Neuroscience and Biobehavioral Reviews 139 (2022) 104747

Contents lists available at ScienceDirect

Neuroscience and Biobehavioral Reviews

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

Relations between emotion regulation strategies and affect in daily life: A systematic review and meta-analysis of studies using ecological momentary assessments

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ARTICLE INFO

Keywords:
Emotion regulation
Positive affect
Negative affect
Ecological momentary assessment
Daily diary

ABSTRACT

Emotion regulation (ER) is a central target in the study of psychological and neurobiological processes of emotions for numerous psychological disorders. Ecological momentary assessments, overcoming retrospective self-reports, allow a better understanding of the relation between the use of ER strategies and daily life affective experiences. A systematic review and meta-analyses of studies testing these relations through experience sampling methods (ESM) and daily diaries were conducted. ESM studies showed significant large effect sizes in contemporaneous relations between negative affect (NA) and rumination, suppression, and worry, and in both contemporaneous and prospective relations between positive affect (PA) and reappraisal; medium effect sizes in prospective relations between NA and rumination, and PA and distraction; and a small effect size in the prospective relation between NA and suppression. Daily diary studies showed significant large effect sizes in contemporaneous relations between NA and rumination and suppression, and in both contemporaneous and prospective relations between PA and reappraisal; medium effect sizes in contemporaneous relations between PA and acceptance, and problem-solving; and a small effect size in the prospective relation between NA and reappraisal. These findings shed light on the temporal relations between the use of ER strategies and affective experiences and highlight conceptual and methodological limitations in the field.

1. Introduction

Emotion regulation (ER) refers to the ability to modulate the intensity, frequency, and duration of positive and/or negative emotions. The ability to regulate emotions effectively, according to ongoing goals and/or contextual demands, is central to multiple areas of psychosocial functioning, including social functioning (Eisenberg et al., 2000), academic and work performance (Brackett and Salovey, 2006) and, particularly, mental health (John and Gross, 2004; Nezlek and Kuppens, 2008).

1.1. Emotion regulation difficulties related to mental health and psychopathology

Individuals who have difficulties in modulating emotional responses in everyday life experience longer and more severe distress periods comprising maintained negative affect and/or reduced positive affect. This, in turn, may be associated with different forms of psychopathology, as described by different theoretical models for depression and anxiety (Mennin and Fresco, 2009; Nolen-Hoeksema et al., 2008), eating disorders (Polivy and Herman, 2002), substance use disorders (Sher and Grekin, 2007), or personality disorders (Linehan, 1997; Salsman and Linehan, 2006), among others. Based on these models, multiple empirical studies have been conducted, demonstrating relations between different psychopathological conditions and the frequency of use of different ER strategies. In the case of emotional psychopathology, for instance, disorders such as depression and anxiety have been related to a high frequency of use of ER strategies like worry (Chelminski and Zimmerman, 2003), avoidance (Barlow, 2004), suppression (Aldao et al., 2010), or rumination (Donaldson and Lam, 2004) and less use of problem-solving (Aldao et al., 2010).

Further, ER difficulties may also reflect different neurobiological (e.g., Messina et al., 2016; Ochsner et al., 2012) and psychological processes (Joormann and Vanderlind, 2014; Villalobos et al., 2021) that

Abbreviations: ER, Emotion regulation; ESM, Experience sampling methods; EMA, Ecological Momentary Assessments.

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https://doi.org/10.1016/j.neubiorev.2022.104747
Received 16 September 2021; Received in revised form 11 June 2022; Accepted 12 June 2022
Available online 16 June 2022

ultimately contribute to the onset and maintenance of multiple forms of psychopathology (Cludius et al., 2020). Improving deficient ER capacities is thus seen as a central aspect, not only in many current psychological interventions but also in other fields, such as neuropsychology, even showing training-induced long-term changes in neural correlates (Denny et al., 2015). These interventions aim to improve ER through specific forms of regulation, like training the use of strategies of reappraisal or problem-solving in cognitive-behavioral therapy (Plate and Aldao, 2017), or exercising acceptance and reducing rumination and/or worry in mindfulness training (Guendelman et al., 2017). Yet, advancing new knowledge in the understanding of these processes of ER is still necessary to better inform mental health models and related interventions.

1.2. The emotion regulation process

Current clinical approaches to ER intervention may still be limited in terms of their potential effectiveness as they typically consider and intervene in only single strategies of ER with a specific focus on reducing negative affect. However, how people regulate both their negative *and* positive emotions are central to psychological well-being and mental health (Gross et al., 2019). Further, attempts to change positive or negative emotions, by intensifying (upregulating) and/or reducing (downregulating) specific positive or negative affective states, can be made with different aims and consequences in different contexts or in response to different events or goals (Aldao et al., 2015). Ultimately, ER is far from being a unitary process (Gross, 1998, 2014), but reflects different types of neural (Morawetz et al., 2020), cognitive and behavioral processes (i.e., ER strategies; Gross and John, 2003), and ER strategies' use and their effectiveness can differ depending upon specific contexts (Tull and Aldao, 2015).

Table 1
Types and definitions of emotion regulation strategies included in the meta-analysis.

Worry. Repetitive negative thinking with a focus on the occurrence of future negative outcomes or their implications (Borkovec et al., 1983; Ehring and Watkins, 2008; Nolen-Hoeksema et al., 2008).
Avoidance. It refers to refraining or escaping from an action, person or situation to avoid anticipated negative consequences (Moos and Schaefer, 1993).
Problem-focused coping. Planning and/or use of active coping strategies to make changes over the source of stress or ameliorate the consequences (Billings and Moos, 1981).
Rumination. It is described as repetitive thinking focused on one's own feelings and their possible causes, meanings and implications (Nolen-Hoeksema, 1991; Nolen-Hoeksema et al., 2008; Trapnell and Campbell, 1999; Watkins, 2015).
Distraction. It involves changing the focus of attention away from the emotion-eliciting stimulus or the undesirable internal state (Gross and Thompson, 2007, p-13).
Reappraisal. It refers to viewing emotional events from a different perspective, generating positive interpretations, which implies changing their emotional resonance before their impact has fully occurred (Gross and John, 2003).
Suppression. Intent to control, avoid or inhibit unwanted thoughts or the expression of emotions when the individual is emotionally aroused (Gross and Levenson, 1993; Wegner, 1989).
Acceptance. Non-judgmental experience of emotions and present-centered awareness of thoughts, feelings and emotions (Segal and Teasdale, 2018; Shapiro and Schwartz, 2000; Kabat-Zinn, 1990).

Over the last decades, different theoretical models have highlighted the relevance for mental health of different types of ER strategies, which are conceptualized as cognitive and behavioral processes that are enacted by individuals to fulfill the goal of influencing emotions (e.g., Folkman and Lazarus, 1986; Gross, 2015; Gross and Thompson, 2007; Hayes et al., 1999; Nolen-Hoeksema et al., 2008). Within such a broad umbrella, different ER strategies (distraction, behavioral avoidance, rumination, acceptance, problem-solving, worry, reappraisal, suppression) have been studied (e.g., Aldao et al., 2010; Gross, 2015; Webb et al., 2012; see Table 1 for the model-based operative definitions of these ER strategies, as used in our review).[1] The use of this set of ER strategies has been found to have differential influences on negative and positive emotional experiences, being studied through different types of methodologies (e.g., self-reports, laboratory experiments). Yet, further advanced understanding of emotion regulation processes that may inform mental health models and interventions require using more ecological methods, as discussed below.

1.3. Relation between emotion regulation and affect through different evaluation methods

The association between the use of ER strategies and negative and positive affect has been studied from multiple angles. First, there is previous meta-analytic work on the self-reported general use of ER strategies via scales and questionnaires (e.g., Aldao et al., 2010), or via experimental studies in laboratory settings (e.g., Webb et al., 2012).

1.3.1. Self-report methods of the use of emotion regulation strategies

The vast majority of the psychological and neurobiological literature has focused on the relationship between individuals' self-reported habitual use of ER strategies and general affect (Aldao et al., 2010). These studies have generally found that positive affect is positively associated with strategies like reappraisal (Aldao et al., 2010; Gross and John, 2003) and problem-solving (Ben-Zur, 2009), and is negatively associated with general use of suppression (Gross and John, 2003) and avoidance (Ben-Zur, 2009). Regarding negative affect, studies have found that it is positively associated with the use of ER strategies like suppression (Gross and John, 2003), rumination (Thomsen, 2006), and avoidance (Ben-Zur, 2009), but negatively associated with the habitual use of reappraisal (Gross and John, 2003), acceptance (Shallcross et al., 2010) and problem-solving (Ben-Zur, 2009). However, in line with the original conceptualization of ER and contemporary ER models (e.g., Aldao et al., 2015; Gross et al., 2019), there is no clear correspondence between the use of specific strategies and their adaptive value, as this will likely depend on the specific event demands and regulatory goals that are prompting the use of ER in each given situation. One might label strategies more typically found to be positively related to psychopathology and/or negative affect (e.g., behavioral avoidance, suppression, rumination, and worry) as 'maladaptive', and those negatively related to psychopathology and/or negative affect (e.g., acceptance, reappraisal, and problem-solving) as 'adaptive'. However, both the context (Aldao et al., 2010) and the individual's strategies and tactics put in motion in each regulation episode (Ford et al., 2019), will likely play a key role in understanding the effectiveness of a given ER strategy.

1.3.2. Emotion regulation measured in the laboratory

Traditional lines of research on ER strategies and affect mentioned above have mostly relied on self-reported information about the respondents' habitual use of strategies in their daily life to regulate emotions. Yet, this format of gathering information is highly vulnerable to informers' memory and self-presentation biases (Schwarz, 2012). Further, these lines of studies including general self-report measures assume that each ER strategy is used similarly across times and different

[1] This is not an exhaustive list of possible ER strategies. In some studies, strategies like emotion expression (Cameron and Overall, 2008), or social support seeking (Carver et al., 1989; Rimé, 2009) have been related to various psychopathologies (e.g. Kahn and Garrison, 2009; Davies et al., 2010) and with general negative affect (Frattaroli, 2006; Ben-Zur, 2009). Nonetheless, these strategies are not consistently considered in current theoretical models of ER (e.g., Folkman and Lazarus, 1986; Gross and Thompson, 2007; Hayes et al., 1999; Nolen-Hoeksema et al., 2008). Thus, we have included the information, analyses and data related to these strategies separately, in the supplementary material.

contexts.

Therefore, to overcome these limitations, researchers have also used experimental procedures to study the impact of different instructed ER strategies on affect under controlled emotional conditions (Webb et al., 2012). This rich avenue of studies has found that instructions to use ER strategies such as worry (e.g., Llera and Newman, 2014; Peasley-Miklus and Vrana, 2000), rumination (Morrow and Nolen-Hoeksema, 1990; Rusting and Nolen-Hoeksema, 1998), and suppression (Ehring et al., 2010) increase the intensity or duration of induced negative affective states. On the contrary, instructions to use distraction (Joormann et al., 2007; LeMoult et al., 2016; Smoski et al., 2014), reappraisal (Ehring et al., 2010), and acceptance (Campbell-Sills et al., 2006) reduce induced negative affect states.

Although laboratory studies have important methodological advantages in revealing potential causal relationships between ER and affect (e.g., Aldao, 2013; Kobylińska and Kusev, 2019; Sheppes, 2014) and their neural bases (Berboth and Morawetz, 2021), they are also subject to some limitations in terms of their external and ecological validity. Procedures, such as inductions of mood, limit the ability to assess naturally experienced processes of emotions in daily life. Also, instructions to use specific ER strategies during the laboratory sessions may limit the comparability of the ER strategies used in the lab with those enacted during daily functioning. Finally, experimental studies have paid more attention to analyzing the impact of the ER strategies on induced negative affect than on induced positive affect.

1.3.3. Ecological evaluations of ER strategies

Going beyond these traditional approaches, Ecological Momentary Assessments (i.e., EMA) were raised as an alternative to trait-based self-reports and experimentally induced moods and ER instructions (e.g., Kahneman et al., 2004; Nezlek and Kuppens, 2008). EMA comprises asking individuals to report on their affective and regulatory experiences in their natural environment. This type of method allows us to better capture the complexity of ecological manifestations in daily life. The implementation of this method has important implications as global self-reports of ER may not reflect the habitual tendency to select an ER strategy in daily life (especially in the case of reappraisal) (Koval et al., 2022). Two main EMA methods have been used to ecologically evaluate ER use: daily diaries, comprising repeated daily assessments of the occurrence of affective and regulatory phenomena, and experience sampling methods (ESM; Csikszentmihalyi and Larson, 2014; Shiffman et al., 2008), which allow intensive longitudinal research by repeatedly assessing individuals' ER behaviors and affective experiences across a variety of daily situations across multiple days (e.g.,Kahneman et al., 2004; Myin-Germeys et al., 2018; Nezlek and Kuppens, 2008).

Daily diaries assess the experience for the whole day, for several days. Individuals are asked to report the ER strategies they have used, and the associated emotions, either when something relevant has happened (e.g., a stressful event) or simply report the use of ER strategies at the end of the day. Diaries differ in the way that responses are registered, through electronic tools or with paper and pencil.

With the advancement of technologies, ESM makes it possible to also evaluate psychological processes several times a day with electronic devices. There are two broad categories of ESM depending on the method of data collection: signal-contingent sampling (within a time-window interval, also called interval-contingent sampling), and event-contingent sampling (concerning a specific stressor or event).

These methodological differences across studies are both theoretically and practically relevant and are potential moderators of the association between ER strategies and affective experiences. Unfortunately, while extensive meta-analytic work has been conducted on the use of EMA methods to study related affective constructs such as emotional intelligence dimensions (MacCann et al., 2020), there are no meta-analytic reviews of studies using EMA methods on the use of ER strategies, related to negative or positive emotional states. This issue is important because one of the ultimate goals of affect research is, as noted by the Human Affectome Project, to learn how affect functions under real conditions in everyday life (Becker et al., 2019).

1.4. Aims of the study

To advance our understanding of ecologically relevant ER processes, the present investigation aims to integrate and analyze the relations between the daily use of ER strategies and negative and positive affective experiences in real-life contexts. We present both qualitative syntheses and quantitative analyses, when possible, of extant research that has used daily diaries and ESM to study the relation between theoretically relevant ER strategies (Table 1) and real-life negative and positive affective experiences.

Therefore, the main aim of this meta-analysis was to shed light on the relations between ER strategies (worry, behavioral avoidance, problem-solving, rumination, distraction, reappraisal, suppression, acceptance) and temporal affective experiences (i.e., contemporaneous and prospective relations with negative and positive affect). We aimed to address two main issues concerning the temporal relations between ER strategy use and affective outcomes (see Fig. 1 for a visual depiction of the full set of models being tested):

*Contemporaneous use of ER strategies and affect (*Fig. 1*, path A)*. How the use of each ER strategy is contemporaneously related to (i.e., co-occur with) the experience of negative and positive affect during the course of a few hours (ESM studies) or the course of an entire day (daily diary studies)? Based on the reviewed literature, we broadly expected to find significant contemporaneous positive associations between negative affect and some ER strategies (i.e., worry, avoidance, rumination, suppression) and significant contemporaneous negative associations with other strategies (i.e., problem-solving, distraction, reappraisal, and acceptance). The opposite pattern of associations was expected for the relations between the use of ER strategies and positive affect.

*Prospective relations of the use of ER strategies with affective experiences (*Fig. 1*, path B)*: What is the relation of the use of each ER strategy with the next assessment of negative and positive affect on the same day (ESM studies), or on the next day (daily diary studies)? Based on the reviewed literature, regarding the momentary relations of different ER strategies and mood changes (e.g., Ehring et al., 2010; Llera and Newman, 2014; Peasley-Miklus and Vrana, 2000), we broadly expected to find the same patterns of associations as for studies analyzing contemporary relations.

Given the unclear 'adaptive' value of specific ER strategies, beyond such general contemporaneous and prospective relations, we expected these relations could be moderated by individual variables (e.g., clinical

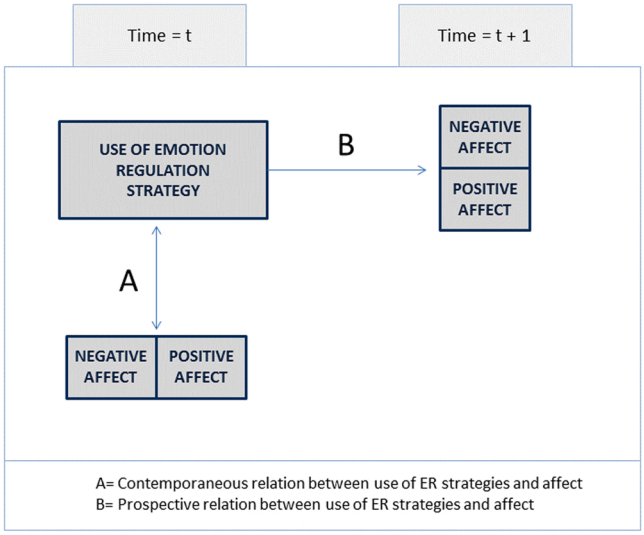

Fig. 1. Model of contemporaneous and prospective associations between the use of emotion regulation strategies and affect.

conditions) and contextual ones (e.g., specifically experiencing stressful events), as well as methodological factors (e.g., statistical control of the influence of the previous affect). In sum, we analyzed existing EMA research on the relations between the level of use of ER strategies and ongoing and subsequent affective states, at different windows of daily functioning, and considered potential moderators of these relations, thus aiming to shed a clearer picture of ecological ER-affect dynamics that may inform models of mental health and interventions on ER processes.

2. Method

2.1. Literature search

The study protocol was pre-registered in PROSPERO, and this report conforms to PRISMA guidelines (Moher et al., 2009). The systematic search was conducted using PsycINFO and PubMed databases to include studies published until March 2021. The keywords for the search were applied in all fields and covered three major topics: (1) experience sampling method: ESM and daily diary; (2) ER strategies: acceptance, suppression, avoidance, problem-solving, reappraisal, rumination, distraction, worry, mindfulness, coping, emotional expression, self-regulation, emotion regulation; and (3) affect: affect, emotion, psychopathology, mood, depression, dysphoria, anxiety, and stress. The exact search string was: ("ecological momentary assessment" OR "daily diary" OR "experience sampling" OR "event sampling" OR "experience sample" OR "daily experience" OR "diary study" OR "experience-sampling") AND (acceptance OR suppression OR avoidance OR avoiding OR problem-solving OR "problem-solving" OR reappraisal OR rumination OR distraction OR worry OR mindful* OR cope OR coping OR "emotional expression" OR "self-regulation" OR "emotion regulation" OR "emotional regulation" OR "emotion expression") AND (affect OR affective OR emotion* OR psychopatholog* OR mood OR depress* OR dysph* OR anxi* OR stress*). Additional search methods were used to retrieve all possible literature. The names of the authors of the studies were entered as key terms into the same databases to uncover additional articles. Then, the references of all the studies found in these searches (including review papers) were consulted. The search process was independently performed by the first and second authors (TB, IN). Discrepancies were resolved by discussion, and in case of remaining disagreement, the last authors (CV and ASL) were consulted. The PRISMA flow diagram depicted in Fig. 2 illustrates the literature search and winnowing process.

2.1.1. Inclusion criteria

The inclusion criteria defined for this meta-analysis consisted of (1) studies that provided data on, at least, one relation between one ER strategy and one affect measure (negative or positive affect), and (2) studies that evaluated the use of ER strategies and affect EMA (i.e., daily diary or ESM).

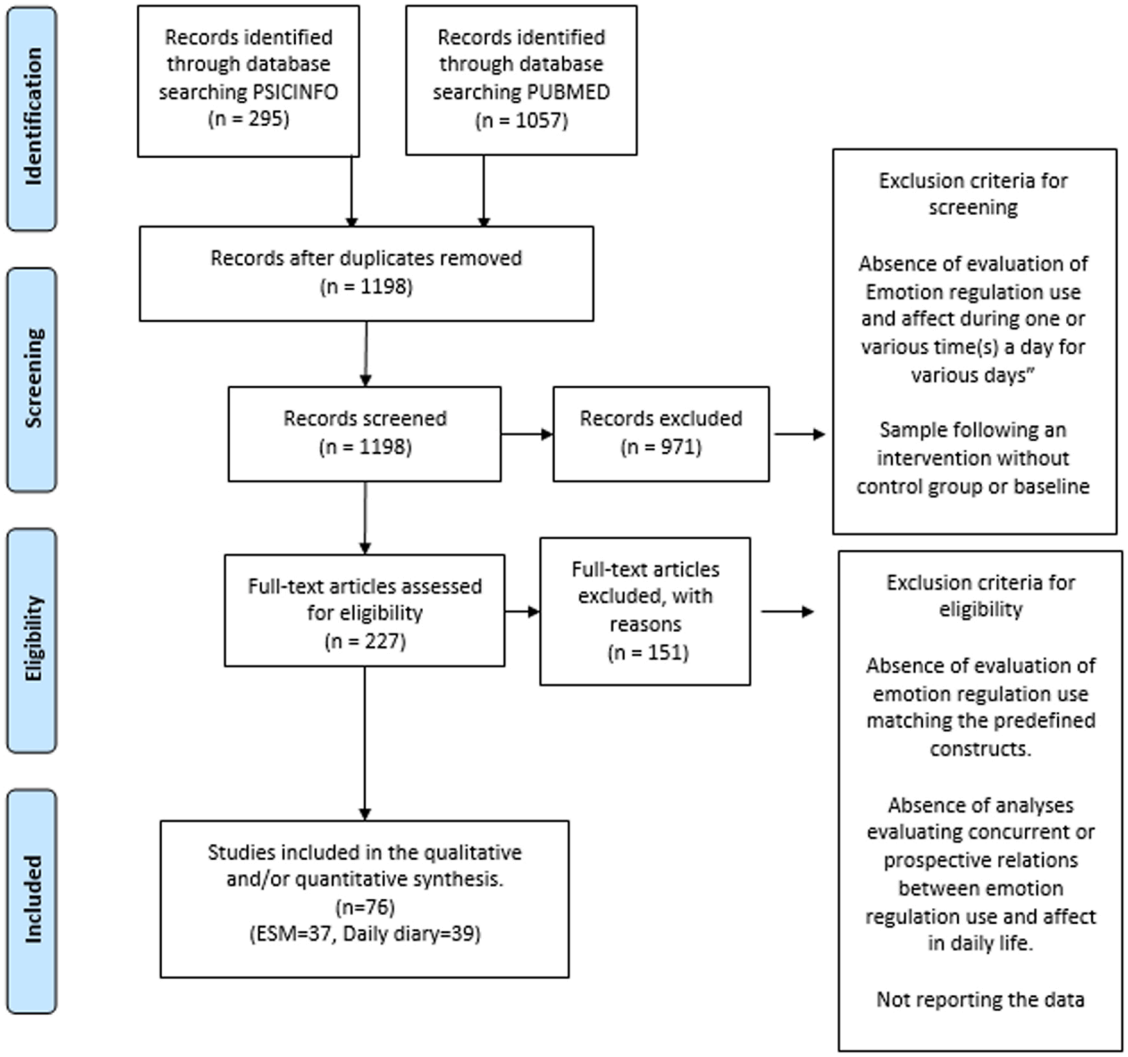

Fig. 2. PRISMA Flow Diagram.

2.1.2. Exclusion criteria

First, we limited the selection of studies to those assessing the use of ER strategies that met predefined definitions, following theoretical models, to ensure comparability between studies. Accordingly, the items employed to measure ER were closely evaluated, (see Table 1), following operative definitions derived from the main conceptual models of ER. Moreover, to reduce heterogeneity, studies that analyzed global or unspecific ER categories, such as engagement and disengagement strategies (Parkinson and Totterdell, 1999), or emotion- and problem-focused sets of coping strategies (Folkman and Lazarus, 1986), were excluded. When primary studies met all inclusion criteria but reported the results for global ER strategies which comprised single ER strategies, authors were contacted to request those independent data for each separate ER strategy.

Second, intervention studies (e.g., studies testing the influence of mindfulness training on subsequent ER strategy and affect interplays) were excluded, except when the data relevant for our analysis had been collected during pre-intervention baseline assessment. The reason for this criterion was our interest in capturing ecological regulatory-affective relations, i.e., unaffected by specific experimental or clinical manipulations.

Third, we excluded studies that recruited participants diagnosed with physical disorders (e.g., cancer, chronic pain), given that these samples use unique ER processes. Individuals diagnosed with serious medical conditions face illness-specific stressors and ER strategies in these studies are framed with those events and relate to affective outcomes specifically related to illness (e.g., Conley et al., 2016).

Fourth, the search was restricted to empirical studies published in peer-reviewed journals in English. Therefore, non-empirical, case studies and conceptual studies were also excluded. When a study met all inclusion criteria but did not provide sufficient data, authors were contacted. The study was excluded when no answer was obtained.

2.2. Screening, eligibility, and organization of included studies

A total of 1352 records were identified through database searches. After removing duplicates, the titles and abstracts of 1198 papers were independently screened by two reviewers (TB, IN) for the initial detection of studies. Then, 227 full articles were screened using the same method described above. Inter-rater reliability was good (kappa = 0.86). The full selection process and reasons for exclusions are described in the PRISMA flow diagram. A total of 76 studies were included in the final review.

Two different databases were created to differentiate daily-diary studies (the use of ER strategies and affect measured once per day) and ESM studies (the use of ER strategies and affect measured several times each day). This was done because effect sizes obtained with these methods need to be analyzed separately as they refer to different time window assessments. The former provides data regarding overall ER and affective experience during the day and its relation on the same day or the following one. The latter provides information on the use of ER in daily functioning at a given moment or in the time immediately preceding that moment, which can range from minutes to a short number of hours. Thus, it provides data for the immediate relations between the use of an ER strategy and the ongoing affective experience during a given moment or the following one (see Fig. 1). Overall, we obtained 39 studies of daily diaries (one measure per day) and 37 of ESM (various measures per day).

Next, we calculated different effect sizes for each sample, based on the temporal association between the ER strategy and affect (contemporaneous or prospective), the type of strategy, and the type of affect (negative, NA, and positive, PA). Separate meta-analyses were conducted for each dataset (daily and ESM). Following the criterion of a previous meta-analysis in the area (Aldao et al., 2010) based on the recommendations given by Hedges and Vevea (1998), only those paths with 5 or more data from primary studies were analyzed quantitatively. Paths without sufficient effect sizes were reviewed qualitatively. The number of effect sizes available for these purposes is described in Table 2.

2.3. Methodological quality assessment

The methodological quality of all selected studies was evaluated with a rating scale based on Downs and Black's Checklist for Measuring Quality (Downs and Black, 1998), previously adapted for meta-analytic research (Everaert et al., 2017; Hughes et al., 2016). The final scale contained 19 items assessing the quality of the report, internal and external validity, and statistical power of primary studies. Each item was rated, based on the fulfillment of each quality criterion, as 1 (yes) or 0 (no). Higher scores represented higher methodological quality.

2.4. Effect size calculation

The *r* coefficient was used as the effect size. Two different results from the hierarchical regression analyses of primary studies were used for calculation. Beta coefficients were transformed using the conversion method described by Peterson and Brown (2005) ($r = \beta + 0.05 * \lambda$), and whenever the authors provided the *t* statistic of the fixed effect models and the degrees of freedom, the Rosenthal and Rosnow's (2008) formula was applied ($r = \mathrm{sqrt}(t^2/t^2+df)$). If both results were reported in a study, the second method was preferred, given that this conversion is more precise (Rosenthal and Rosnow, 2008). In line with recommendations (Cohen, 1992), resulting *r* effect sizes were interpreted as small when $r < 0.10$, medium for $r < 0.30$, and large for $r < 0.50$. If multiple effect sizes were provided in one primary study, these were independently included in the meta-analysis as long as they were derived from different samples (e.g., clinical and healthy individuals; children, adults, and elderly). In cases in which different results were provided for the same variable and sample within one study (e.g., those using two different measures), only one effect size was calculated by averaging those results.

Random-effects meta-analyses were conducted for each combination of relations between the use of ER strategies and affect (negative and/or positive) at different time windows (contemporaneous and prospective). This was done separately for daily diary and ESM studies. Random-effect models are preferred over fixed-effect models given that they are more conservative and allow for both between and within-studies variability, which reduces the risk of type I errors (Field, 2003). These analyses were run using the SPSS macros MeanES and MetaF (Wilson, 2005).

2.5. Heterogeneity analyses

Homogeneity was assessed using the Q-value of the test of heterogeneity, and the I^2 index. It is considered that studies are estimating the same parameter whenever the Q value has a significance level higher than.05 (the null hypothesis of homogeneity is not rejected). Moreover, the categorization of I^2 values is established as follows: 0 % = no heterogeneity; equal to or higher than 25 % = low heterogeneity; equal to or higher than 50 % = moderate heterogeneity; and equal to or higher than 75 % = high heterogeneity (Borenstein et al., 2009).

Initially, relevant variables identified in previous research (Brown and Ryan, 2003) were coded to conduct moderation analyses whenever heterogeneity was found to be high. These variables included the year of publication, sample characteristics (sample size, age group, and health condition), and methodological characteristics (number of assessments per day, number of days, percentage, and number of completed assessments, type of repeated measures method, recording method, item(s) employed to evaluate the use of ER strategies and affect measures, and whether they were gathered from validated questionnaires, and which ones). The specific information of the assessment method was also coded, which refers to the instruction followed by participants when completing daily measures (i.e., "before going to bed" – referred to

Table 2
Number of size effects (k) included in the systematic review and meta-analyses.

	Contemporaneous relations				Prospective relations			
	Negative affect		Positive affect		Negative affect		Positive affect	
	ESM	Daily diary	ESM	Daily diary	ESM	Daily diary	ESM	Daily diary
Worry	5	1	1	0	2	0	2	0
Problem-solving	5	8	3	8	2	3	2	1
Rumination	9	8	3	2	16	3	9	1
Distraction	2	5	0	3	5	2	5	3
Reappraisal	3	11	2	9	7	5	6	5
Suppression	8	14	4	7	5	3	4	3
Acceptance	2	5	2	5	4	1	4	0

average daily ER use and/or affective level-, "whenever something stressful happens" – stress-specific –, or in general "during the day") or ESM repeated measures ("when something stressful happened", "since the last beep", "right now"). As for variables related to the analyses, we also coded the type of analysis applied to control for previous time (t-1) variables of affect and ER strategy use. Specifically, it was coded whether the studies controlled for previous time point affect in their prospective models, as this offers a closer examination of the impact of the given ER strategy use on subsequent affective changes. An overview of the main characteristics can be found in Supplementary Table 1 and full details of all these variables for each study are reported in Supplementary Table 2. Moderation analyses were, ultimately, not conducted as the methodological recommendation of having at least ten effect sizes per variable of interest (Higgins and Green, 2011) was not met. Nonetheless, given the specific relevance of the instruction followed by participants, and the control for affect in the previous time point in the prospective models, further sensitivity analyses were considered. The first comprised only studies that assessed ER strategy-affect relations in the context of specific stress events. The second one included only those prospective studies that controlled for the previous affect in their lagged models. Further sensitivity analyses in terms of personal intervening factors (i.e., clinical conditions) were not feasible given the insufficient number of studies that included clinical groups (see below).

2.6. Risk of bias

Publication bias was analyzed by inspecting the funnel plot, which represents the precision of each primary study (standard error; SE) against its effect size (ES; Rosenthal, 1979). This representation is a good way to visualize whether small studies with small effect sizes are missing. Whenever studies are asymmetrically represented around the pooled effect size, it suggests the presence of publication bias (Rothstein, 2008). On the contrary, if the studies are found symmetrically distributed around the mean, it indicates no publication bias. Two different methods were used to test the symmetry of the funnel plot. Kendall's Rank correlation tested the null hypothesis that the ES and the SE are independent. Egger's regression test for funnel plot asymmetry (Sterne et al., 2006) tested the null hypothesis that there is perfect symmetry in the plot (starting point of the regression line equal to 0).

3. Results

Table 3 presents detailed statistics of the analyses examining the overall effect size of each pathway under study with negative and positive affect, in different time windows (contemporaneous, and prospective) and assessment levels (ESM, daily diary). A comprehensive visual depiction of all pathways is provided in Fig. 3. Further, the full set of forest plots for each path meta-analyzed is provided in Supplementary Figure 1.

3.1. Characteristics of the studies

Studies were published between 1999 and 2021. Sample sizes ranged from 8 to 1188 participants (M= 169.25, SD= 204.90). The studies assessed different age groups: 9.21 % of studies evaluated children and/or adolescents, 90.79 % evaluated adults, and 1.32 % of studies evaluated elderly participants.

Samples also differed in their clinical condition. Most studies (80.26 %) included samples comprising healthy participants (of those, 53.22 % evaluated undergraduate students). The remaining studies (19.74 %) included clinical samples (9.21 % of the total number of studies including evaluations with only participants with clinical problems and 10.53 % including both clinical samples and healthy comparison groups).

The duration of the studies varied from 3 days to 101 days with a mean of 13.16 days (SD= 13.72). Further, studies using ESM methods differed in the number of assessments per day, ranging from 2 to 12 notifications per day with a mean number of 6.30 notifications (SD= 2.84).

Almost all studies analyzed at least one relationship between the use of ER strategies and negative affect (except one study that provided data only for positive affect), whereas only 51.97 % also included an analysis of at least one association between the use of ER strategies and positive affect.

As for the number of ER strategies analyzed in this review and meta-analysis, we included 37 studies including only one single ER strategy, 24 studies including 2 strategies, 8 studies including 3 strategies, 1 study including 4 strategies, 3 studies including 5 strategies and 3 studies including 6 strategies. Besides, we found methodological variability between studies in the way the assessment of the ER strategy use was framed. We found 51.63 % (ESM=13, daily diaries=27) of studies included a stress-event framing, whereas the rest of the studies assessed ER strategy use "since the last beep" (ESM=13, daily diaries=0), "right now" (ESM=8, daily diaries=2), and "during the day" or habitual use (ESM=0, daily dairies=8).

We also took into consideration whether studies reporting data for the prospective relation between ER strategy use and affect (34 studies) controlled for the previous affect. We found 22 studies (64.71 %) that controlled for the previous affect when reporting prospective relations. Due to this methodological heterogeneity, we included sensitivity analyses.

3.2. Methodological quality

The average percentage of the quality criteria met across studies included in the systematic review (both in the quantitative meta-analyses and in the qualitative synthesis) was 69.08 % (SD=9.83), with values ranging from 44.44 % and 88.89 %. Means and standard deviations of the items evaluating methodological criteria are presented in Table 3 in the Supplementary Material. The lowest scores were consistently found for those items assessing the report of the duration of the recruitment process and the validity and reliability of the

Table 3
Overall effect sizes and heterogeneity for each ER-affect pathway.

Emotion regulation strategy			k	r	95 % CI	p value	Q-statistic (p)
Acceptance	Daily contemporaneous	Negative	5	0.01	[− 0.41;0.44]	.95	111.49 (<.001)
		Positive	5	0.17	[0.10;0.24]	< .001	3.09 (.54)
	Daily prospective	Negative	1	–	–	–	–
		Positive	0	–	–	–	–
	ESM contemporaneous	Negative	2	–	–	–	–
		Positive	2	–	–	–	–
	ESM prospective	Negative	4	–	–	–	–
		Positive	4	–	–	–	–
Distraction	Daily contemporaneous	Negative	5	0.27	[− 0.88;0.63]	.14	97.59 (<.001)
		Positive	3	–	–	–	–
	Daily prospective	Negative	2	–	–	–	–
		Positive	3	–	–	–	–
	ESM contemporaneous	Negative	2	–	–	–	–
		Positive	0	–	–	–	–
	ESM prospective	Negative	5	0.03	[− 0.19;0.25]	.77	19.23 (<.001)
		Positive	5	0.20	[0.00;0.41]	.049	16.08 (.003)
Problem-solving	Daily contemporaneous	Negative	8	0.06	[− 0.09;0.22]	.42	50.04 (<.001)
		Positive	8	0.21	[0.13;0.29]	< .001	16.72 (.02)
	Daily prospective	Negative	3	–	–	–	–
		Positive	1	–	–	–	–
	ESM contemporaneous	Negative	5	0.03	[− 0.43;0.49]	.89	98.87 (<.001)
		Positive	3	–	–	–	–
	ESM prospective	Negative	2	–	–	–	–
		Positive	2	–	–	–	–
Reappraisal	Daily contemporaneous	Negative	11	-0.02	[− 0.16;0.12]	.80	64.30 (<.001)
		Positive	9	0.42	[0.09;0.76]	.01	195.13 (<.001)
	Daily prospective	Negative	5	-0.09	[− 0.17; − 0.01]	.03	1.71 (0.79)
		Positive	5	0.34	[0.26;0.42]	< .001	3.75 (.44)
	ESM contemporaneous	Negative	3	–	–	–	–
		Positive	2	–	–	–	–
	ESM prospective	Negative	7	-0.12	[− 0.26;0.03]	.11	19.21 (.003)
		Positive	6	0.31	[0.11;0.51]	.003	20.45 (.001)
Rumination	Daily contemporaneous	Negative	8	0.68	[0.34; 1.03]	.0001	244.28 (<.001)
		Positive	2	–	–	–	–
	Daily prospective	Negative	3	–	–	–	–
		Positive	1	–	–	–	–
	ESM contemporaneous	Negative	9	0.33	[0.17;0.48]	< .001	42.62 (<.001)
		Positive	3	–	–	–	–
	ESM prospective	Negative	16	0.16	[0.07;0.26]	.001	48.55 (<.001)
		Positive	9	-0.15	[− 0.40;0.11]	.27	77.49 (<.001)
Suppression	Daily contemporaneous	Negative	14	0.55	[0.32;0.79]	< .001	245.63 (<.001)
		Positive	7	-0.08	[− 0.28; 0.13]	.46	38.55 (<.001)
	Daily prospective	Negative	3	–	–	–	–
		Positive	3	–	–	–	–
	ESM contemporaneous	Negative	8	0.47	[0.24; 0.70]	.0001	74.65 (<.001)
		Positive	4	–	–	–	–
	ESM prospective	Negative	5	0.08	[0.02;0.14]	.006	2.60 (.63)
		Positive	4	–	–	–	–
Worry	Daily contemporaneous	Negative	1	–	–	–	–
		Positive	0	–	–	–	–
	Daily prospective	Negative	0	–	–	–	–
		Positive	0	–	–	–	–
	ESM contemporaneous	Negative	5	0.44	[0.27;0.62]	< .001	14.92 (.005)
		Positive	1	–	–	–	–
	ESM prospective	Negative	2	–	–	–	–
		Positive	2	–	–	–	–

assessments. Further, low to intermediate scores were found for items assessing other aspects of the quality of the report (proportion of selected participants recruited and analyzed, statistics of main findings, probability values, withdrawals, and drop-outs), and power analysis. General quality ratings of ESM studies and daily diaries were similar. The average percentage of the quality criteria fulfilled across ESM studies was 68.17 % (SD= 9.77), and for diary studies was 70.00% (SD=9.12).

3.3. Daily contemporaneous relations

3.3.1. Negative affect

Studies assessing contemporaneous emotion regulation at the daily level showed that acceptance ($r = 0.01$; k = 5; 95 %CI [−0.41;0.44]), distraction ($r = 0.27$; k = 5; 95 %CI [−0.09;0.64]), problem-solving ($r = 0.06$; k = 8; 95 % CI [−0.08;0.23]), and reappraisal ($r = -0.02$; k = 11; 95 % CI [−0.16;0.12]) were not significantly associated with negative affect. However, rumination ($r = 0.68$; k = 8; 95 %CI [.34; 1.03]) and suppression ($r = 0.55$; k = 14; 95%CI [.32;0.79]) were significantly and positively related to negative affect, with large effect sizes. Sensitivity analyses with only those studies that evaluated stress-dependent emotion regulation (see Supplementary Table 4) showed no differences from the main analyses, except in the case of rumination, for which the effect size became not significant ($r = 0.70$; k = 4; 95 %CI [.09; 1.49]). In the qualitative review, only one study evaluated the contemporaneous relationship between negative affect and worry (Nelson and Bergeman, 2021) and behavioral avoidance (Doorley and Kashdan, 2021) at the daily level, both showing a positive significant

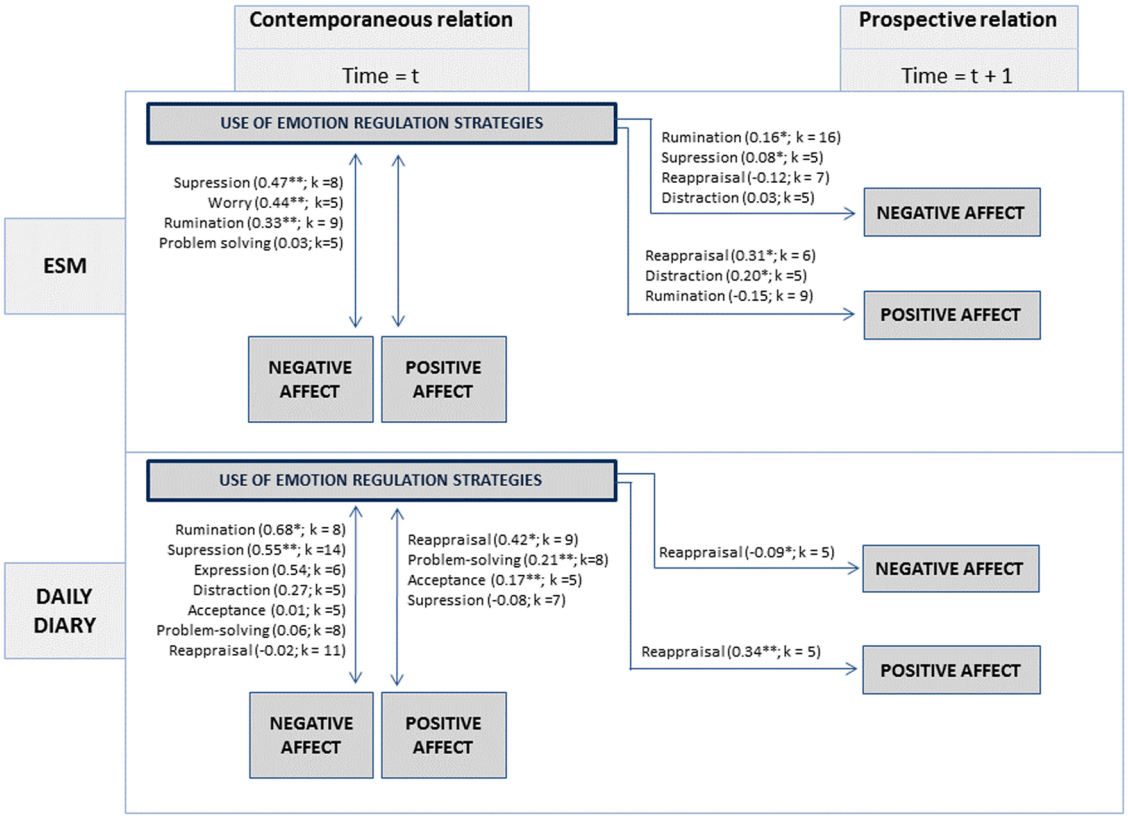

Fig. 3. Summary of overall effects sizes for each of the paths included in the meta-analyses, *Notes*. * <0.05 * *< 0.001; k = number of effect sizes.

relation.

3.3.2. *Positive affect*

Studies assessing contemporaneous emotion regulation at the daily level showed that acceptance ($r = 0.17$: k = 5; 95 %CI [.10;0.24]), problem-solving ($r = 0.21$: k = 8; 95 %CI [.13;0.29]), and reappraisal ($r = 0.42$: k = 9; 95 %CI [.09;0.76]) were significantly and positively related to positive affect. The relationship between suppression and positive affect at the contemporaneous daily level was not significant ($r = -0.08$: k = 7; 95 %CI [−0.28;0.13]). Sensitivity analyses including only those studies evaluating stress-dependent emotion regulation (see Supplementary Table 4) showed no differences with the main analyses in the effect sizes. There were not enough data to meta-analyze behavioral avoidance (k studies=1), rumination (k studies=2), and distraction (k studies=3) in this path. No significant relations were found in studies evaluating the contemporaneous relation between behavioral avoidance (Doorley and Kashdan, 2021) and daily positive affect. We found mixed findings in the use of rumination and contemporaneous positive affect, such that one study showed a positive, but not significant relation (Brose et al., 2015), and the second one found a negative significant relation (Wang and Yip, 2019). The findings on the use of distraction, and its contemporaneous relation to positive affect, were also mixed. Troy et al. (2019) found that daily use of distraction was negatively related to daily experienced positive affect (significant in Study 2, but not in Study 1), while Blaxton and Bergeman (2017) found a trend of positive relation, although it was not significant.

3.4. *ESM contemporaneous relations*

3.4.1. *Negative affect*

The effect sizes for the contemporaneous relationship between suppression ($r = 0.47$; k = 8; 95 %CI [.24;0.70]), rumination ($r = 0.33$; k = 9; 95 %CI [.17;0.48]), and worry ($r = 0.44$; k = 5; 95 %CI [.27;0.62]) were significant and positively correlated to negative affect. However, problem-solving ($r = 0.03$; k = 5; 95 %CI [−0.43;0.49]) was not significantly associated with negative affect. Sensitivity analyses with only studies that evaluated stress-dependent emotion regulation (see Supplementary Table 4) showed no differences with the main analyses in the effect sizes. There were not enough data from ESM studies to quantitatively analyze the contemporaneous relations between negative affect and behavioral avoidance (k studies= 1), distraction (k studies= 2), reappraisal (k studies= 3), and acceptance (k studies= 2). The qualitative review showed mixed findings in the relation between distraction and negative affect. Stone et al. (2019) found a negative non-significant relation between contemporaneous distraction and ongoing negative affect, while Gruber et al. (2013) found a positive significant relation. As for the contemporaneous relation between reappraisal and negative affect, two studies found a negative significant relation (Geisler et al., 2013; Silva et al., 2018), but the third one showed a positive significant relation (Gruber et al., 2013). Two studies explored the contemporaneous relation between acceptance and negative affect, finding that they were negatively related (Blanke et al., 2020, Study 1 and 2). The contemporaneous relation between negative affect and behavioral avoidance (Hajal et al., 2019) varied depending upon the emotion measured. Some emotions (i.e., disappointment and irritation) showed a negative relation, while others (sad and anger) showed positive relations with behavioral avoidance.

3.4.2. *Positive affect*

Only a qualitative review of the results evaluating the contemporaneous relationship between the use of ER strategies and positive affect could be made, due to the lack of enough studies: worry (k studies=1), behavioral avoidance (k studies=1), problem-solving (k studies=2), rumination (k studies=3), reappraisal (k studies=2), suppression (k studies=4). In the case of worry, Naragon-Gainey (2019) did not find a significant contemporaneous relation with positive affect. For

avoidance, in the only study included in the review (Hajal et al., 2019), the authors found a significant negative contemporaneous relation between behavioral avoidance and positive affect. Two studies evaluating the use of problem-solving and positive affect were included, and they found non-significant relations (Daniels et al., 2009; Rumbold et al., 2020). In the case of rumination, studies consistently found significant and negative relations with positive affect (Blanke et al., 2020, Study 1 and 2; Takano et al., 2013). Mixed findings were found for reappraisal. One study found a positive significant relation with positive affect (Gruber et al., 2013), while the other study found a non-significant negative relation (Silva et al., 2018). Suppression was found to be negatively related to positive affect in three out of four studies. However, two of them showed non-significant results (Gruber et al., 2013; Yeung and Fung, 2012), and only one showed a significant relation (Silva et al., 2018). A fourth study found a contemporaneous positive, but not significant, relation with positive affect (Mill et al., 2018).

3.5. Daily prospective relations

3.5.1. Negative affect

The prospective relationship between the use of ER strategies and negative affect at the daily level could only be analyzed for reappraisal (k = 6), which showed a significant, negative effect size ($r = -0.09$; k = 5; 95 % CI [−0.17; −0.01]). This, however, became non-significant in sensitivity analyses when including only those studies evaluating stress-dependent ER ($r = -0.08$, k = 4; 95 % CI [−0.18;0.01]). All the studies included in the analysis controlled for affect at t-1. Thus, no further sensitivity analyses were conducted for this path. There were not enough data from daily diary studies to quantitatively analyze the prospective relations between negative affect and behavioral avoidance (k studies=1), problem-solving (k studies =3), acceptance (k studies =1), rumination (k studies =2), distraction (k studies =2), and suppression (k studies =3).

The use of behavioral avoidance was significantly and positively related to the next day's negative affect (Weiss et al., 2019). Mixed results were found in three studies for the prospective relation between problem-solving and negative affect. One study found no significant prospective relations between problem-solving and negative affect (Neupert et al., 2016). A second study found significant positive relations (Dunkley et al., 2014), whereas a third study reported no significant relations (Cardona et al., 2020). The two studies analyzing the prospective relation between rumination and negative affect found a significant positive association (Massey et al., 2011; White and Shih, 2012). Two studies found that distraction was significantly and positively related to next day negative affect (Troy et al., 2019, Study 1 and 2). Mixed findings were obtained for the prospective relation between suppression and next day negative affect across three studies. One study found a non-significant positive relation (Troy et al., 2019, Study 1), while the other two studies found a non-significant negative relation (Le and Impett, 2016, Study 2; Troy et al., 2019, Study 2). The study reporting data for the relationship between acceptance and negative affect found a negative non-significant prospective relation (Cardona et al., 2020).

3.5.2. Positive affect

At the daily level, the prospective relationship between reappraisal was positive and significant (r=.34; k=5; 95 %CI [.26;0.42]), which did not change when including only studies evaluating stress-dependent emotion regulation (see Supplementary Table 4). All the studies included in the analysis controlled for affect at t-1 (see Supplementary Table 5). Thus, no further sensitivity analyses were conducted for this path. A qualitative review was made for the prospective relation between the following strategies and positive affect: problem-solving (k studies = 1), rumination (k studies =1), distraction (k studies =2), and suppression (k studies =3) The only study analyzing the prospective relation between problem-solving and positive affect showed a significant positive relation (Dunkley et al., 2014). Also, only one study analyzed the prospective relation between the use of rumination and next day positive emotions, finding a negative significant relation (Massey et al., 2011). Besides, Troy et al. (2019) found the use of distraction was negatively related to the next day's positive affect, although this relationship was only significant in their Study 2. For suppression, three studies analyzed the prospective relation of its use and positive affect, and all studies found a non-significant positive relation (Le and Impett, 2016, Study 2; Troy et al., 2019, Study 1 and 2).

3.6. ESM prospective relations

3.6.1. Negative affect

There were significant effect sizes for the prospective relations between rumination (r=.16; k = 16; 95% CI [.07;0.26]) and suppression (r=0.08; k = 5; 95%CI [.02;0.14] with negative affect. Yet, the relations between distraction (r=0.03; k = 5; 95%CI [−0.19;0.25]) and reappraisal (r=−0.12; k = 7; 95%CI [−0.26;0.03]) with negative affect were not significant. When performing sensitivity analyses including only the studies that controlled for affect at t-1, results for suppression became non-significant (r=0.05; k = 3; 95%CI [−0.08;0.18]). Sensitivity analyses including only those studies that evaluated stress-dependent emotion regulation (see Supplementary Table 4) showed no differences from the main analyses, except for rumination which yielded a non-significant effect size (r=.09; k = 3; 95%CI [−0.05;0.23]). There were not enough data to meta-analyse worry (k studies=2), problem-solving (k studies=2), and acceptance (k studies=5). In the qualitative review, we found two studies analyzing the prospective relation between worry and negative affect. One study did not find significant results (Kircanski et al., 2018), while the second one found a positive and significant relation (Groen et al., 2020). Two studies assessing problem-solving showed mixed findings. One study found a non-significant relation between the use of problem-solving and negative affect (Daniels et al., 2009). The second study (Iida et al., 2017) found negative relations that differed in the level of significance when considering differences in stress intensity. Significant negative relations between problem-solving and negative affect were found only when stress was perceived as highly intense. Of the four studies measuring the use of acceptance, three studies found non-significant prospective relations with negative affect (Brans et al., 2013, Study 1 and 2; Chaudhury et al., 2017). A fourth study (Iida et al., 2017) found different results when considering contextual differences in stress intensity. Acceptance was negatively and significantly related to negative affect when stress intensity was perceived as low, but positively and non-significantly related when perceived as highly intense.

3.6.2. Positive affect

The prospective relations between positive affect and distraction (r=0.20; k = 5; 95%CI [.00;0.41]) and reappraisal (r=0.31; k = 6; 95% CI [.11;0.52]) were significant. The effect size for the prospective relation between positive affect and rumination at the hour level was not significant (r= −0.15; k = 9; 95%CI [−0.40;0.11]). Either none or one study included in each of these analyses evaluated the use of ER strategies dependent on stress. Therefore, sensitivity analyses were not conducted in this regard. Sensitivity analyses including only those studies that controlled for affect at t-1 showed no difference, except for distraction which yielded a non-significant effect size (r=0.14; k = 4; 95%CI [−0.06;0.34]). The ER strategies qualitatively reviewed were worry (k studies =1), suppression (k studies =4), and acceptance (k studies=4). One study was included in the qualitative review that measured the prospective relation between worry and positive affect (Kircanski et al., 2018), which produced a non-significant relation. There were mixed findings among the four studies analyzing the relationship between suppression and positive affect. Brans et al. (2013) found a significant negative relation in Study 2, but the relation was not significant in two other studies (Brans et al., 2013, Study 1; Silva et al.,

2018). A fourth study found a significant and positive prospective relation between suppression and positive affect (Ludwig et al., 2020). Four studies analyzed the association between acceptance and positive affect, yielding mixed effects in terms of significance levels and direction. Two studies found a significant and positive relation (Brans et al., 2013, Study 1 and 2), a third study found a significant negative relation (Ludwig et al., 2020) and a fourth (Chaudhury et al., 2017) found a non-significant negative relation(Chaudhury et al., 2017).

3.7. Publication bias

The funnel plot (see Fig. 2 in the Supplementary Material) shows a symmetrical shape, which suggests the absence of publication bias in our meta-analysis. Furthermore, Kendall's tau showed a non-significant effect (Kendall's tau = −0.02, p = .65), as well as Egger's test (test for funnel plot asymmetry: z = −0.340, p = .73) which again supported the absence of a publication bias in our sample.

4. Discussion

The main aim of this study was to provide a comprehensive systematic review and meta-analysis of how momentary and daily use of different ER strategies is contemporaneously and prospectively related to negative and positive affect. Clarifying the temporal relationships between emotion regulation strategies and affect, using EMA methodologies, is an essential first step in understanding the psychological and neurobiological functioning of emotions. Our results reflect the contemporaneous relation of each ER strategy with separate indicators of positive and negative affect, as well as the prospective relation of each ER strategy with affective experiences in ESM (ranging from minutes to hours) and daily diary studies (by studying consecutive day periods).

4.1. Contemporaneous relations between use of ER strategies and affect

Our first main hypothesis, related to the contemporaneous associations between the use of different ER strategies and negative and positive affect, was partially confirmed (see Fig. 2). Meta-analytic results showed that suppression was positively and significantly related to contemporaneous negative affect in both daily diary and ESM studies. These results, together with the fact that the association between daily suppression and contemporaneous positive affect was not significant, go in line with the traditional conception of suppression as an ER strategy specifically used during the experience of negative emotions (Gross and John, 2003). Rumination was also positively and significantly related to contemporaneous negative affect at both levels of measurement (daily diaries and ESM). In fact, the daily contemporaneous relation between rumination and negative affect was the largest effect size (r=0.68, p < .001) found in our study. This result provides support for a trait-like perspective on rumination, which suggests that this ER strategy may be characteristic of distressed individuals (Nolen-Hoeksema et al., 2008).

Worry, which could only be quantitatively analyzed in ESM studies, was also positively and significantly related to contemporaneous negative affect. Interestingly, there were not enough studies to analyze prospective relations between worry and negative affect, which is surprising as worry has been conceptualized as concern about future events and consequences (Ehring and Watkins, 2008).

Problem-solving, distraction, acceptance, and reappraisal were not significantly related to contemporaneous negative affect. These non-significant meta-analytic findings inform about the specificity of the co-occurrence of negative emotion related to the use of different ER strategies (suppression, rumination, and worry) in association with negative affect.

The analysis of contemporaneous associations between the use of ER strategies and positive affect was also partially in line with the first main hypothesis. Acceptance, problem-solving, and reappraisal, evaluated using daily diaries, were significantly associated with positive affect. Interestingly, none of these strategies was significantly associated with negative affect.

Although ER strategies might cover multiple functions and goals (Ford et al., 2019), the results of our meta-analysis suggest that the use of ER strategies may be associated with only one type of affective experience. In other words, based on the limited number of studies that could be meta-analyzed, no ER strategy had significant contemporaneous relations with both positive and negative affect. This finding, in turn, indirectly supports the relative independence of positive and negative affect (Barrett et al., 2001).

4.2. Prospective associations between use of ER strategies and affect

Results on prospective associations complement the contemporaneous perspective by not only providing information on the frequency of use of each strategy in relation to positive and negative affect but also by approaching the possible predictive effectiveness of ER strategies to influence affect measured at a later moment (ideally controlling for levels of the previous affective state). Our second main hypothesis was related to these prospective associations, which was again partially confirmed. Concerning daily diary methods, a relevant finding from our meta-analysis was the general lack of studies analyzing prospective relations between the use of ER strategies and affective experience.

Reappraisal was the only strategy that could be included in our analysis with prospective data using that methodology. It is also interesting that this ER strategy was the only one that could be meta-analyzed in relation to both types of affective experiences (positive and negative) using both types of methodologies (daily diaries and ESM). Results showed that there was a small negative association with negative affect, which became non-significant in sensitivity analyses that included only the studies that evaluated stress-dependent ER. In contrast, reappraisal showed significant prospective associations with positive affect using both daily diary and ESM methods. These results provide further support to the idea of specificity of associations between the use of specific ER strategies and affect.

A close inspection of Fig. 3 reveals that there were many more prospective studies apt to be meta-analyzed using ESM than daily diary methods. The findings of ESM methods revealed that several ER strategies were prospectively associated with affect. First, rumination and suppression were positively and significantly associated with next-hours negative affect. Second, distraction and reappraisal were positively and significantly associated with next-hours positive affect. Sensitivity analyses showed that, when controlling for affect level at the previous assessment, only the effect size for rumination and reappraisal stayed significant with negative and positive affect, respectively. These sensitivity analyses may be revealing some potential causal relations between the use of ER strategies and affective experiences. This represents a significant theoretical advancement in the field of ER, specifically in the context of previous work that used self-report measures and experimental approaches.

As for rumination, results from self-reports have typically supported the general and frequent use of this strategy as a vulnerability factor for depression (Aldao et al., 2010) which further relates to negative affect (Thomsen, 2006). Results from experimental studies have also provided support for the idea that instructed rumination increases (Donaldson and Lam, 2004; Morrow and Nolen-Hoeksema, 1990; Nolen-Hoeksema and Morrow, 1993) and maintains (Donaldson and Lam, 2004) negative affect. Results from our sensitivity analyses suggest that rumination has a potential causal effect on daily life experiences of negative affect.

As for reappraisal, self-report studies have found that the general and frequent use of this strategy is negatively related to psychopathology (Aldao et al., 2010), and positively related to positive affect and interpersonal functioning (Gross and John, 2003). In experimental research, where negative affect is induced and participants are instructed to use reappraisal in controlled conditions, this ER strategy is related to a reduction of negative affect (Ellis et al., 2013; Millgram et al., 2015). It is

remarkable that we did not find significant relations between this ER strategy and negative affect, but only with positive affect. Sensitivity analyses controlling for the previous affect supported that reappraisal was related to increases in positive affect. Thus, reappraisal does not seem effective at ameliorating negative affect but instead boosts positive emotions over time.

The discrepancy between these results and the ones from self-report and experimental research highlights the importance of studying participants' ER strategies as they are enacted in daily life.

4.3. Limitations of the literature

Beyond the main conclusions derived from this systematic review and meta-analyses, a series of limitations in the present study must be highlighted. These limitations can be linked to conceptual and methodological recommendations for future EMA studies aiming to shed light on ER processes in daily life.

4.3.1. Range of ER strategies and affect processes under study

First, we found a clear paucity of studies exploring real-life relations between the use of ER strategies and positive affect. Extant research has been mostly focused on the study of negative affect regulation. Despite the growing research field on positive emotions, both in healthy individuals and in those with mental health problems (Vazquez, 2017), the present study reflects that EMA research on ER has not paid enough attention to the role of positive emotions yet. In our quantitative analyses, only 31.68 % of the total number of included effect sizes referred to positive affect relations. This empirical gap limits a complete understanding of ER processes given that both negative and positive emotions are integrative parts of the emotional experience. According to the broaden-and-build theory (Fredrickson, 2000), positive emotions help to broaden cognitive and behavioral repertoires and to repair the emotional impact of stressors and life difficulties. Further, recent meta-analytic evidence shows that neurophysiological processes implicated in the experience and regulation of positive emotions are highly dynamic and modifiable and ultimately contribute to increased well-being (Alexander et al., 2021). However, despite the evidence that positive and negative affect systems are relatively independent of one another (Watson and Clark, 1999), there are only a few EMA studies that included positive emotions that could be aggregated in our meta-analysis. This is important because positive emotions are, across ages, the most prevalent emotional states (Charles et al., 2001), and difficulties to maintain or regulate positive emotions are a common difficulty in a variety of mental health disorders (Gruber et al., 2020). Thus, the study of positive emotions should occupy a larger space in this field of research, to be able to provide a balanced and more accurate picture of ER. Of note, we could not perform analyses for any ER strategy in association with concurrent positive emotions in ESM studies, and we could only analyze five daily diary studies for the prospective association between ER and positive affect. Despite this limitation, knowing which ER strategies influence the maintenance of positive affect is essential for this field.

Furthermore, considerable research is needed to understand how some ER strategies function in daily life, such as worry, behavioral avoidance, problem-solving, or acceptance. This lack of prior work is surprising, given that these ER strategies are considered to be central risk components of affective disorders in multiple frameworks, and are targeted by several psychological interventions (Beck, 1995; Hayes et al., 2009; Linehan, 2014).

In terms of the selection of measures, a considerable number of studies used items to measure the use of ER strategies that were not based on validated questionnaires. Due to this fact, we had to exclude many studies evaluating general categories (i.e., engagement or disengagement coping) that did not provide detailed information about the use of specific ER strategies. Moreover, studies generally employed composite measures of positive and negative emotions instead of studying them individually, which would enrich the research on the relationships between the use of ER strategies and different types of negative or positive emotions. There is recent evidence showing that there are almost thirty distinctive emotional states that users of the English language can distinguish and use to label their own emotions. Thus, the standard practice of providing sum scores of different emotions may obscure the findings of more fine-grained associations between different emotions (Cowen and Keltner, 2017), and the use of different ER strategies. Acknowledging that different and seemingly antagonist emotions (e.g., sadness and joy) may coexist in individuals' daily experiences could bring unique intrinsic value for further developments in theories of emotion and adaptiveness. For instance, Ong et al. (2018) have shown that 'emodiversity' (i.e., the breadth and abundance of emotions that individuals experience) have significant salutatory effects as measured by inflammation markers. In sum, it seems necessary that future research pays more attention to the complexities of the map of emotions experienced at different assessment points.

4.3.2. Limitation of the number of studies and populations examined

One clear limitation of the field is the still limited number of EMA studies evaluating ER and daily affective experiences. Given this finding, we were not able to perform the planned moderation analyses (see Table 2 in Supplementary Material for all the variables codified). Instead, we performed sensitivity analyses to account for contextual (ER strategy use in response to a stressful event) and methodological (statistical control of the influence of the previous affect) characteristics. This reflects a clear need for further research in the field in the upcoming years. It would also be highly valuable to replicate and extend findings across populations and contexts. For instance, it is common to evaluate university students, which limits the age range under which ER processes in daily life are studied. As it has been recently proposed concerning the development of science in general (Henrich et al., 2010), future studies should include broader and more representative samples (e.g., in terms of age, education, socioeconomic status, or health-related conditions) to better understand how regulatory dynamics differ in different relevant groups. This will allow for future meta-analytic work to evaluate the role of these moderators in explaining the heterogeneity in ER processes. In these cases, when counting with multiple effect sizes per study, it would also be advisable to use multilevel structure meta-analytic models (Cheung, 2015). The latter was not applied in our meta-analyses, which can be considered a methodological limitation in the present study.

As seen in this meta-analysis, there is also a need to expand the study of ER strategy use in clinical samples outside of clinical interventions (many studies were excluded given that participants were evaluated after or during an intervention). As previously proposed by Hervas (2010), difficulties in specific stages of the ER process may explain the onset and maintenance of distinct affective disorders. Thus, applying ESM methods may capture differences in the frequency of use and efficacy of ER strategies, while shedding light on the transdiagnostic role of ER strategies in daily life concerning various psychopathological conditions.

4.3.3. Methodological heterogeneity and potential moderators in the design of intensive longitudinal EMA protocols

Results also showed high levels of methodological heterogeneity across studies between and within each methodology (ESM and daily diaries). It has been discussed that daily diaries could be more subjected to retrospective bias (e.g. Bolger et al., 2003), as they cover a broader time window. This difference between ESM and daily diaries could help to explain that results of the contemporaneous relations (in daily diary studies) showed larger effect sizes.

Daily diaries may be capturing not only the contemporaneous relations between the use of ER strategies and affect, but also the prospective relations that may be occurring during the day, as well as

retrospective bias of both affective experience and ER. This was one of the reasons to report results from both methods separately. However, a high level of heterogeneity was also revealed within the methods. For instance, the number of assessments per day (ESM) and the number of days (daily diaries and ESM) were largely variable, and this may account for different magnitudes of ER processes under study. In this respect, there is a necessity to reflect on the appropriate frequency of ESM signals and on the appropriate duration of intensive repeated measure protocols to capture meaningful changes in ER, while not generating burnout, boredom, or stress reactiveness for the participants.

Repeated-measure assessments could diminish compliance rates or even alter the naturalistic ER processes being evaluated. It is well known that repeated measures of depressive symptoms may modify how individuals subsequently rate their moods and observe themselves (Sharpe and Gilbert, 1998). Paying attention to one's emotions has a regulatory effect that may attenuate the intensity of emotions (Shrout et al., 2018). In the case of ESM studies, sending notifications various times a day to participants may alter the quality or the frequency with which they reflect on inner states. It has been found that the mere repetition of assessments leads to weaker intensity of negative emotions compared to a single measurement (Johar and Sackett, 2018), or even provokes negative reactions in participants (Bos et al., 2019; Scollon et al., 2009). However, this is not always the case (e.g., Cerin et al., 2001). Some studies have shown that repeated assessments can improve emotion differentiation which affects the use of different ER strategies (Tugade et al., 2004). Therefore, it is necessary that future studies using intensive repeated measure assessments, especially ESM, start considering participants' reactivity to the evaluation method itself, and define the specific duration and signal frequency protocols based on specific research and application purposes (Janssens et al., 2018).

4.3.4. *Broadening the scope of temporal relations between affect and ER strategies*

Future investigations should look even closer at the temporal relations between the use of ER strategies and affect. Most of the extant research has focused on either studying contemporaneous and/or prospective relations between ER use and affective experiences. However, it would also be interesting to study the prospective relations between affect and subsequent ER use. Some studies have already applied this approach. For example, it has been shown that negative affect is prospectively and positively related to rumination at the subsequent time point, while positive affect is negatively related to subsequent rumination in healthy adults (Borders and Lu, 2017; Hoorelbeke et al., 2016; Jones et al., 2017), and in individuals with bipolar disorder (Leung et al., 2019; Pasyugina et al., 2015; Pavlickova et al., 2013) and their adolescent offspring (Pavlickova et al., 2015). The same type of relations have been found with suppression (Keller et al., 2014) and worry (Naragon-Gainey, 2019). Another study found that negative affect was prospectively and positively related to subsequent distraction, whereas positive affect was negatively related to distraction at the subsequent time point (Pasyugina et al., 2015). The study of these types of relatively unexplored relations may be very enriching for research on the spontaneous use of ER strategies.

Furthermore, future research needs to shed light on whether the preceding use of an ER strategy itself (e.g., rumination) could be prospectively related to its use at subsequent time points (e.g., hours or a day later) when facing a new emotion-eliciting event. This will be essential to further understand to what extent the use of different ER strategies is stable across time and situations, and which ones depend more on contextual or personal characteristics.

4.3.5. *Comprehensive integrative models of affect dimensions*

Another future avenue to improve our understanding of ER is incorporating the evolutionary perspective of emotions. The nature of emotions and their functions may encourage the use of selected ER strategies. For instance, on one hand, sadness is assumed to elicit sympathy in others and motivate people to seek comfort and social connectedness (Badcock et al., 2017), thus facilitating resources from within the social group (e.g., Bonanno and Mancini, 2008). In this sense, emotional expression and social support seeking (results reported in Supplementary materials) would be highly related and it would probably be very efficient to regulate that emotion as there seems to be a correspondence between the emotion and the behavior or action tendency (Frijda, 1986).

On the other hand, from an evolutionary perspective, one of the functions of fear is reducing the exposure to a feared stimulus to prolong survival. This reduction may lead to avoidant coping when experiencing fear. This makes it plausible that stronger interplays among situational fears and avoidant strategies are captured, in contrast with the relation between avoidance use and other types of emotions. However, this convergence may imply difficulties in differentiating the affective experience and the ER strategy. For this reason, ER strategies such as emotional expression and social support seeking may reflect an overlap between ER-affect measures.

4.3.6. *Comprehensive integrative models of ER strategies and processes*

The field of ER research is faced with increased complexity regarding its theoretical components, action mechanisms, and underlying neural processes that have been related to mental and physical health (Lopez et al., 2018). For instance, there is growing evidence that within an ER episode, individuals may adopt multiple regulation strategies, whether sequentially or concurrently, which has been labeled as *polyregulation* (Ford et al., 2019).

Furthermore, ER strategies can be used in 'pure' format or rather in a blended format combining features of different strategies. For emotional experiences themselves, new developments in the science of emotions also pose a challenge to simplistic approaches to the study of ER. Primary studies typically rely on a set of discrete emotion categories (e.g., anger, joy, or sadness) that individuals are asked to identify. However, the selection of categories is not a simple decision. Research on emotions has shown that individuals can identify dozens of different discrete emotional states (Cowen and Keltner, 2017) which, in many instances (e.g., adoration, awe), are rarely represented in the list of emotions presented in questionnaires or applications. Furthermore, having mixed emotions (i.e., the simultaneous appearance of different emotions at a given episode) is not an uncommon experience and poses some theoretical challenges to the field of emotion research (Russell, 2017; Zaborowski, 2019). For instance, an individual may feel depressed and, at the same time, also feel angry or anxious. In these situations of 'emotional overproduction' (Hervas and Vazquez, 2011), ER strategies can consist of using a single strategy or goal (i.e., reducing anger as a priority) for a selected emotion or instead of the use of a polyregulation strategy aimed at regulating different emotions with one or more tactic (Ford et al., 2019).

Although ER studies on mixed emotions (e.g., nostalgia) are rare, there is a growing interest in ambivalent emotional states or blended emotions that combine simultaneous positive and negative valenced states (Vaccaro et al., 2020). Thus, the design of EMA studies should consider the possibility of complex scenarios that go beyond simple correspondences of single emotions coupled with single ER strategies.

Furthermore, to better understand the efficacy of ER strategies, future EMA research must also take a closer look at the context in which strategies are employed. This implies the study of coping and emotion regulation flexibility, namely the use of multiple ER strategies, with each strategy being implemented on specific occasions as a function of ongoing contextual characteristics in each situation, such as emotional intensity, perceived control, contextual goals or outcome expectancies. Also, part of this flexibility is related to the tactics used by the individuals to achieve the desired regulation (Ford et al., 2019). Coping flexibility has been consistently found to be related to better psychological adjustment (Cheng et al., 2014), and to be attenuated in participants with MDD, with inflexibility being associated with greater

depression severity (Stange et al., 2017). Coping flexibility has been conceptualized in diverse ways, and one source of coping flexibility variation to take into account in future intensive longitudinal research is related to its components, defined in terms of abilities (Bonanno and Burton, 2013): the sensitivity to the situational context, the ability to utilize a repertoire of regulatory strategies, and the ability to monitor feedback and maintain or readjust regulatory strategies as needed.

4.4. Implications and future directions

According to our results, there are ER strategies that are differently related to different types of affect. For instance, our results suggest that, at least from a prospective point of view, reappraisal techniques consistently predict increases in positive affect and reductions in negative affect. This supports the rationale at the core of traditional cognitive interventions which, in general, attempt to facilitate generating alternative views of patients' experiences (Beck, 1995). Likewise, third generation interventions using acceptance and mindfulness techniques are consistent with the potential value of finding less harmful ways of valuing one's experience (Hayes et al., 2009; Linehan, 2014). On the other hand, evidence from ESM studies also seems to support the importance of considering specific therapeutic strategies aimed specifically at reducing rumination or suppression (e.g., Watkins, 2015; Wells, 2011). It would be interesting for future research on the mechanisms involved in the efficacy of these interventions to integrate EMA methods to test whether these changes in ER strategies are mediating the effectiveness of these interventions.

Besides, generally self-reports are employed to detect behavioral changes on a daily basis at the beginning of any of these psychological interventions, as an evaluation method. This practice is closely related to the rationale of using EMA and allows the patient to associate the characteristics of the context with his/her thoughts, emotions and behaviors at the individual level. Thus, we think that this work comprehensively reflects the existing evidence on the different relation of distinct used ER strategies and positive and negative affect, which may be useful to be taken into account, not only at the beginning of therapy, but also during the whole treatment, through personalized feedback (Leertouwer et al., 2021), and after the contact with the therapist has ended, for the maintenance of long-term psychological well-being. Nonetheless, due to the lack of data about some ER strategies and their relation to the regulation of positive affect, more research is needed to reach clear conclusions on this issue. Future research on ER will require a comprehensive approach that integrates the analysis of numerous factors, such as the co-occurrence of multiple ER strategies with concurrent, preceding, and subsequent levels of specific emotional states and clinically relevant affective conditions.

4.5. Study limitations

Our investigation had some limitations. First, we only included published revised articles in English, excluding articles published in different languages. Second, we have not included gray literature (e.g., conference proceedings, dissertations, unpublished reports, etc.). Nevertheless, although it is recommended to include this literature in an ideal meta-analysis, there is evidence that this type of literature may have a larger impact on the results in areas in which there are few studies or when there are questionable interests in the published literature (Hartling et al., 2017) which does not seem to be the case in the field of ER. Also, it is important to note that we did not find a publication bias in the analyses (see the funnel plot in Fig. 2 in the Supplementary Material*). Also,* publication bias was evaluated using conventional methods (e.g., Egger's test). We recommend future studies to include in the pre-registration and in the design the codification of the data to compute p-curves, which would be very informative to complement conventional methods to measure publication bias.

5. General conclusion

This meta-analysis provides evidence about the momentary and daily relations between the use of ER strategies and negative and positive affect. We synthesized information from empirical studies using EMA that have analyzed the use of ER strategies in people's daily life, together with its contemporaneous and prospective relations with affective experiences. Results from our meta-analysis help us to gain a broader picture of real-life ER processes and put them in perspective with previous literature based on cross-sectional and experimental studies. Thus, the present study provides a broader view of the state of the art of ecological use of ER strategies in daily life. We consider necessary the extension of future investigation considering diverse time relations between the use of ER strategies and affective experiences, considering possible individual, contextual and methodological factors involved in those relations, to effectively understand and conversely train ER in the clinical practice.

Funding

This work was supported by a Program of Attraction of Scientific Talent of the Community of Madrid (Spain) [2017-T1/SOC-5359] to Alvaro Sanchez-Lopez, a Spanish Ministry of Science and Innovation grant (Spain) [PID2019-108711GB-I00] to Carmelo Vazquez and a University Complutense of Madrid Predoctoral Fellowships (Madrid, Spain) to Ines Nieto [CT17/17-CT18/17] and to Teresa Boemo [CT63/19-CT64/19]. These funding sources had no role in the design of this study and in its execution, analyses, interpretation of the data, or decision to submit results.

Declaration of Competing Interest

None.

Data Availability

Data will be made available on request.

Acknowledgments

We thank Malvika Godara for her help in editing the paper and Belén Fernández-Castilla for technical advice.

Trial registration

This systematic review and meta-analysis was prospectively registered on PROSPERO number CRD42018114855.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.neubiorev.2022.104747.

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