Daily Stress Encounters: Positive Emotion Upregulation and Depressive Symptoms

Abstract

When it comes to coping with stress, positive emotion upregulationis of utmost importance. Positive emotions have been suggested to be an important resource duringstressful times, since people try to create and upregulate pleasant emotional states when feeling stressed.Accordingly, individual differences in the ability to generate and savor positive emotional states could also affect one's skillsin dealing with stress. In this regard, an important factor might be depression, which is associated with impaired positive emotion regulation. In order to disentangle the reciprocal influence between perceived stress and positive emotion upregulation, we conducted an Ecological Momentary Assessment (EMA) study (n=92) in which we assessed participants' stress levels and use of positive upregulatingstrategies (attentional deployment, cognitive change, and response modulation)three times a day over two weeks. Results from linear mixed-effects models showed that higher levels of perceived stress at one point predicted increased use of positive upregulating strategies from this point to the next which, in turn, resulted in subsequent diminished stress levels. Interaction analyses indicated that participants with higher depressive symptoms implemented upregulating strategies to a lower extent whenexperiencing intense stress. Furthermore, attentional deployment was less effective in decreasing stress in individuals higher in depression, whereas the other strategiesshowed comparable or even higher efficacy. Overall, positive emotion upregulation might be regarded as an adaptive tool that helps cope with stress. This mechanism might be altered in people higher in depression, whospecifically struggle to implement positive upregulating strategies during times of stress.

Keywords: positive emotion regulation, stress, ecological momentary assessment, depressive symptoms.

1. INTRODUCTION

Coping skills refer to the set of resources and personal qualities that people possessto manage stress and face adverse life events (Connor & Davidson, 2003). These skills involve the use of both problem-focused and emotion-focused strategies in response to stressors (R. S. Lazarus & Folkman, 1984). In the context of to the latter, stressful situations commonly lead to the experience of negatively-valenced emotional states, such as anxiety, anger or sadness(R. S. Lazarus & Folkman, 1984), which require the deployment of regulatory processes (Shallcross et al., 2015; Wang & Saudino, 2011) and the use of strategies to downregulate them(Boemo et al., 2022; Tabibnia, 2020). Impaired abilities to regulate negative emotions during times of stress can result in prolonged negative mood, thus constituting a risk factor for mental health(Sheldon Cohen et al., 2007; Martin & Dahlen, 2005). Nevertheless, even though most of the coping literatureis focused on the role of distress and negative emotions, there is now increasing evidence supporting the importance of positive emotions and their regulation in the coping process (Folkman & Moskowitz, 2000).

The beneficial role of positive emotions on emotional well-being has long been studied. Positive emotions have been demonstrated to enhance approach behaviors, encourage the exploration of novel situations, and reduce the anticipation of threats and potential risks (Cacioppo & Berntson, 1999; Forgas, 1995). Furthermore, they are an important signal for the body to calm down and lower vigilance levels (Barbara L. Fredrickson, 1998), thus reducing one's physiological activation after the experience of negative emotional states (Barbara L. Fredrickson & Levenson, 1998). In the same direction, the Broaden-and-Build Theory states that positive emotions extend the scope of attention, cognition and action (B L Fredrickson, 2001; Barbara L. Fredrickson, 1998, 2004), thus promoting resilience and well-being (Barbara L. Fredrickson & Joiner, 2002). Together, positive emotions extend beyond mere pleasant states, representing an important resource to deal with challenging situations (Fred B. Bryant & Smith, 2015; Pavani et al., 2016).

In the context of stress,Lazarus et al. (1980) first defined positive emotions as a potential motivator for coping, a break from distress and a way to recover after a stressful situation. Substantial support for this hypothesis emerged in the 1990s, when Folkman et al. (1997) observed that negative and positive affect were likely to co-occur during periods of intense stress. Since then, positive emotions have gained growingattention in the stress literature(Pressman & Cohen, 2005). The dynamic affect model posits that, while negative emotions typically prevail in stressful situations, the experience of positive emotions can alleviate the impact of these negatively-valenced responses(Zautra et al., 2005). Positive emotions have an “undoing effect” on stress by counteracting the cardiovascular and autonomic aftereffects of negative emotions, making recovery from stress faster, and aiding in the development of skills and resources that prove beneficial in times of stress(B L Fredrickson, 2001; Barbara L. Fredrickson, 2013; Barbara L. Fredrickson & Levenson, 1998). Laboratory studies where positive emotions are induced after a stressor have provided causal evidence for their stress-buffering role (van Steenbergen et al., 2021). These studies have also shed light on the underlying biological mechanisms, including the impact of positive emotions on cardiovascular and hormonal responses, the activation of the brain reward system, and the release of stress-alleviating neurochemicals (Cavanagh & Larkin, 2018; Dutcher & Creswell, 2018; Yang et al., 2018).

Since regulating emotional experiences in response to stressors is an important component of the coping process (R. S. Lazarus & Folkman, 1984), the use of strategies that enhancepositive emotionsmight significantly influence how stress is experienced and handled.Positive emotion regulation encompasses the use of attentional, cognitive or behavioral strategies to either upregulate or downregulate positive emotional states. For the aim of the current study, we will focus on positive upregulating strategies, whose aim is to create, maintain and amplify positive emotions (Fred Boyd Bryant & Veroff, 2007; Quoidbach et al., 2015). These strategies can be deployed atdifferent stages of the emotion generation process(Gross, 1998; Quoidbach et al., 2015; Vanderlind et al., 2022): (1) by selecting situations that improve mood (situation selection); (2) by focusing attention on stimuli that amplify positive emotions (attentional deployment); (3) by positivelyinterpreting a stimulus in order to enhancepleasantemotions (cognitive change); and (4) by modifying and enhancing the expression of positive emotional states (response modulation).

Extensive empirical evidence has shown that engaging in positive upregulatingstrategies leads to higher levels of happiness and emotional well-being (Jose et al., 2012; Quoidbach et al., 2010). Besides, recent theoretical modelssuggest that positive emotion regulation might also represent a potential route to resilience, so that people upregulate positive emotions during stressful situations rather than onlydownregulating negative ones(Tabibnia, 2020; Waugh, 2020). The tripartite model of resilience-building identifies the use of strategies to boost positive emotional states (e.g., humor, positive reminiscence, social support) and self-transcendence experiences (e.g., mindfulness, spirituality) as potential mechanisms to cope with stress(Tabibnia, 2020). In the same vein, Waugh et al. (2020) argued that, in reaction to stress, the upregulation of positive emotions might be intentionally sought by individuals to reduce stress. Furthermore, some laboratory studies have provided support for this hypothesis.

For instance, engaging in mindfulness practice (i.e., attentional deployment; Basso et al., 2019; Creswell & Lindsay, 2014)or attributing a positive meaning to ordinary daily events (i.e., cognitive change; Folkman et al., 1997; Folkman & Moskowitz, 2000) can counteract the negative consequences of stress. Similarly, expressing positive emotions significantly reduces physiological and self-reported stress levels (i.e., response modulation; Kraft & Pressman, 2012; Zander-Schellenberg et al., 2020).

Interestingly, to the best of our knowledge,studies examining the impact of positive upregulation strategies on stress in everyday life have not yet tested such hypotheses. A large number of studies have been conducted on a related issue, that is, positive emotion regulation and negative emotional experiences. Interestingly, initial findings suggested that positive upregulating strategies were not enacted more after intense negative emotions (e.g., Brans et al., 2013; Pavani et al., 2016).By contrast, more recent studies with more extensive samples and examining more numerous regulatory behaviors(Quoidbach, Sugitani, et al., 2019; Quoidbach, Taquet, et al., 2019; Taquet et al., 2016) provided support for the hypothesis that positive upregulating strategies tend to be enacted to cope with unpleasant emotions. More specifically, strategies aimed at boosting positive emotions were found to be implemented more extensively after the experience of intense negative emotions, leading to a reduction of these negative emotions and/or an enhancement of positive ones.

If positive upregulating strategiesplay a crucial role in the coping process, individual differences in the ability to generate and savor positive emotional states couldaffect one's ability to deal with stress. One of the factors that might be of interest in the context of coping corresponds to depressive symptomatology. Depression has been linked to decreased levels of positive emotions and impaired abilities to upregulate positive emotions in all stages of the emotion generation process(Carl et al., 2014;

Griffith et al., 2023; Heininga & Kuppens, 2021).Thus,individuals experiencing depressive symptoms are less likely to seek out pleasurable situations (i.e., situation selection), focus less on positive stimuli (i.e., attentional deployment), engage less in positive reappraisal (i.e., cognitive change),and express positive emotions less frequently (i.e., response modulation)(for a review, see Vanderlind et al., 2020b).This impairment has been related to various factors, such as a diminished reaction to positive stimuli (Bylsma et al., 2008; Rottenberg et al., 2005), a greater and more frequent deployment of maladaptive strategies (Liu & Thompson, 2017; Vanderlind et al., 2022) and a reduced preference for experiencing positive emotional states (Millgram et al., 2015, 2019; Tamir, 2009; Tamir et al., 2016). Moreover, the available research consistently shows that people with depression tend to use more dampening strategies, that is, strategies aimed at decreasing positive emotions (Griffith et al., 2023; Vanderlind et al., 2022). Therefore, the adaptive role ofpositive upregulating strategiesin stress management might be disrupted in people suffering from depression.

The current study

So far, the existing literature indicates that positive emotions and their upregulation are crucial in the context of stress(e.g., Tabibnia, 2020; Waugh, 2020). Although the downregulation of negative emotions is a central component of stress management (R. S. Lazarus, 1991)and numerous studies haveinvestigated these regulatory mechanisms in ecological settings (for a meta-analysis, see Boemo et al., 2022), the role of positive emotion upregulation has been less explored. Given the divergent findings observed between laboratory-based studies and ecological investigations, exploring positive emotion regulation in real-life contexts seems of utmost importance (D. Colombo et al., 2020; Heininga & Kuppens, 2021). In this sense, it remains unclear whether momentary stress predicts changes in the subsequent use of positive upregulating strategies, and whether increased use of positive upregulating strategies reduces subsequent stress levels.Moreover, no previous studies have explored how depressive symptomatology might influence the use of positive upregulating strategies to counteract the negative impact of stress.

In the present study,we conducted an Ecological Momentary Assessment (EMA) study to monitor participants' stress levels and their daily use of positive upregulating strategies,namely, attentional deployment, cognitivechange and response modulation. More specifically, we focused on perceived stress, defined as the '[…] feelings that an individual has about how much stress they are under at a given point in time' (Phillips, 2013).

The two primary objectives of the current study were the following.

1. To investigate whether attempts to upregulate positive emotions are effective in improving one's emotional experience (i.e., positive and negative mood). In line with the previous literature about the adaptive role of positive upregulationstrategies for emotional well-being (Jose et al., 2012; Quoidbach et al., 2010), we hypothesized that the use of all strategies at one point would predict higher subsequent positive mood and lower subsequent negative mood.

2. To explore the reciprocal influence between stress and positive emotion upregulation in daily life. More specifically, (a) we examined the relationship between momentary stress and the subsequent implementation of positive upregulating strategies,(b) explored the impact of positive upregulating strategies on subsequent levels of stress, and (c) investigated whether mild or moderate depressive symptoms modify the reciprocal association between momentary stress and positive emotion upregulation.Consistent with the evidence that positive emotions(Folkman, 2008; van Steenbergen et al., 2021) and positive emotion upregulation(Tabibnia, 2020; Waugh,

2020) are important resources to build resilience and cope with stressful situations, we expected thathigher levels of stress would predict an increase in the subsequent use of positive upregulating strategies, and that increased use of upregulating strategies would result in lower stress levels at the following assessment. Furthermore, we hypothesized that this mechanism would be disrupted in individuals experiencing higher depressive symptoms, so that greater stress levels would not lead to increased use of positive upregulating strategies and, consequently, to diminished stress levels.

2. METHOD

2.1 Sample and procedure

To be eligible for the study, individuals had to meet the following criteria:be aged between 18 and 65 years, be able to read and understand Spanish, and not be under pharmacological or psychological treatment. The final sample included 92 undergraduate students (82.61% female), with a mean age of 21.36 (*SD*=3.5). The sample size was similar to previous studies exploring affective dynamics and emotion regulation mechanisms through EMA designs(e.g., Brans et al., 2013; Pavani et al., 2016; Pe et al., 2013; Heiy & Cheavens, 2014).

The recruitment was performed through community flyers and online advertisements about a smartphone-based study exploring daily pleasant emotions and experiences. Participants willing to participate were invited to send an email to the main researcher of the study and schedule an explanatory session at the laboratory. During this first face-to-face visit, participants received more details regarding the study, signed the informed consent and completed the PHQ-9 baseline measure.

Over two weeks, three daily semi-randomized email-based surveys (between 9:30 a.m. and 2:00 p.m., 2:00 p.m. and 6:30 p.m., and 6:30 p-m.and 11:00 p.m.) were sent through the data collection program Qualtrics. If the link was not accessed within sixty minutes of receipt, the assessment would be marked as missing. The implemented sampling frequency is similar to other EMA studies that assessed emotion regulation dynamics (Desirée Colombo, Suso-Ribera, et al., 2020; Heiy & Cheavens, 2014). In our sample, the mean compliance was 76.9%. This study was approved by the ethics committee of Jaume I University(certificate number: CD/57/2019). This study was not pre-registered.

2.2 Measures

Depression: Depressive symptoms were measured with the Spanish validation of the Patient Health Questionnaire-9 (PHQ-9) (Diez-Quevedo et al., 2001; Kroenke et al., 2001), a brief self-report scale with good psychometric properties (Wittkampf et al., 2007). In our sample, the internal consistency was adequate (α=.89). According to the PHQ-9 scores (Diez-Quevedo et al., 2001; Kroenke et al., 2001), 39 participants did not show any significant depressive symptoms (PHQ9 ≤ 4), 38 participants reported mild depressive symptoms (5 ≤ PHQ9 ≤ 9) and 15 participants presented moderate to moderately severe depressive symptoms (PHQ9 ≥ 9). The mean score was 5.92 (min=0, max=23; *SD* = 4.00).

EMA measures: At each assessment, the participants were asked to rate the following items.

*Momentary mood:*Similar to previous studies (Desirée Colombo, Fernández-Álvarez, et al., 2020; Desirée Colombo, Suso-Ribera, et al., 2020), participants were asked to rate momentary positive mood (‘To what extent are you experiencing positive emotions right now?’) and negative mood (‘To what extent are you experiencing negative emotions right now?’)on a 0-100 scale (0 = not at all; 100 = a lot).

Perceived stress: The transactional theory of stress questions the assumption that certain events are inherently stressful. Instead, it emphasizes the key role of one's appraisal of a situation as well as coping skills to deal with it (S. Cohen et al., 1983; R. S. Lazarus & Folkman, 1984). In this vein, studies have demonstrated that the way individuals subjectively perceive stress is more strongly linked to stress-related physiological dysregulation and prolonged negative mood than the actual occurrence of stressful events (Clark et al., 2007; Hawkley et al., 2011; van Eck et al., 1998). Accordingly, in the present study we assess perceived stress with the item 'How stressed do you feel right now?' on a 0-100 scale(0 = not at all; 100 = a lot).This scale has already been used in a previous EMA study(Grégoire et al., 2020) and it is similar to the item used by Karvounides et al.(2016)to assess perceived stress in an ecological study.

Positive upregulating strategies: The momentary use of three upregulating strategies (0 = no adoption; 100 = high adoption) reflecting (1) attentionaldeployment (focusing attention on the present moment and positive feelings: 'I'm trying to be focused on the present and concentrate on how good I feel'), (2) cognitive change (infusing positive meaning to ordinary events and feelings: 'I'm thinking about how lucky I am to live in this moment and feel so good') and (3) response modulation strategies (expressing positive emotions on the outside: 'I'm trying to express and emphasize my emotions on the outside by showing them; for instance, by smiling or laughing') were administrated. Each strategy was assessed through single items. While the cognitive change item was created based on the extensive review by Quoidbach et al. (2020) about cognitive change strategies (i.e., counting blessings) to upregulate positive emotions, the attentional deployment and response modulation items were similar to those usedin a previous EMA research on the regulation of positive emotions('I tried to revel in the moment and concentrate on how good I felt' and 'I emphasized my emotions by showing them', respectively) (Heiy & Cheavens, 2014). Situation selection was not taken into consideration, since participants were asked to report ongoing feelings and momentary strategy use (i.e., the situation had already been previously selected). Furthermore, the effectiveness of situation selection in increasing short-term positive emotions has been shown to be weak, whereas attentional deployment, cognitive change and response modulation have been found to significantly increase positive emotions in the shortrun (for a review, see Quoidbach et al., 2015). Laboratory-based studies suggest that all three strategies are effective in mitigating the impact of stress (Basso et al., 2019; Creswell & Lindsay, 2014; Folkman & Moskowitz, 2000; Kraft & Pressman, 2012; Zander-Schellenberg et al., 2020).

Importantly, in most EMA studies on emotions (e.g., Koval et al., 2023), strategy use is usually assessed between t0 and t1 by asking participants to try to remember the emotion regulation strategies they have enacted since the last assessment. To avoid observations contaminated by memory biases, we decided to assess strategy use by asking participants to indicate what they were currently doing. In order to convert these time point-related variables into variables that are closer to the emotion regulation variables generally assessed in EMA studies (i.e., behaviors that are related to periods between two consecutive time points), we computed change scores for each strategy, i.e., to what extent the use of a certain strategy increased or decreased at a time point (t1) as compared to the previous assessment (t0). To avoid the so-called 'regression toward the mean effect', we calculated these change scores by taking the residuals of a model in which each strategy at t1 was regressed on itself at t0 (Barnett et al., 2005; Yu & Chen, 2014).Computing residualized change scores was done for simplicity. Readers interested in emotion regulation research are familiar with strategy use-related variables that are located within a time interval (e.g., “How intensely have I used a strategy since the last assessment point?”). By computing residualized change scores, our strategy use-related variables could be located within such a time interval.

Measures that are supposedly dynamic should be sensitive to within-person change and capture moment-to-moment variability. The proportion of variance at the within-individual level in our items was very close to what is generally obtained with emotion-related variables (Podsakoff et al., 2019), namely 48% for our item of attentional deployment, 48% for our item of cognitive change, 49% for our item of response modulation, and 57% for our item of stress.

2.3 Statistical analyses

All statistical analyses were performed with R 4.4.2 and RStudio 2023.03.0 and were similar to previous EMA studies on the reciprocal influence between emotional states and ER (Brans et al., 2013; Pavani et al., 2016; Quoidbach, Sugitani, et al., 2019).P-values lower than .05 were considered statistically significant. All models performed consisted of linear mixed-effects models fitted with maximum likelihood estimation, in order to take into account the hierarchical nature of the data (i.e., several observations nested within several individuals).

Before running the analyses, we person-mean-centered all the within-individual variables[1]and lagged the data in order to explore the relationship between two consecutive assessments, so the data pointsthat were not preceded or followed by a

[1]Person-mean-centering our within-individual variables served to remove the variance in these variables that was attributable to stable between-individual factors, as it is commonly done in EMA studies (e.g., Koval et al., 2023). It prevented us from examining whether depression affected the average intensity with which each individual displayed these variables. However, our hypotheses did not regard such individual averages. Rather, they pertained to the influence of depression on the relationships between different within-individual variables.

valid assessment were deleted[2].

To achieve the first objective, we explored whether change in the use of upregulating strategies from t0 to t1 resulted in higher subsequent positive mood and lower subsequent negative mood(i.e., t1). To do so, we calculated two linear mixed-effects models containing one random intercept per participant using maximum likelihood with the R lmerTest package (Kuznetsova et al., 2017). The dependent variables of each model werenegative mood and positive moodat t1, respectively, whereas the main independent variables were changes in upregulating strategies from t0 to t1.

Regarding the second objective, wefirst explored the effects of momentary stress on the subsequent implementation of upregulating strategies.Three linear mixed-effects models containing one random intercept per participant were estimated. The dependent variable of each model was the change in the use of each strategy, respectively, whereas the main independent variable was stress at t0. Since stress at t1 was related to stress at t0 and strategy changes from t0 to t1, it could represent a confounding variable when attempting to determine the association between stress at t0 and strategy changes from t0 to t1. Therefore, we included stress at t1 and the use of each strategy at t0 as control variables.

Subsequently, we investigated the effect of change in strategy use on subsequent levels of stress. To do so, we estimated one linear mixed-effects model using stress at t1 as the dependent variable and changes in upregulating strategies from t0 to t1 as independent variables, while controlling for stress at t0 to neutralize the 'regression toward the mean' effect. The effectiveness of a strategy use would be suggested by a

[2] In the present study, we did not apply any correction for the first measurement of the day. Doing so, for instance by deleting all rows where t0 referred to the last measurement of one day and t1 referred to the first measurement of the next day, would have reduced the statistical power without any empirical change. Indeed, the results (i.e., regression coefficients) described here correlated at .98 with results obtained while considering this first measurement.

negative regression coefficient. In this context, negative regression coefficients would mean that the more the use of a strategy increased from t0 to t1, the less stress was experienced at t1.

Finally, we examined whether the aforementioned relationships were moderated by depression. After computing z-scores for the baseline PHQ-9 measures, we performed four more linear mixed-effects models, following the same approach as in the first and second steps (i.e., using the same dependent and independent variables), but also including the PHQ-9 z-scores and the interaction term between stress at t0 and depression as further independent variables.

Analyses were also performed while controlling for gender. As results were similar (i.e., no statistically significant result becomes nonsignificant and vice-versa), the results displayed in the present article were obtained while neglecting gender.

2.4 Transparency and openness

This study is part of a broader project about positive emotion regulation in daily life(Colombo et al., 2021). The dataset of the present study and the R script of the analyses have been uploaded on the OSF website at https://osf.io/u3m6a/?view_only=47425bf5f0894fc48e58fd13955cd9c1(Colombo, 2024).

3. RESULTS

3.1 Preliminary analyses

An initial general overview of the association between the variables of interest is shown in **Table 1**.

Table 1

Correlations between positive upregulating strategies and stress, positive and negative mood at the within- and between-individual level. Means and standard deviations have been computed on the raw variables. (PHQ9: Patient Health Questionnaire–9)

	M (*SD*)	1	2	3	4	5	6	7
Within-individual correlations								
1. Stress	28.42 (17.03)	1.00						
2. Positive mood	55.14 (18.40)	-.334***	1.00					
3. Negative mood	22.34 (12.28)	.466***	-.486***	1.00				
4. Attentional deployment	54.19 (20.25)	-.253***	.527***	-.329***	1.00			
5. Cognitive change	49.64 (21.32)	-.258***	.468***	-.320***	.629***	1.00		
6. Response modulation	45.19 (22.19)	-.169***	.399***	-.225***	.468***	.465***	1.00	
Between-individual correlations								
1. Stress	28.42 (17.03)	1.00						
2. Positive mood	55.14 (18.40)	-.270**	1.00					
3. Negative mood	22.34 (12.28)	.770***	-.202	1.00				
4. Attentional deployment	54.19 (20.25)	-.157	.812***	-.241*	1.00			
5. Cognitive change	49.64 (21.32)	-.126	.710***	-.180	.850***	1.00		
6. Response modulation	45.19 (22.19)	-.038	.724***	-.092	.694***	.671***	1.00	
7. PHQ9	5.92 (4.00)	.370***	-.530***	.489***	-.427***	-.397***	-.390***	1.00

*p<.05, ** p<.01, ***p<.001

Overall, attentional deployment was used to a greater extent than the other strategies, whereas response modulation was the least adopted strategy. At the within-individual level, a more intense use of positive upregulating strategies was associated with lower levels of stress and negative mood, as well as higher levels of positive mood over the course of the 2-week study. At the between-person level, higher depressive symptoms were associated with higher experienced stress and negative mood, lower rates of positive mood, and lower use of positive upregulating strategies.

3.2Objective 1: Effect of upregulating strategies on emotional experience

Regarding the first objective of the study, linear mixed-effects models showed thatincreased use of attentional deployment, cognitive change and response modulation strategies at t0 resulted in higher positive mood at t1 (attentional deployment: $b = 0.355$, $SE = 0.022$, $p < 0.001$; cognitive change: $b = 0.142$, $SE = 0.028$, $p < 0.001$; response modulation: $b = 0.146$, $SE = 0.020$, $p < 0.001$), as well as lower negative moodat t1 (attentional deployment: $b = -0.215$, $SE = 0.024$, $p < 0.001$; cognitive change: $b = -0.149$, $SE = 0.025$, $p < 0.001$; response modulation: $b = -0.043$, $SE = 0.021$, $p < 0.05$). In line with our hypothesis, these findings suggest that an increase in the use of all strategies was related to subsequent higher positive emotions and lower negative ones.

3.3 Objective 2: Reciprocal association between stress and upregulating strategies

To address thesecond aim of this study, we first exploredwhether stress levels at t0 predicted changes in strategy use at t1.The results are shown in**Table 2**.

Table 2

Results of the linear mixed-effects models predicting change in strategy use from stress at t0.

	Change in	*Change cognitive*	*Change response*

	attentional deployment		*change*		*modulation*	
	b	*SE*	*b*	*SE*	*b*	*SE*
FIXED EFFECTS						
Stress (t0)	.059**	.021	.067**	.021	.048*	.022
Attentional deployment (t0)	-.072**	.026	.055*	.026	.063*	.027
Cognitive change (t0)	.095***	.026	-.047	.026	.058*	.027
Response modulation (t0)	.030	.022	.034	.022	-.053*	.023
Stress (t1)	-.280***	.021	-.266***	.021	-.186***	.022

*p<.05, ** p<.01, ***p<.001

In line with our hypothesis, the effects were all positive and significant, so experiencing higher levels of stress was associated with a subsequent increase in the use of attentional deployment, cognitive change and response modulation strategies.

We therefore examined whether changes in the use of all strategies predicted the subsequent levels of stress. The effects were all negative and significant, so increased use of attentional deployment (b = -0.163, SE = 0.018, p < 0.001), cognitive change (b = -0.133, SE = 0.025, p < 0.001) and response modulation strategies at t0 (b = -0.044, SE = 0.026, p < 0.05) predicted lower stress at t1, while controlling for stress at t0 (b = 0.202, SE = 0.019, p <0.001), thus confirming our hypothesis.

Finally, we explored whether depressive symptomatology affected the reciprocal association between momentary stress and positive upregulating strategy use. We hypothesized that the association between stress at t0 and change in strategy use from t0 to t1 would be moderated by depression, so higher levels of stress at t0 would predict an increase in the subsequent use of positive upregulating strategies, but only in individuals with lower symptoms of depression.As individuals with higher symptoms of depression were hypothesized to display effects of stress on subsequent strategy use that are less positive/more negative, we expected to obtain negative regression coefficients for these interaction effects.

As shown in **Table 3**, the results partially confirmed our hypothesis. Depressive symptoms significantly moderated the association between stress at t0 and the use of cognitive change and response modulation strategies at t1, but not its association with attentional deployment change (*p*=0.06). More specifically, the relationship between stress at t0 and the use of cognitive change and response modulation strategies was less positive (or even negative) for those with higher levels of depression than for those with lower levels of depression. For those with higher levels of depression (PHQ-9 z-scores = 1), on average, the slope coefficients relating stress level at time t0 to the use of positive upregulating strategies at t1 were close to 0 or negative, ranging from 0.002 to -0.021. However, for those with lower levels of depression (PHQ-9 z-scores = -1), on average, these slope coefficients were positive, ranging from 0.099 to 0.114 (**Figure 1**).

Table 3

Results of the linear mixed-effects model predicting the impact of stress at t0 on change in strategy use at t1, moderated by depression. (PHQ9: Patient Health Questionnaire–9)

	Change in attentional deployment		*Change in cognitive change*		*Change in response modulation*	
	b	*SE*	*b*	*SE*	*b*	*SE*
FIXED EFFECTS						
PHQ9 (z-scores)	.002	.024	.004	.024	-.006	.025
Stress (t0)	.052*	.022	.058**	.021	.039	.022
Attentional deployment (t0)	-.071**	.026	.057*	.026	.065*	.027

Cognitive change (t0)	.093***	.026	-.049	.026	.056*	.027
Response modulation (t0)	.029	.022	.033	.022	-.053*	.023
Stress (t1)	-.028***	.280	-.270***	.021	-.185***	.022
Stress (t0) * PHQ9 (z-scores)	-.047	.024	-.056*	.025	-.060*	.026

*p<.05, ** p<.01, ***p<.001

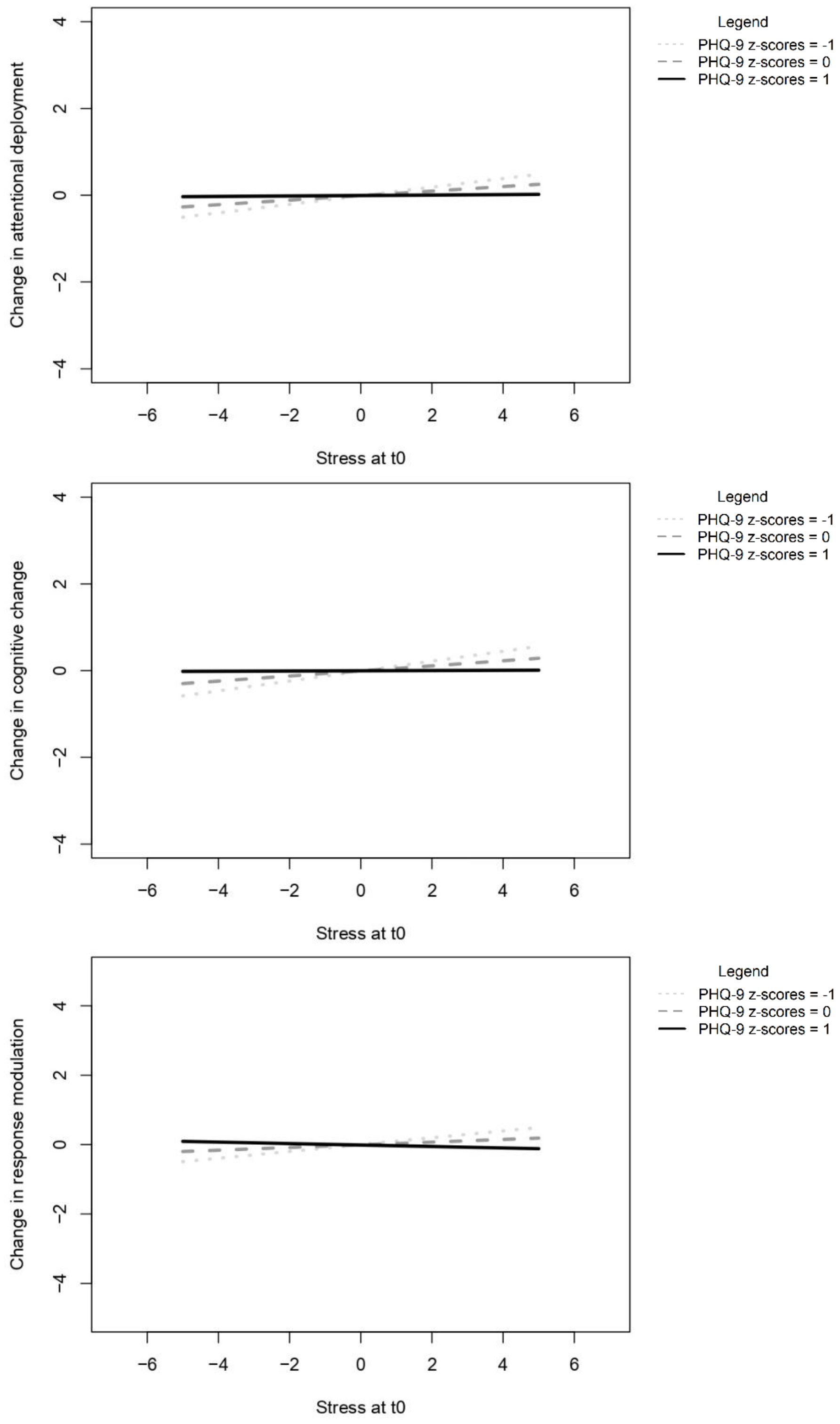

Figure 1.

Graphical representation of the effect of stress at t0 on subsequent changes in strategy use, moderated by depression.

Similarly, we tested whether the link between change in strategy use from t0 to t1 and stress at t1 was moderated by depression. More specifically, we expected that increased use of all strategies would predict reduced stress levels at t1 to a greater extent for those with lower (vs. higher) levels of depression. As individuals with higher symptoms of depression were hypothesized to display effects of change in strategy use on stress that are less negative/more positive, we expected to obtain positive regression coefficients for these interaction effects. Our hypothesis was confirmed only in the specific case of attentional deployment (**Table 4** and **Figure 2**).

Table 4

Results of the linear mixed-effects model predicting the effect of change in strategy useat t0 on stress at t1, moderated by depression. (PHQ9: Patient Health Questionnaire–9)

	Stress (t1)	
	b	*SE*
FIXED EFFECTS		
PHQ9 (z-scores)	.0001	.023
Change in attentional deployment	-.155***	.025
Change in cognitive change	-.138***	.026
Change in response modulation	-.049*	.022
Stress (t0)	.202***	.019
Change in attentional deployment * PHQ-9 (z-scores)	.083**	.031
Change in cognitive change * PHQ-9 (z-scores)	-.068*	.031
Change in response modulation * PHQ-9 (z-scores)	-.021	.029

*p<.05, ** p<.01, ***p<.001

The interaction between change in attentional deployment and depression was in the hypothesized direction, so an increase in the use of this strategy to diminish subsequent stress levels was more effective in individuals with lower (vs. higher) depressive symptoms. For those with higher levels of depression (PHQ-9 z-scores = 1), on average, the slope coefficient relating the change in the use of attentional deployment and stress level at time t1 was -0.072, whereas it was -0.238 for those with lower levels of depression (PHQ-9 z-scores = -1).

Surprisingly, the results of the interaction between change in cognitive change and depression were in the opposite direction, suggesting that increased cognitive change predicted a greater stress reduction in individuals with higher (vs. lower) depressive symptoms. For those with higher levels of depression (PHQ-9 z-scores = 1), on average, the slope coefficient relating the change in use of cognitive change and stress level at time t1 was -0.206, whereas it was -0.070 for those with lower levels of depression (PHQ-9 z-scores = -1). Finally, no significant interaction was observed between depression and change in response modulation.

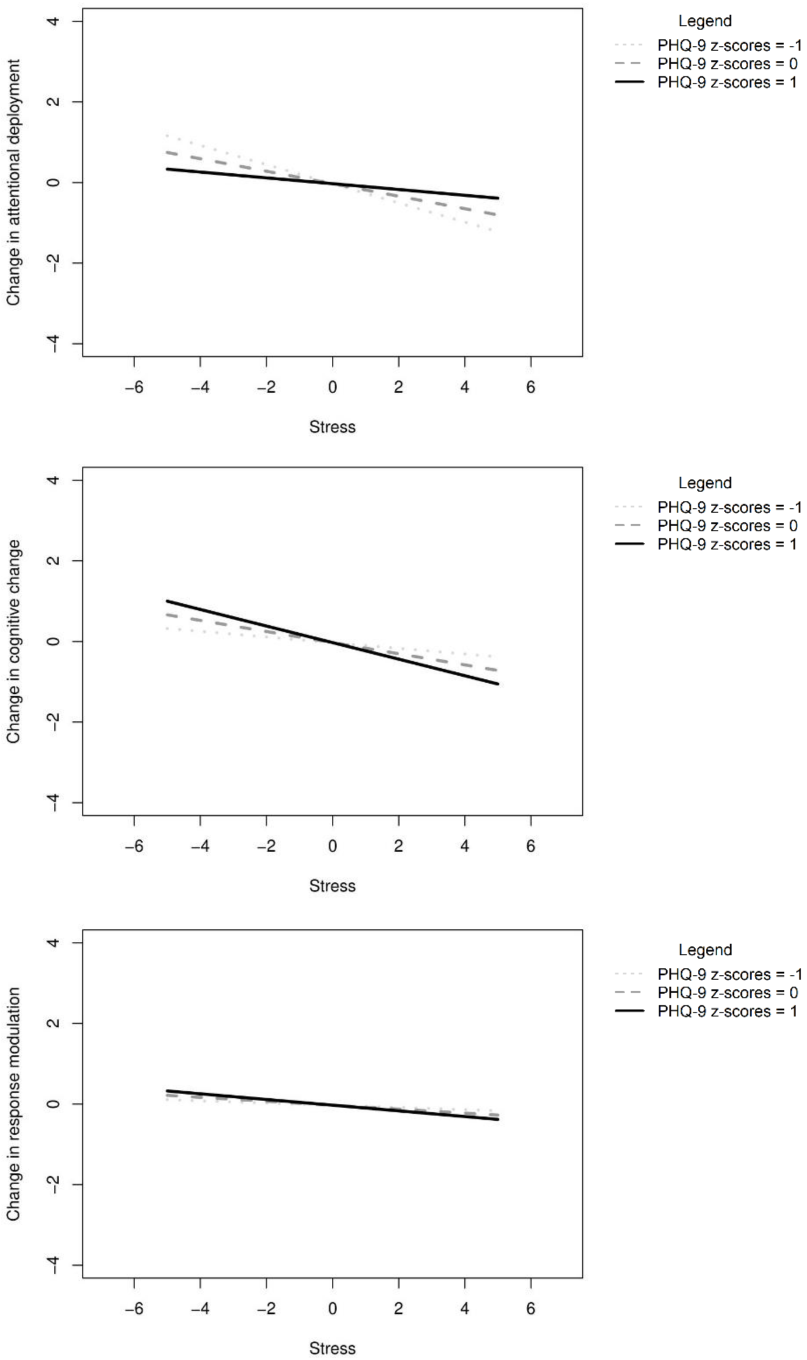

Figure 2.

Graphical representation of the effect of change in strategy use on subsequent stress (t1), moderated by depression.

4. DISCUSSION

When it comes to coping with stress, positive emotions and the use of positive upregulating strategies can be of utmost importance to counteract its negative effects (Folkman, 2008; Tabibnia, 2020; van Steenbergen et al., 2021; Waugh, 2020). Accordingly, the ability to cope with stressful situations might be affected in individuals whose skills to regulate positive emotions are impaired, such as in depression (Vanderlind et al., 2020). Although a growing body of literature has emphasized the importance of positive emotions during stressful times(Folkman et al., 1997; Richard S. Lazarus et al., 1980; van Steenbergen et al., 2021), most of the previous works relied on laboratory-based and retrospective designs. Yet, there is evidence indicating that real-life emotion regulation differs significantly from the patterns observed in laboratory-based studies (D. Colombo et al., 2020; Heininga & Kuppens, 2021). In the present study, we explored the reciprocal influence between perceived stress and positive emotion upregulation in the context of daily life. Furthermore, we investigated whether depressive symptoms moderatedthese associations.

The results of ourstudy showed thatincreased use of upregulating strategies predicted higher positive moodas well as lower negative mood at the subsequent assessment, which supports the evidence about the beneficial impact of positive emotion upregulation on emotional well-being (Desirée Colombo et al., 2021; Jose et al., 2012; Quoidbach et al., 2010). Additionally, the findings indicated thathigher levels of stress at one point predicted increased use of upregulating strategies from this point to the next one, and that increased use of upregulating strategiesat one point predictedlower stress levels at the following assessment. These findings confirm the important role of positive emotion regulation in the coping process (Tabibnia, 2020; Waugh, 2020) and replicate the previous literature on the efficacy of attentional deployment (Basso et al., 2019; Creswell & Lindsay, 2014), cognitive change (Folkman et al., 1997; Folkman & Moskowitz, 2000), and response modulation strategies (Kraft &

Pressman, 2012; Zander-Schellenberg et al., 2020)for reducing perceived stress, but this time in an ecological context. Overall, short-term stress might lead people to upregulate positive emotional states, so thattheymay intensify the effort put into the deployment of strategies that generate pleasant emotional states to reduce the experience of stress. This might be seen as a highly adaptive mechanism for well-being, since it encourages the use of one's attentional, cognitive or behavioral resources to upregulate positive emotions only in case of need (i.e., whenperceived stress is high). In that sense, positive emotion regulationdoes not only serve as a tool to generate and intensify the experience of positive emotional states (Fred Boyd Bryant & Veroff, 2007; Gentzler et al., 2013; Jose et al., 2012; Quoidbach et al., 2010), but it could also contribute to the management of stress and its negative effects.

Not surprisingly, the reciprocal association between perceived stress and upregulating strategiesdiffered in individuals experiencing more depressive symptoms, who typically struggle with upregulating positive emotions (Liu & Thompson, 2017; Vanderlind et al., 2020). Overall, our findings indicate that the impact of depressive symptoms on the implementation of positive upregulating strategies in stress management outweighs their influence on effectiveness, since only attentional deployment showed reduced efficacy. These results are in line with other recent studies, showing that depressive symptomatology affects the implementation, rather than the effectiveness, of positive upregulating strategies in both adolescents (Griffith et al., 2023)and adults(Vanderlind et al., 2022).

With regards to the association between stress and subsequent positive upregulating strategies use, the results were in the hypothesized direction. More specifically, whereas higher levels of stress predicted a subsequent increase in the use of positiveupregulating strategies in participants with lower depressive symptomatology, this association became less positive (and even negative in the case of response modulation) for individuals with higher depressive symptoms. Although the design of the current study does not allow a conclusion to be made as to why increased stress does not leadto increased use of positive upregulating strategies in these individuals, two possible explanations might be provided. According to the instrumental model of emotion regulation, people are likely to select and implement strategies that are consistent with their emotion preference (i.e., desired emotional state) (Tamir, 2009; Tamir et al., 2016). Since depression has been associated with a reduced preference toward positive emotional states (Vanderlind et al., 2020), individualswith more severe depressive symptoms might be less prone to implement positive upregulating strategies, even when they experience unpleasant affective states such as distress. Another potential explanation might be related to the emotion regulation self-efficacy concept, that is, the set of beliefs about one's capacity to successfully manage and change emotional states (Bandura, 1997; Bardeen & Fergus, 2020; Tamir & Mauss, 2011). Self-efficacy is considered an essential component of successful emotion regulation, since it boosts the pursuit of more ambitious goals (Bandura, 1997). Lower confidence in one's abilities to regulate emotional states has been associated with more severe depressive symptoms (Caprara et al., 2008; Catanzaro & Mearns, 2004; Catarizaro & Mearns, 1990) and with a greater tendency to use maladaptive strategies, such as avoidance (De Castella et al., 2018). In relation to the findings of the present study, we might argue that people with more severe depressive symptoms might not chose to upregulate positive emotions when feeling stressed because of low expectancies to achieve them.

Regarding the moderating role of depression in the association between change in upregulating strategies use and subsequent stress levels, the findings were quite unexpected.First, no difference was observed in the impact of increased response modulation on subsequent stress, so this strategy was equally effective among all the participantsin reducing perceived stress levels.The self-perception theory suggests that behaving as though one has a specific emotion by, for instance, activating facial muscles (Tourangeau & Ellsworth, 1979), can lead to the experience of that emotion(Bem, 1972; Laird, 1974). Within the facial feedback hyphothesis framework(Izard, 1977; Tourangeau & Ellsworth, 1979), smiling manipulation has been shown to result in decreased physiological and psychological stress as well as increased perceived happiness, even when participants are not aware of it (Coles et al., 2022; Kraft & Pressman, 2012). This effect seems to be due to the sensorimotor feedback produced by facial expressions, which automatically trigger changes in both the brain and the autonomic nervous systemactivities (Coan et al., 2001; Levenson et al., 1990). It might be that the effect of expressing emotions through body actions on one's emotional state is more biologically-based. Thus, it has an adaptive effect on stress levels, regardless of depressive symtpoms.

Second, attentional deployment more strongly reduced stress levels in individuals with lower depressive symptoms, which was coherent with our intial hyphothesis. Individuals with high depressive symptomatology have a tendency to focus more on negative information and have difficulty shifting their attention towards positive things (Gotlib & Joormann, 2010). This bias hinders the flexible selection and implemention of adaptive strategies, thus leading to a greater use of maladaptive ones(Gotlib & Joormann, 2010; LeMoult & Gotlib, 2019; Vanderlind et al., 2020), such as ruminative thinking (i.e.,the repetitive rehashing of negative events and feelings;Nolen-Hoeksema & Morrow, 1993). Accordingly, the tendency of individuals with high depressive symptoms to s more extensively focus on negative content, as well as to dwell on negative thoughts, might interfere with the attempt to focus their attention on the present moment and positive feelings as a way of alleviating stress, thereby reducing its effectiveness. Stated differently, it is possible that, after implementing this strategy, individuals with more depressive symptoms could shift their attention from positive emotions to negative material more rapidly, which could reduce its efficacy over time. This interpretation is in line with the meta-analysis by Picó-Pérez et al. (2017), who found that impairments in the management of attentional and inhibitory resourses in depression can potentially explain emotion regulation deficits.

Finally, cognitive change seemed to be more effectivein reducing pervceived stress in people with higher depression, which was unexpected. This surprising outcome could be explained by the negative bias that characterizes depression, i.e., the tendency to focus more on the negative side and intepretation of an event(Beck, 1987). According to Abramson et al. (1989), individuals suffering from depression typically show a negatively-biased cognitive style, which includes the propensity to blame oneself for the occurrence of an adverse event, as well as to identify stable and enduring causes for its occurrence and potential consequences. Since the use of cognitive change strategies to upregulate positive emotions involvesthe attempt to infuse positive meaning into ordinary events,itcould be particularly effective for individuals with more depressive symptoms, as itchallenges the negative cognitive style which typically underlies depression. However, further research is needed to better understand the differential impact of positive reframing strategies in individuals with high and low levels of depression. As positive strategies were assessed through ad-hoc single items, it might also be that this unexpected finding was the result of the EMA measure implemented to assess cognitive change.Specifically, participantsmight have agreed with the first part of the item ("thinking about how lucky I am to live in this moment") while not being fully aligned with the second part ("feeling so good"), particularly among individuals with higher symptoms of depression. This discrepancy could have made it challenging for participants to provide a cohesive and consistent rating for the entire item.

Although the present study sheds new light on the mechanisms underlying the reciprocal influence between stress and positive emotion regulation in daily life, this study is not free from limitations and additional avenues for further research could be proposed. First, although the sample size was similar to previous EMA studies exploring affective dynamics in daily life, future studies should try to replicate the present findings in a larger sample, equally represented by gender and age. Furthermore, the sample size should be determinedon the basis of an a priori power analysis rather than on the sample size observable in previous research. Second, our sample mainly included individuals with mild or moderate depressive symptoms, which makes it difficult to generalize the results to people who meet the criteria for a major depressive disorder. Third, we only investigated the use of positive upregulating strategies, so that the roles of positive downregulating strategies (i.e., dampening) along with negative emotion regulation, which might play a crucial role in stress management, are still open questions. Fourth, the emotion regulation assessment relied on the use of ad-hoc single items, which were mainly adapted from previous studies. Even though there is evidence showing that single items are often as valid as multi-item questionnaires (Allen et al., 2022) and methodologically accepted in EMA studies (Song et al., 2023), the items of our study might have not managed to capture what we wanted to measure. In this sense, future research is needed to validate items and/or questionnaires for assessing the momentary use of different emotion regulation strategies in ecological settings. Likewise, stress level was measured with a single item that assessed one’s emotional reaction at a given time point, which is consistent with the definition of perceived stress suggested by Phillips (2013). Nevertheless, perceived stress does not necessarily correspond to the occurrence of stressful events, as one may feel highly distressed despite the absence of a specific stressor. Future studies might be interested in disentangling the potential different impact of objective (i.e., the presence of stressors or stressful situations) and subjective stress (i.e., the phenomenological experience of feeling stressed) on positive emotion regulation, as well as its association with depressive symptoms. It is also worth mentioning that our study assessed what a person was doing and/or perceiving at the time of the notification. In the context of EMA studies, researchers typically employ two distinct strategies: (1) prompting participants to recall their behaviors and/or feelings since the last notification or (2) inquiring about their current behaviors and/or feelings. Both approaches possess inherent merits and drawbacks. The first option has the potential to yield a more representative variable of emotion regulation behaviors, but it is prone to retrospective memory bias - a common occurrence when individuals are asked to recall and estimate their past emotions(Desirée Colombo, Suso-Ribera, et al., 2020). Conversely, the second option provides a less biased assessment of a person's behavior but captures only isolated moments, offering a less comprehensive representation of daily ER patterns. In choosing to assess the momentary ER behavior of participants, we aimed to minimize biases associated with retrospective memory. In this sense, future studies adopting either a retrospective EMA approach or a momentary approach with a higher frequency of daily assessments are needed to confirm the robustness of our findings. Finally, even though we suggested potential explanations regarding the disrupted reciprocal association between stress and positive emotion upregulation in people with more depressive symptoms, definitive conclusions cannot be reached due to the correlational design of the study. Future studies should try to investigate other factors that might explain this prototype of stress regulation, such as self-efficacy beliefs or emotion preference, both as trait and/or state variables.

5. CONCLUSIONS

Overall, the findings point towards the important role of positive emotions during times of stress. Intense stress might lead people to upregulate their positive emotions and thuspositive emotion regulationmight be regarded as an adaptive tool to buffer stress. This mechanism could be altered in people with higher depressive symptoms, who seem to struggle toimplement positive upregulating strategies when feeling stressed. Still, when implemented to reduce stress levels,the use of response modulation in people higher in depression was equally effective in reducing distress, while cognitivechangewas even more effective than in participants lower in depression. Future studies should try to clarify the mechanisms underlying this implementation issue, thus opening new stimulating research lines for the understanding of positive emotion regulation and its association with depression. Furthermore, our results suggest that fostering the use of cognitive change strategies to deal with perceived stress might be particularly beneficial for people with mild or moderate depressive symptoms.

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