Second, the ecological validity of the studies findings on DLS recovery increases as psychology is taken into a naturalistic setting (Napa Scollon et al., 2009). Third, the recall bias decreases as there are not more than 90 minutes between the beep and the response (Napa Scollon et al., 2009). Fourth, this study gives information about the momentary dynamics. With investigating the ER strategies directly at the beep when the stressful event has been noted, this study does not present delayed nor static data, but more precise momentary data. Lastly, to the researcher's knowledge this is one of the first studies

investigating the role of ER strategies in the relationship between DLS recovery and depressive symptoms in naturalistic settings.

With presenting the strengths, it is important clarifying the limitations of this study. First, this study has a relatively small sample (N = 51) and small percentage of used measurement points (9.02%). A small sample and a small percentage of used measurement points both impact the statistical power which could lead to a higher possibility for false negatives and false positives (Button et al. 2013; Sterne & Smith, 2001; Ioannidis et al., 2011). For the present study, the results should therefor be viewed with caution, as there can be an increased possibility for both false significant and false non-significant findings, which can affect the validity of the results. Second, this study has a rather homogeneous sample. With more than 86% participants being female, the mean age being 23.96 years old, and more than 88% being Belgium, this sample does not show an equal distribution of gender, age, and nationality. Notably, previous research suggested females show higher DLS scores, suffer more from DLS, and report more stress reactivity, reduction, and recovery (Rausch et al., 2008; Matud, 2004). Older adults show a reduced exposure to DLS, and their NA is less affected by DLS exposure (Scott et al., 2013; Stawski et al., 2008). An unequal distribution in gender and age could therefore lead to an overall more positive association regarding DLS recovery. Consequently, the generalizability and the accuracy of the studies results are diminished. Third, only psychological self-reports are included in this study. These measures are still sensitive to the following factors: cognitive biases, social desirability, and cultural norms. These factors can influence the responses at the momentary level of reporting (Napa Scollon et al., 2009). In the present study, these factors and their impact should therefor be considered when interpreting the results, as not being able to solely measure the intended concepts could impact the studies validity. Fourth, this study assumes that rumination has predominantly maladaptive components and cognitive reappraisal has predominantly adaptive components. However, as it was shown by Joorman et al. (2006), rumination can also have adaptive components. There is also reason to believe that the same accounts for cognitive reappraisal, which can also have maladaptive components (Troy et al., 2013). The opposite components of rumination and cognitive reappraisal are not considered in the present study. Yet, these opposite components could influence the impact of rumination and cognitive reappraisal on the DLS recovery as these impacts could be in opposite directions.

Future research

Future research should include the following recommendations: To start, it is important to repeat this study with a bigger and more heterogeneous sample for replicating the

present studies outcomes. First, future studies should include a combination of multiple reports: psychological self reports and physiological reports. Including physiological reports, such as heart rate variability, which is a biomarker of stress, can give more precise insight into DLS. Combining these with psychological self reports can reduce the problems relating to psychological self reports (e.g., sensitivity to cognitive biases, social desirability, and cultural norms) and can increase the objectivity of the data (Napa Scollon et al., 2009). Second, other ER strategies should also be included in future studies. This study includes rumination and cognitive reappraisal, but there are several other ER strategies (suppression, distraction, avoidance, problem solving, social sharing, acceptance) which could have an impact on the stressor's recovery (Krkovic et al., 2018). Third, future studies on DLS recovery and depressive symptoms should include interventions and treatments of ER. Specifically, ER training, (e.g., for training cognitive reappraisal) could be incorporated to study its possible positive effect on depressive and (daily-life) stress symptoms (Jenaabadi, 2017; Training, 2015).

Conclusion

To conclude, the present study investigated the role of momentary rumination and momentary cognitive reappraisal on the relationship between DLS recovery and the severity of depressive symptom severity in a naturalistic setting. The findings suggest that individuals with more severe depressive symptoms show the best DLS recovery in moments of reported high rumination. In moments of reported high cognitive reappraisal individuals with less severe depressive symptoms show poorer DLS recovery and individuals with more severe depressive symptoms show the best DLS recovery. These findings contribute to a better understanding of DLS recovery. Moreover, these findings have the potential of enhancing ER interventions to reduce (daily-life) stress and depressive symptoms in the long run. Future research is needed on the role of momentary ER on the relationship between DLS recovery and depressive symptoms in a naturalistic setting. Future research should also consider including multiple reports (e.g.: psychological and physiological reports) and exploring alternative ER strategies.

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