Higher positive appraisal style is associated with fluctuations in negative affect within participants

Emma Hermsen

Supervisors:

Sophie Bögemann[1,2], Erno Hermans[1,2]

Affiliations:
1: Department of Cognitive Neuroscience, Radboud University Medical Center, Nijmegen, The Netherlands
2: Donders Centre for Cognitive Neuroimaging, Nijmegen, The Netherlands

Corresponding author: Emma Hermsen, emma.hermsen@donders.ru.nl

Abstract: Previous research revealed several protective factors of mental health, so-called resilience factors (Veer et al., 2021; Southwick, Vythilingam & Charney, 2005). One in particular has had a lot of attention in the past few years, the emotion regulation strategy positive appraisal style (PAS). PAS thought to play a key role in maintaining mental health in times of adversity (Kalisch, Müller & Tüscher, 2015). It is found that PAS is related to affect. However, the exact relationship is unclear, as is whether this relationship exists both within-participants and between-participants. The present study addressed this gap using linear mixed modeling. 42 students participated in a longitudinal daily life study and answered a biweekly PAS questionnaire and reported on daily life negative affect (NA), positive affect (PA), and event pleasantness for six weeks spread over six months. The affect measures were used to calculate affect mean, variability and reactivity. Results showed that participants experienced more fluctuations of NA in weeks they used more PAS. And that participants with higher average NA used more PAS, although this finding did not withstand outlier removal. No associations were found for PA mean, PA variability, and reactivity. This suggests that the association between PAS and affect rely on different processes. These findings highlight that the association between PAS and affect is more complicated than anticipated, and this is important to consider in future research.

Keywords: positive appraisal style, resilience, resilience factors, daily life affect, negative affect variability

Introduction

Recent research on resilience revealed that positive appraisal style (PAS), plays an important role in stress and resilience (Kalisch, Müller & Tüscher, 2015). Recent studies have been looking into the relationship between PAS and affect, in laboratory setting (Gross & John, 2003), but also in daily-life (e.g., Gunaydin, Selcuk, & Ong, 2016; Silva, Freire, and Faria, 2018). However, there is no consensus on the relationship between affect and PAS. Furthermore, within-person and between-person associations regarding PAS and affect have not been compared within one study yet. Thus, the present study investigated the association between PAS and daily-life affect, within- and between-participants. It is of interest to reveal those associations because literature reveals that maladaptive emotion regulation is associated with psychopathological symptoms, and positive and negative emotions are involved in vulnerability to psychopathology (Eftekhari, Zoellner, & Vigil, 2011; Kalisch et al., 2015).

Mental health and resilience

In the last decades there has been growing interest in mental health. There is increasing knowledge about the burden of mental health problems on society and the key role stress plays in the development of mental health problems (Vos et al., 2015). Literature states that long-lasting stress is a risk-factor in the development of a broad range of psychiatric disorders, e.g., mood disorders, psychotic disorders, posttraumatic stress disorder, anxiety disorders (Vargas, Conley & Mittal, 2020; Kessler, 1997; Stetz et al., 2007). Correspondingly, a lot of research is done on finding effective ways to deal with mental health problems. Instead of fixating on psychopathology, a fairly recent development is a shift in focus towards stress resilience. This shift arises because resilience is not the result of absence of disease, but rather an active adaptation mechanism (Friedman et al., 2014 ; Russo, Murrough, Han, Charney, & Nestler, 2012). Resilience is defined as the maintenance of mental health and well-being, during and after times of adversity. Which means it is seen as an outcome rather than a static trait. With this, an answer is sought to the question why some individuals develop psychopathological symptoms and others do not, while seemingly facing the same level of adversity. This strategy offers new opportunities for treatment but also for prevention of psychopathologies (Kalisch et al., 2015).

Several protective factors of mental health have been revealed, so-called resilience factors (RFs), such as optimism, perceived social support, cognitive flexibility, and emotion regulation strategies, in particular PAS (Veer et al., 2021; Southwick, Vythilingam & Charney, 2005).

Positive Appraisal Style

In the recent years, there is increasing evidence that PAS plays a key role in maintaining mental health. Based on this, Kalisch and colleagues (2015) proposed the Positive Appraisal Style Theory Of Resilience (PASTOR), which describes the role positive (re)appraisal plays in mental health. The generalized tendency to appraise situations that are potentially aversive in a non-negative way, is referred to as PAS. The authors claim that PAS is the key factor to maintain mental health in times of adversity, and positive reappraisal mediates this mechanism. Positive reappraisal is an emotion regulation strategy in which an individual appraises aversive stimuli in a positive way. This is used to change one's attitude in an adverse situation. Furthermore, it is thought that PAS mediates the effects of other RFs on resilience. Individuals who apply PAS appraise an adverse event or threat in a realistic or positive way, while they avoid catastrophizing, pessimism and helplessness as well as delusional positive perceptions. This results in an optimally regulated stress response. Neither significantly underestimating a situation nor spending resources longer or more than necessary. PAS is considered a relatively stable factor that may change throughout life as a result of life experiences and interventions (Petri-Romao et al., 2021, Kalisch et al., 2015).

In the literature, the concept of PAS is used in different frameworks and with slightly different definitions, for instance related to anhedonia in Major Depressive Disorder (MDD) (Yilmaz, Psychogiou, Ford, & Dunn, 2021), or as an umbrella term for appraisal strategies with a positive outcome. In the present study, PAS describes the generalized tendency to regulate negative emotions and appraise aversive stimuli in a non-negative way, in accordance with the PASTOR study (Kalisch et al., 2015). Furthermore, the terms cognitive and positive reappraisal are used interchangeably, however, there is a difference in meaning. Cognitive reappraisal is an emotion regulation strategy in which one changes the meaning of a situation by reinterpreting it (Gross & John, 2003), this can also refer to the regulation of negative, positive or ambiguous emotions. Positive reappraisal on the other hand, refers only to positive reinterpretation of an aversive event

(Kalisch et al., 2015; Garland, Gaylord & Park, 2009), and thus specifically concerns the downregulation of negative emotions or the upregulation of positive emotions. Positive reappraisal is considered a key tenet of PAS. From now on, cognitive reappraisal refers to reinterpreting a negative situation and make it more positive, unless mentioned otherwise. Thus, it is interchangeable with positive reappraisal, however, cognitive reappraisal is used in the majority of the literature.

Other findings support PASTOR. For example, Crego and colleagues (2016) found that cognitive reappraisal is negatively associated with perceived stress, and experiencing higher levels of stress is associated with poorer academic performance. This indicates that using positive reappraisal protects one against stress, and malfunction related to stress. Additionally, during the start of the Corona-crisis, Veer and colleagues (2021) investigated the impact of the Corona-crisis on resilience. The association between several RFs, including PAS, and resilience was studied. In line with PASTOR, a positive association between PAS and resilience was found. Considering this study only used one point in time, the authors performed an additional longitudinal study (Bögemann et al., *in preparation*). The relationship between several RFs and resilience was again studied. Here, the authors made a distinction between RFs measured as "style", a baseline measurement (describing how much the RF is "used" in general), and on a weekly basis (describing how much the RF was "used" in that particular week). This distinction allows for observing dynamic associations, how future resilience is influenced by general trait-like use of the RF and how the use within a week is associated with resilience. Positive appraisal style, both in a general style and on a weekly basis, was again associated with resilience. This demonstrates that both within-participants and between-participant fluctuations in resilience are captured by PAS.

Taken together, these results suggest that positive appraisal is protective of mental health. Moreover, PAS scores are positively associated with stress and emotion regulation capacities. Following an adverse event, an increase in PAS is related to an appropriate emotional response, which means that the response is not higher nor longer than necessary.

Affect in daily life

Literature reveals that distorted emotion (regulation) often interferes with the ability to function. Positive and negative emotions are involved in vulnerability to psychopathology, and emotion can be distorted in mental disorders (psychotic disorders, MDD, dysthymia, etc.) (Gross & Muñoz, 1995; Gross, 2013). To investigate emotions, affectivity is measured. Affect is to what extent a person experiences negative emotions (negative affect: NA) or positive emotions (positive affect: PA). A commonly used method to observe affect in daily life situations is ecological momentary assessment (EMA). This method allows repeated sampling of thoughts and behavior of individuals in daily life by sending out multiple questionnaires during multiple days, usually via a smartphone or smartwatch. Accordingly, characteristics of affect can be measured. It is a consistent finding that affect functioning is linked to general well-being and psychopathologies (Trull, Lane, Koval, & Ebner-Priemer, 2015; Sperry, Walsh, & Kwapil, 2020). Fluctuations in several aspects of affect functioning are linked to mental health.

Mean

One characteristic that has been consistently linked to mental well-being, is mean affect. This represents the average level of negative affect or positive affect an individual experienced over time. A very consistent finding is that reduced psychological well-being and increased depressive symptoms are associated with a low mean PA (Heininga et al., 2019; Peeters, Nicolson, Berkhof, Delespaul, & deVries, 2003; Houben, van den Noortgate, & Kuppens, 2015). Additionally, symptoms of depression were associated with higher NA mean in participants diagnosed with major depressive disorder (Peeters et al., 2003), and higher NA mean was related to more depressive symptoms, anxiety, and perceived stress (Brose et al., 2020).

Dynamics

Considering affect is a dynamic entity and fluctuations are present over time, there are several variables that measure these dynamics (e.g., variability, instability or inertia). The two characteristics prominent in EMA literature regarding mental health, are variability and instability. Variability represents the deviation from the mean over time, the within-person variance, while instability is to which extent emotions fluctuate from moment-to-moment. Increased NA and PA variability and instability are associated with reduced well-being

(Gruber, Hay, & Gross, 2013; Van Roekel et al., 2015), and with a decrease on several aspects of psychological well-being in the general non-clinical population, such as depression diagnosis, neuroticism, and anxiety symptoms (meta-analysis by Houben et al., 2015). However, in a review on PA in EMA, Heininga & Kuppens (2021) address that not all studies find associations between PA dynamics and mood disorders. Furthermore, although NA variability is consistently linked to depressive symptoms in healthy participants and MDD in both lab and daily life (e.g., Nelson, Klumparendt, Doebler, & Ehring, 2020), this association is not found for NA instability (Koval, Pe, Meers, & Kuppens, 2013). Additionally, the meta-analysis by Dejonckheere and colleagues (2019) shows that when predicting psychological well-being outcomes, most of the data is explained by mean levels of affect and variability. Thus, including other dynamic affect variables does not add much value. For that reason, the only dynamic variable that will be included in the present study is variability.

Reactivity

Another measure commonly used in EMA studies is in relation to events that happen during the day, and is known as reactivity. Reactivity represents the emotional, PA or NA, fluctuations in response to (minor) daily life events. These events can be either positive (PE) or negative (NE), depending on what is of interest. This measure is repeatedly related to psychological well-being in literature. A consistent finding related to negative emotional reactivity in patients with MDD is that NA reactivity to PE (NA-PE) is higher, and there is no difference for NA reactivity to NE (NA-NE) (Thompson et al., 2012; Peeters et al., 2003; Nelson et al., 2020). Showing that depression is associated with differences in reactivity of negative emotions. Additionally, reactivity of PA to PE (PA-PE) in the lab is reduced in individuals with MDD (Bylsma, Morris & Rottenberg, 2008). However this does not seem to apply for EMA evidence, indicating a different relationship is captured in a controlled laboratory setting or daily life. EMA studies often find no relationship with (Thompson et al., 2012; Nelson et al., 2020; Heininga et al., 2019), or even increased reactivity of PA. This increase in PA after a PE specifically, is called 'mood brightening effect' and is also found as a decrease of NA. This effect is specifically found in people with depression. An increase in mood means a decrease in NA and a larger increase in PA. This finding has been replicated and is seen increasingly (Heininga & Kuppens, 2021).

It must be pointed out that most literature regarding reactivity is based on the MDD population rather than on a more versatile combination of mental well-being factors in healthy participants. The mechanisms behind affect reactivity might differ. Taken together, there is no consensus on the exact roles the affect variables play in mental well-being. However, it is demonstrated that affect is related to several aspects of mental health and well-being.

Association positive appraisal & daily life affect

Given positive reappraisal (a key tenet of PASTOR) is an emotion regulation strategy, which means it is used to change emotions and emotional reactions to the environment, the link between affect and PAS is studied increasingly. Various studies examined the link between cognitive (re)appraisal and (fluctuations in) affect in laboratory settings. Gross & John (2003) found the use of cognitive reappraisal is associated with experiencing an increase in positive emotion and a decrease in negative emotion experience in a laboratory setting. Additionally, use of cognitive reappraisal is associated with a decrease in emotional reactivity for both PA and NA after watching a film in both individuals with bipolar disorder and healthy controls (Gruber et al., 2013). It must be noted that the instruction was to watch the film objectively, without letting it influence your feelings, rather than positively interpreting negative events. This shows that when experimentally manipulating cognitive reappraisal, this has effect on several aspects of affect.

Because experimentally manipulated studies have low ecological validity, these associations have also been studied in daily life studies with EMA. However, the findings are inconsistent. In general, using cognitive reappraisal is associated with better affect. In other words, an increase in PA and a decrease in NA (e.g., Richardson, 2017; Brans, Koval, Verduyn, Lim, & Kuppens, 2013; Pavani, Le Vigouroux, Kop, Congard, & Dauvier, 2015). Nevertheless, Silva and colleagues (2018) found a significant increase in NA associated with state (concurrent) cognitive reappraisal, no significant association was found for trait cognitive reappraisal. This suggests that using cognitive reappraisal does not automatically decrease NA. The authors propose that trait cognitive reappraisal buffers the relationship between state cognitive reappraisal and concurrent NA, considering more frequent use of cognitive reappraisal is associated with less NA (John &

Gross, 2004). However, this concerns a lab study. These concurrent associations were not significant for PA and cognitive reappraisal. Nevertheless, another study found no correlation with cognitive reappraisal for both NA mean and NA variability, only a negative correlation with NA-NE (Bastiaansen et al., 2018). In accordance with this, use of cognitive reappraisal is associated with lower NA-NE and PA-PE, but not for NA-PE and PA reactivity to NE (NA-PE) (Gunaydin et al., 2016). All evidence considered, it is apparent that the findings on the association between PAS and affect are inconsistent. Therefore, it is necessary that more research is done, comparing the affect variables in one study for both PA and NA.

Relevance

All previous literature considered, these findings show that different aspects of affect are related to PAS in a specific manner, and revealed that the characteristics of this relationship are ambiguous. Most studies focused on relating one or a few affect variables to PAS, and did not put them next to each other. Previously presented results show the significance of studying multiple variables, considering the different processes underlying these variables. Furthermore, the designs of previously mentioned EMA studies usually concern a couple of days in a row. There is a lack of evidence on studying daily life in a longitudinal manner with multiple weeks over a considerable amount of time, to study within and between individuals side by side. This longitudinal design gives insight in whether the effects differ within participants and between participants.

Previous evidence has not been able yet to get a clear picture of the association between PAS and several relevant affect variables. The present study aims for better understanding the relationship between PAS and daily life affect within and between healthy individuals. This contributes to the existing ambiguous evidence. Both EMA and questionnaires are combined, which allows examination of the dynamics between those measures, rather than on a static level. Accordingly, in this paper it is studied whether and how positive appraisal style is associated with daily life affect, specifically mean, variability, and reactivity. Other dynamics variables are not included in the analysis because the meta-analysis on affect measures of Dejonckheere and colleagues (2019) shows that measuring other affect variables than mean and variability does not add substantial value.

Based on previously presented evidence regarding PAS and daily affect, it is hypothesized that participants with higher PAS have increased PA mean, and decreased NA mean, NA and PA variability, PA-NE, PA-PE, NA-PE, and NA-NE. It is expected that these expectations exist both within and between participants.

Overview of study

To study the association between PAS and different daily life affect measures, an EMA study was done. EMA was used to measure affect in daily life. The participants received questionnaires 10 times a day for 6 days in a row in 6 different weeks divided over 6 months in total. These questionnaires consist of questions on NA, PA, the most important event that happened after the last beep, and how pleasant or unpleasant they experienced this event. Furthermore, at the same time of the EMA weeks, PAS was measured with the Positive Appraisal Style Scale, process-focused (PASSp, Veer et al., 2021) questionnaire that participants received every two weeks. Only the questionnaires measured contemporaneous with the EMA weeks were used. The PASSp questionnaire asks how much participants applied several aspects of PAS in their lives during stressful situations in the past two weeks. This is not a trait measure, considering change is expected over the weeks, but also not a state measure per se because it is asked out for the past two weeks.

From the EMA measures NA mean, NA variability and reactivity of both PA and NA are extracted. Reactivity is the relationship between affect measured in the current beep and pleasantness rating of the last event. This is done for both NA and PA and both PE and NE, resulting in four different measures (PA-PE = PA in relation to PE; PA-NE = PA in relation to NE; NA-PE = NA in relation to PE; NA-NE = NA in relation to NE).

Linear Mixed Effect Modelling is used to calculate the association between the dependent variables (PA mean, NA mean, PA variability, NA variability, NA-NE, NA-PE), and the scores on the PASSp between and within participants as independent variables. It is expected that higher PASSp scores are associated with lower NA mean, lower variability, lower reactivity, and higher PA mean.

Methods

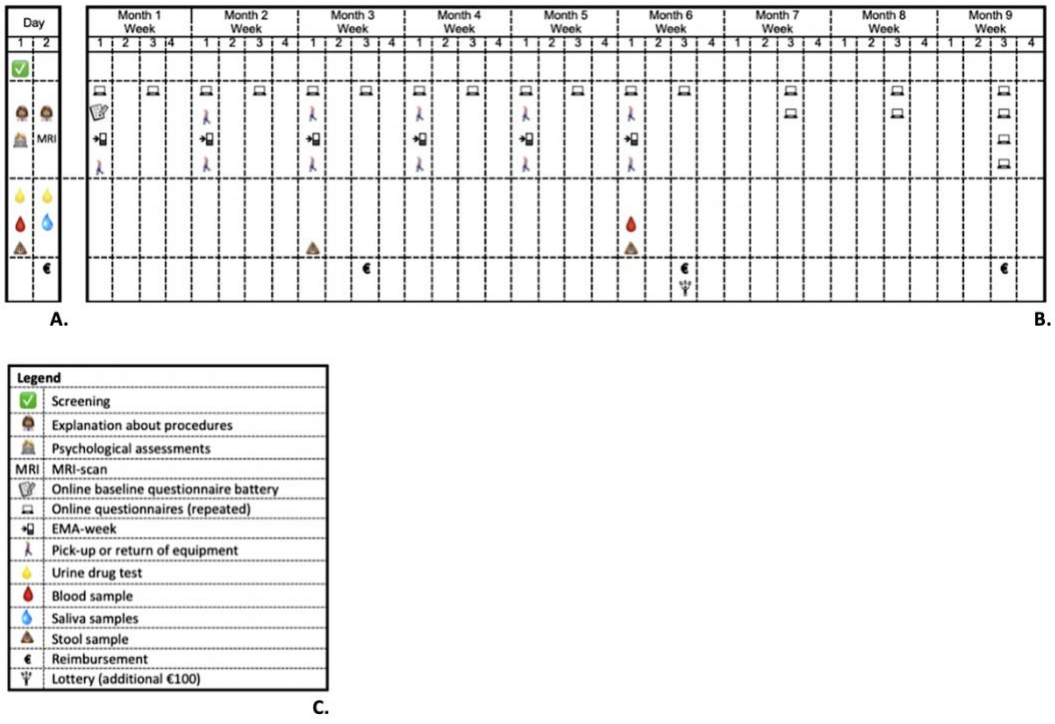
The present study is part of the DynaM-OBS study, which belongs to the DynaMORE consortium (Dynamic MOdelling of REsilience, https://dynamore- project.eu). DynaMORE aims to unravel the mechanisms behind resilience on a psychological, biological and neural level. The DynaM-OBS study (Wackerhagen et al., 2021) is a longitudinal multicenter study with the goal to identify protective factors of resilience in the development of mental disorders despite adversity. Exclusively the data collected in Nijmegen is used.

Participants engaged in a cluster of psychological, neural, behavioral and physiological experiments, separated in baseline experiments and longitudinal experiments, for a period of 9 months in total (figure 1). The baseline experiments were conducted at the Donders Centre for Cognition and Neuroscience (DCCN) in Nijmegen. These consisted of baseline questionnaires, (f)MRI battery and neuropsychological tasks. The longitudinal experiments consisted of repeated bio-samples, and several experiments conducted at home. This included online questionnaires, EMA and ecological physiological assessments (EPA). The latter is used for physiological measurements (heart rate, temperature, skin conduction) in daily life. Data collection was approved by the local ethics committee METC Oost-Nederland.

For the present study, exclusively the EMA data and the PAS questionnaires measured simultaneously with the EMA weeks (week 1 of month 1 to 6) were used (see Appendix A).

Figure 1

Timeline of DynaM-OBS study



Note. Shown are the experimental design during two days in the lab (A), the longitudinal design consisting of six EMA weeks and three follow-up weeks (B), and the legend (C). The baseline experiments, except for the questionnaires, were conducted at the Donders Centre for Cognition and Neuroscience (DCCN) in Nijmegen. The longitudinal experiments were conducted at home, except for the blood drawing which was done in the hospital.

Participants

The sample consisted of 50 participants. After data cleaning, 42 participants (24 females) remained. Eight participants were excluded from the dataset due to incompleteness, for a specific description of excluded data, see the data analysis section below. All participants were students between the age of 18 and 25 (mean: 21.3 years old, SD: 2.27). Recruitment was done through flyers, websites, mailing lists, and via an announcement in the online research participation system of the Radboud University in Nijmegen.

Participants first performed an online pre-screening, to make sure all requirements were fulfilled. It was assessed that they were not diagnosed with severe lifetime mental or organic disorder affecting neurodevelopment (e.g., schizophrenia, autism spectrum disorder, stroke, etc.) and were not currently receiving psychiatric treatment. Participants were included based on having at least three burdening life events from the Life Events Questionnaire (LEQ) (mean: 6.7 events, SD: 3.3). A translation of the adapted version of the Life Events (Cochrane & Robertson, 1973) was used, consisting of 27 items concerning potential stressful events. Additionally, participants scored at least 20 on the General Health Questionnaire (GHQ) (mean score: 26.2, SD: 5.8). Which is composed of 28 questions concerning general health in the following categories: somatic symptoms, anxiety and insomnia, social dysfunction, and severe depression (Goldberg, 1972; Koeter & Ormel, 1991).

Upon arrival at site, a drug test was done on all participants to assure the (neuroimaging results and psychological assessments) are not affected by drugs. Additionally, participants were screened with Mini-International Neuropsychiatric Interview (MINI version 6.0, Sheehan et al., 1998). This is a short diagnostic interview to assess mental disorders as defined by DSM (Diagnostic and Statistical Manual of Mental Disorders) & ICD (International Classification of Disorders). Both lifetime and currently ongoing disorders were assessed. When no current (i.e., within nine months before inclusion) psychiatric disorders were assessed, participants were included. An exception was made for current mild depressive episodes, and substance abuse. Three participants experienced such a current episode. 17 participants experienced at least one previous episode of any mental disorder. Table 1 shows an overview of these episodes.

Table 1

Episodes assessed during baseline experiments

	Past	Current
Mild MDD	14	3
Severe MDD	7	-
Alcohol abuse	2	-
Generalized social phobia	1	-

Note. The amount of participants assessed with several neuropsychiatric episodes is shown. The left column represents episodes experienced in the past, the right column represents participant with an episode during the start of the study. Some participants were assessed with multiple episodes.

Ecological Momentary Assessment

Participants received a Moto E6 Play smartphone with the RADAR active RMT application. This application is created by RADAR-CNS (https://radar-base.org/) for EMA purposes. For a period of six days, participants received a number of notifications, so-called "beeps", notifying a questionnaire is ready for them ("It is time for a new questionnaire"). Those beeps arrived 10 times a day between 7:30 and 22:30, set at semi-random interval every ~2 hours (range: 30 minutes – 3 hours). This procedure was repeated once every four weeks, six times in total (see figure 1). The questionnaires asked about subjective feelings of mood (PA and NA), the current activity participants were involved in, social events, event pleasantness, event anticipation, and substance use. For the present study, exclusively subjective feelings of mood and event pleasantness were used. These measures are further elaborated upon in the next paragraphs.

EMA measures

Event pleasantness

Participants rated the pleasantness of most important event that happened since the previous beep, on a scale from -3 to 3. An event was marked negative (NE) when participants answered -3, -2 or -1, and positive (PE) when participants answered 1, 2 or 3. Neutral events (score = 0) were not used.

Affect

Negative affect (NA) per beep was calculated by averaging eight items measured at each time point asking about negative feelings (in what intensity participants felt irritated, anxious, insecure, sad, stressed, restless, tired, and couldn't lose thoughts). Likewise, positive affect (PA) was measured by averaging five items at each time point concerning positive feelings (in what intensity participants felt cheerful, relaxed, satisfied, mind at ease, and could concentrate). Both affect measures were rated by participants on a Likert scale from 1-7. These values were then averaged per participant per week, resulting in a weekly PA and NA score, PA mean and NA mean.

Subsequently, variability and reactivity were computed per participant for both NA and PA separately. Affect variability was calculated as the standard deviation (SD) reflecting average deviation from the mean per week for both NA and PA. Weekly reactivity was operationalized as the slope between affect and experienced events, corrected for the previous affect measure ($affect_t = B0 + event\ pleasantness_t * B1 + affect_{t-1}$). Reactivity was defined separately for PA and NA, as well as PE and NE, resulting in PA-PE, PA-NE, NA-PE, NA-NE. Only weeks with more than five PE and/or more than five NE per individual were included (calculations based on Geschwind et al., 2010), to ensure enough power.

Positive Appraisal Style

The Positive Appraisal Style Scale, process-focused (PASSp) questionnaire was sent to participants every two weeks. Assessing thinking processes in difficult or stressful situations during the past two weeks. This questionnaire is a refined version of existing questionnaires specifically assessing PAS, consisting of 14 questions in total. PASSp is composed of two questions of the Brief Coping orientation to problems experienced questionnaire (Brief COPE; Carver, 1997) on a 4-scale (not at all, a little bit, quite much, a lot), 10 questions extracted from the short version of the Cognitive emotion regulation questionnaire (CERQ short; Garnefski et al., 2001) on a scale with five options ((almost) never, sometimes, occasionally, often, (almost) always), and two self-composed questions regarding cognitive distancing on a 5-scale. With help of a combined principal component analysis, the component 'positive appraisal strategies' was extracted. There are seven subscales of two questions each: Perspective taking (CERQ), Positive Reappraisal (CERQ), Refocusing on planning (CERQ), Acceptance (CERQ), Positive refocusing (CERQ), Cognitive distancing (self-generated), and Humor (COPE). For instance, questions were asked such as "I thought that I have to accept the situation" (Acceptance) or "I've been making fun of the situation" (Humor).

Data analysis

All data processing steps were performed using R (version 1.4.1106; R Core Team, 2020). For a complete overview of all packages used for data cleaning and analysis, see Appendix D.

Data processing

All variables were centered by subtracting the average of all datapoints of the variable, essentially resulting in demeaned values. This was done to increase interpretability and avoid non-essential multicollinearity which undermines the statistical significance of an independent variable (Dalal & Zickar, 2011). Non-essential multicollinearity can arise as a result of scaling, centering reverses this. Simultaneously, the variability and reactivity scores were global-mean scaled (divided by their standard deviations) to eliminate variability in scales between the dependent variables. This is an important step to assure that every variable contributes equally to the analysis and to increase interpretability. The mean scores were not global-mean scaled to increase interpretability of the effects (i.e., on the original Likert scale).

Data preprocessing and inspection

To remove inconsistencies and errors in the data and thus increase quality, the data was cleaned by removing for instance participants with a low compliance rate. A complete overview of the cleaning steps is described

in Appendix B. After data cleaning, a remainder of 203 weeks from 42 participants is included in the analyses, consisting of 9292 beeps in total.

Additionally, to rule out that the data was driven by compliance, the correlation between compliance and all variables was investigated.

Next, the intraclass correlation coefficient (ICC) was calculated for all variables, to (a) justify the use of linear mixed effects models for the main statistical analyses and to (b) determine what proportion of the total variance of the data was explained by between-person and within-person difference in PAS. This was done by creating empty linear models per variable to obtain the estimated variances. Afterwards, the variance of interest was divided by the total variance, resulting in a value between 0 and 1.

Subsequently, the PAS variable was separated into two variables, weekly PAS and mean PAS. Weekly PAS comprises the fluctuations per person, subtracting the six month average per individual from their week average for every week. This is used to determine within-participant effects. Whereas, mean PAS is an averaged value of all six months per participant, covering between-participant effects.

Statistical analyses

For all statistical models, the lme4 package (Bates, Maechler, Bolker, & Walker, 2015) was used. Separate linear mixed effect models were used to calculate the association between PAS and each dependent variable (mean NA, NA variability, PA-PE, PA-NE, NA-PE, NA-NE), resulting in eight different models. For the independent variable, both the demeaned variable (weekly PAS) and its mean score per participant (mean PAS) were included as fixed effects in the models. Covariates were included as additional fixed effects, and included: age, EMA week number, gender, presence of current episode assessed with the MINI, and presence of previous episode assessed with the MINI. Presence of episode was indicated in a binary way (present or not present), regardless of episode type and number of occurrences. Participant and weekly PAS were included as random effect, allowing weekly PAS to vary per participant in terms of intercept and slope.

The dependent variables were measured on three levels: beeps (level 1), within participants (level 2), within weeks (level 3). The independent variable (PASSp) was measured on 2 levels: participants (level 1) within weeks (level 2). As a result of this incompatibility, beeps-level dependent variables were averaged per week per participant. The model thus contained 2 levels; weeks (level 1) within participants (level 2).

***Model 1**: PA mean ~ weekly PAS + mean PAS + gender + week + current episode + past episode + (weekly PAS | participant)*
***Model 2**: NA mean ~ weekly PAS + mean PAS + gender + week + current episode + past episode + (weekly PAS | participant)*
***Model 3**: PA variability ~ weekly PAS + mean PAS + gender + week + current episode + past episode + (weekly PAS | participant)*
***Model 4**: NA variability ~ weekly PAS + mean PAS + gender + week + current episode + past episode + (weekly PAS | participant)*
***Model 5**: PA-PE ~ weekly PAS + mean PAS + gender + week + current episode + past episode + (weekly PAS | participant)*
***Model 6**: PA-NE ~ weekly PAS + mean PAS + gender + week + current episode + past episode + (weekly PAS | participant)*
***Model 7**: NA-PE ~ weekly PAS + mean PAS + gender + week + current episode + past episode + (weekly PAS | participant)*
***Model 8**: NA-NE ~ weekly PAS + mean PAS + gender + week + current episode + past episode + (weekly PAS | participant)*

Assumptions

Assumptions important for mixed linear modelling (i.e., linearity, homoscedasticity and normal distribution of residuals) were graphically checked. As described by Fox (2008), visual checks suffice and significance

testing has no additional advantages. In case the assumption of normality was not met, the variable was transformed to improve normality. In Appendix C, the assumption checks are described in more detail.

Outlier removal

For each significant model, outliers were removed from the dependent variables to see whether the results were robust, or whether outcome would be purely driven by outliers. The outliers were not removed from the initial analysis because outliers that cannot be explained by experimental errors may contain important information about the dataset, such as random variation or an underlying scientific process (Frost, 2019).

Outlier removal occurred in two steps. First, influential outliers were determined with Cook's distance. This is an estimate often used to determine whether outliers drive the model fit (Glen, 2016). A distance greater than 1 indicates datapoints with high influence on the outcome of the regression. Therefore, all datapoints that exceeded this distance were removed from the dataset for all dependent variables separately (based on the calculations used by Silk, 2019). The model was then fit again and skewness was measured to examine the effect of the influential outliers on the fit of the dataset.
Second, remaining outliers were detected using a box plot. A box plot is a useful way to detect potential outliers since data is depicted. Quartiles are displayed, as well as variability outside the quartiles. All data points above the upper quartile plus 1.5 times the interquartile range (IQR) and under the lower quartile minus 1.5 times IQR were considered outliers and removed per dependent variable. To examine the effect of outlier removal, the model was fitted once again and skewness was measured.

Results

Data preprocessing & inspection

Before the statistical analyses, ICC results were calculated and confirmed the hierarchical structure of the data. The percentage of PAS variation explained within and between participants was approximately equal: 49% was explained within participants and 51% between participants. Furthermore, correlation was calculated between compliance and the (in)dependent variables to verify whether the data could be explained by compliance rates. No correlation was found between compliance and the independent or the dependent variables ($r < 0.15$). The average compliance was 60.5%, meaning that 60.5% of the questionnaires were answered. Additionally, the number of events per week were checked to calculate reactivity scores, as described in the methods section. 273 NE and 3 PE were excluded, and in total 954 NE and 4958 PE from 101 weeks NE and 201 weeks PE were included to calculate reactivity. Table 3 shows descriptive statistics on the occurrence of events.

Associations between PAS and NA

Before interpreting the statistical results, assumptions were checked. The assumption of linearity was met for all variables. Likewise, no patterns of heteroscedasticity were observed when graphically checking the residuals against the fitted values, hence, the data was considered homoscedastic. After a log transformation, normality improved for all variables (for a more extensive description see Appendix C).

In contrast to the expectation to find a negative association between PAS and NA mean, mean PAS showed a significant positive association with NA mean (table 4 model 2, ß=0.28, p=.05). Indicating that individuals with higher PAS scores (compared to others) experience, on average, higher daily NA than individuals with lower PAS scores. No association was found between NA mean and weekly PAS scores, likewise, a negative association was expected. In this model, the variance in intercepts was 0.75 (indicating that 95% of intercepts fall in the interval [-1.18 : 1.75]), and the variance in the slopes was 0.06 (indicating that 95% of slopes fall in the interval .18 : .39]).

Weekly PAS was positively associated with NA variability (table 4 model 4, ß=0.33, p=.03). Thus, in weeks where individuals have a higher PAS score (compared to themselves), they experience significantly more variability in daily NA than in weeks with low PAS scores. There was no relation between NA variability and average PAS levels. This is in contrast with the expectations that PAS was associated with NA variability both within- and between-participants. In this model, the variance in the intercepts was 0.50 (indicating that

95% of intercepts fall in the interval [-.66 : 1.31]) and the variance in the slopes was 0.03 (indicating that 95% of slopes fall in the interval .27 : .38]).

Associations between PAS and other affect variables

The remaining models showed that PAS was not significantly associated with PA mean (model 1) nor with PA variability (model 3), PA-PE (model 5), NA-PE (model 6), PA-NE (model 7), NA-NE (model 8). As is shown in the table below (table 4).

Table 4

Positive appraisal style association with daily affect variables.

	PA mean	NA mean log	PA variability log	NA variability	PA-PE log	NA-PE	PA-NE	NA-NE log
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Weekly PAS	-.06	.09	.15	**.33***	-.23	.23	-.13	-.22
	p = .36	*p = .38*	*p = .35*	***p = .03***	*p = .33*	*p = .29*	*p = .80*	*p = .60*
Mean PAS	-.03	**.28***	-.08	.05	-.03	.09	-.14	.13
	p = .77	***p = .05***	*p = .52*	*p = .71*	*p = .73*	*p = .28*	*p = .25*	*p = .32*
Gender: Male	.25	-.40	.16	-.12	.14	.08	.44	.04
	p = .16	*p = .16*	*p = .49*	*p = .63*	*p = .34*	*p = .65*	*p = .07*	*p = .89*
Week	.01	.003	**-.14****	-.05	.06	-.03	-.05	**.18***
	p = .28	*p = .89*	***p = 0.00***	*p = .10*	*p = .17*	*p = .54*	*p = .51*	***p = .02***
Current ep.	-.02	-.41	-.72	-.87	-.02	.17	.60	-.71
	p = .96	*p = .45*	*p = .10*	*p = .07*	*p = .93*	*p = .60*	*p = .10*	*p = .08*
Previous ep.	-.003	.02	.21	.18	.09	.19	-.18	-.06
	p = .99	*p = .95*	*p = .37*	*p = .46*	*p = .58*	*p = .28*	*p = .45*	*p = .83*
Constant	-.12	.13	.23	.14	-.26	-.09	-.03	-.28
	p = .45	*p = .60*	*p = .30*	*p = .55*	*p = .14*	*p = .64*	*p = .89*	*p = .30*
Observations	203	203	203	203	189	188	63	61

** p<0.05; ** p<0.001*

Reference categories: Female (*Gender*)

Note. Multilevel models of each of the eight dependent variables are shown. Fixed effect estimates and p-values of the dependent variables (columns) and independent variables (rows) are displayed. Significant results are shown in bold and marked with (*). The bottom row shows the total number of observed weeks included in the analysis.

Robustness significant results

To check robustness of the results, outliers were removed from significant models. Two outliers were removed from the log transformed NA mean variable and one from NA variability, originating from different participants. Fitting the models afterwards showed that the assumptions were met regardless of outlier removal. Skewness remained approximately similar after outlier removal.

The follow-up models revealed one significant association (table 5): Weekly PAS was still associated with NA variability (ß=.36, p=.02) (only one outlier was removed), but not with NA mean (ß=.23, p>0.05) (two outliers removed). This suggests that the observed association was mainly driven by outliers indicating that this result is not very robust. The removed outliers (responsible for this effect) came from two different participants. Both had an extreme positive value, allegedly driving the significant positive association between PAS and NA mean between participants (figure 2).

Table 5

Effect of outlier removal on the significant associations between NA mean and mean PAS and NA variability and weekly PAS.

	NA mean		NA variability	
	Original	Outliers removed	Original	Outliers removed
Weekly PAS	.09	.03	**.33***	**.36***
	p = .38	p = .75	**p = .03**	**p = .02**
Mean PAS	**.28***	.23	.05	.07
	p = .05	p = .10	p = .71	p = .60
Gender: Male	-.40	-.38	-.12	-.09
	p = .16	p = .15	p = .63	p = .71
Week	.003	-.002	-.05*	-.04
	p = .89	p = .92	p = .10	p = .16
Current episode	-.41	-.36	-.87*	-.86*
	p = .45	p = .48	p = .07	p = .06
Previous episode	.02	-.06	.18	.15
	p = .95	p = .83	p = .46	p = .53
Constant	.13	.16	.14	.11
	p = .60	p = .52	p = .55	p = .64
Observations	203	201	203	202

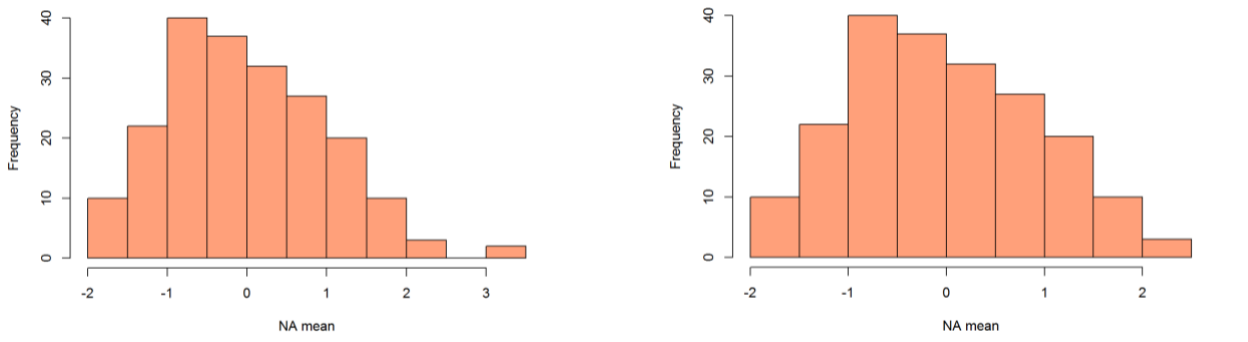
p<0.05

Reference categories: Female (*Gender*)

Note. The rows represent the predictors and covariates of the multilevel model. The columns are separated in the scores of model 2 "NA mean" and model 4 "NA variability" and display the results from the main analysis "Scaled" and the results after outlier removal "All outliers removed". Significant results are shown in bold and marked with (*). On the bottom row the number of observed weeks is shown.

Figure 2

NA mean distribution before and after outlier removal.



Note. A) shows the distribution of log transformed centered NA mean values, B) shows the distribution after removal of outliers with a value of 3 and 3.4.

Interactions between NA variability and NA mean with PAS

Variability as a measure does not distinguish between different means; low and high NA mean scores are equated. If variability is high, what does this say about the mean? Variability, measured in SD, is the proximity of the data points to the mean (Reichardt, 2010), but does not take the value of the mean into account. Dejonckheere and colleagues (2019) show that the SD of NA has additional value to the mean in explaining well-being, it accomplishes the highest explanation. Most of the data is explained by these two

measures, other "complex" dynamic measures do not have much additional value. Suggesting that the mean and variability both explain something else. This was studied, to show whether variability and mean explain a different phenomenon in the data. To verify that the significant findings were not explained by an interaction between the mean and variability, two additional models were created to investigate the interaction between PAS and respectively NA mean and NA variability. Similar to the models used in the main analyses (model 9 & model 10).

In the first additional model (model 9) investigating NA mean, the interaction between NA variability and PAS was included, both for mean PAS and weekly PAS. These interaction terms were included in addition to the PAS predictors (weekly PAS and mean PAS), as well as to the covariates (gender, week, current episode, and past episode). In a similar fashion, interaction terms for NA mean and PAS (both for mean PAS and weekly PAS) were added to the second additional model (model 10), investigating the effect of PAS on NA variability.

Model 9: *NA mean ~ weekly PAS + mean PAS + NA variability + NA variability*weekly PAS + NA variability *mean PAS + gender + week + current episode + past episode + (weekly PAS | participant)*
Model 10*: NA variability ~ weekly PAS + mean PAS + NA mean + NA mean*weekly PAS + NA mean*mean PAS + gender + week + current episode + past episode + (weekly PAS | participant)*

The interaction terms were, in addition, not significant (ß=-.005, p=.83). Indicating that the interaction between PAS and NA variability does not explain the association between NA mean and mean PAS. Additionally, NA mean and NA variability were significantly associated (ß=0.17, p=1.32e-09).
In model 10 the same pattern was observed. Interaction terms were found not significant (ß=-.26, p=.28), indicating that the association between weekly PAS and NA variability was not explained by the interaction between NA mean and PAS, and thus the association between PAS and NA variability is not driven by the mean. This means that a higher mean is not necessarily related to higher variability of NA, and vice versa. Furthermore, the NA variability term was significant (ß=0.98 p = 3.12e-10), which confirms the significant association between NA mean and NA variability found in model 9. Taken together, NA mean and NA variability both have additional value in explaining the data.

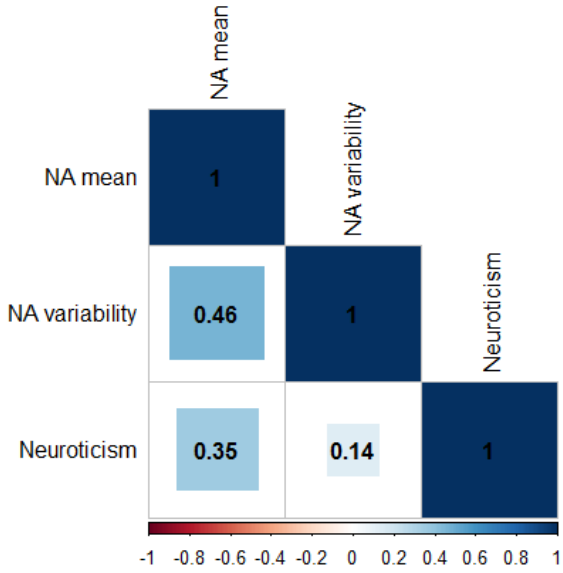
Correlation with neuroticism

As the reported association between negative affect and PAS (model 2 & 4) were opposite to the expectations, it was decided to post-hoc investigate how much both negative affect variables are associated with neuroticism. Neuroticism is one of the domains of personality identified in psychology (Leary & Hoyle, 2009) and is also identified as emotional instability, negative emotionality. Moreover, there is consensus on neuroticism being a negative predictor for mental health; individuals with a higher score for this personality trait are at higher risk of developing psychopathologies (Jylhä & Isometsä, 2006; Hettema, Neale, Myers, Prescott, & Kendler, 2006; Gale et al., 2016). Furthermore, neuroticism is consistently linked to both high NA variability and high NA mean in the literature (Larsen & Ketelaar, 1991; Jacobs et al., 2011;). For that reason, NA mean and NA variability were correlated with neuroticism scores to verify whether we measure what we intended to measure, namely the mean and variability of negative emotions experienced in participants. The NEO-FFI scores (Costa & McCrae, 1992) measured during the baseline questionnaires were used to calculate neuroticism. The self-report questionnaire consists of 60 questions on a scale of 1 to 5. Twelve of these questions focused on neuroticism and were averaged to create a neuroticism trait score per participant (overall mean: 2.71 ± 0.70).

Figure 3 shows the correlation matrix displaying the correlation coefficients between neuroticism and NA mean and NA variability. Neuroticism was positively correlated to NA mean (r=0.35) and NA variability (r=0.14), however not strong. In other words, more neuroticism is related to higher NA mean and NA variability, as expected. Which indicates that the variables measured in the present study represent negative emotionality. Furthermore, both NA variables (variability and mean) are moderately correlated (0.46). Confirming the results of the interaction models.

Figure 3

Correlation matrix showing strength of the correlation coefficient between trait neuroticism, and the dependent variables NA mean and NA variability.



Note. Positive correlations are represented by a blue color. Intensity of the color is matched with size of correlation coefficient, more intense illustrating a stronger correlation. Negative correlations are usually represented in red, however, no negative correlations were found here.

Discussion

The main focus of this study was to investigate whether there is an association between PAS and daily life affect measures. It was found that PAS was associated with larger weekly fluctuations in NA. Furthermore, a significant positive association was found between mean PAS and NA mean, an important marker of mental health. However, this finding did not withstand outlier removal. No significant association was found between PAS and PA mean, nor PA variability, nor the reactivity measures. Even though the results point out an association between PAS and affect, this is not in line with the hypotheses that PAS would be significantly associated with all daily life measures. Likewise, the direction of the results appear opposite to what was expected, potentially due to a more complicated relationship between PAS and affect than anticipated.

By including both the weekly PAS and mean PAS scores, it was possible to specifically disentangle within- and between-subject effects. It was expected that the results within participants would be similar to the results between participants. This was not found. In fact, although PAS and NA variability were associated within participants, the results demonstrated no association between mean PAS and NA variability. Vice versa for the association between PAS and NA mean. This indicates that the relation between PAS and NA variability relies on weekly-varying processes, while the relation between PAS and NA mean appears to be more stable over time.

As a result of the positive associations found between PAS and NA, post-hoc explorative analyses were done to investigate whether these associations can be explained by the interaction of NA mean and NA variability. The analyses were not significant, suggesting that the association between PAS and NA variability is not driven by the mean, and vice versa. This indicates that the mean and variability indices describe different aspects, and both variables have additional explanatory value. (Dejonckheere et al., 2019). Furthermore, NA mean and NA variability were positively associated. This suggests that both affect variables, however related, are not interacting in their associations with PAS. Both variables add separate explanatory value in their relationship with PAS.

For better interpretability of the direction of the results, explorative correlation analyses with neuroticism, NA mean and NA variability were performed. The correlations between neuroticism and the NA variables were positive, but not strong. Thus, higher neuroticism scores were related to higher NA mean and NA variability. Indicating that the daily life affect measures indeed reflected emotional instability. In line with previous research (Jacobs et al., 2011), there was a moderate positive correlation between NA mean and NA variability. This confirms the findings of the interaction models, both NA variables are related. Suggesting that the NA experienced within the sample is relatively stable.

Complicated relationship

Contrary to what was hypothesized, the recent findings did not detect a significant relationship between PAS and daily life measures PA mean, PA variability, and reactivity. A likely explanation is that the association between the variables is more complicated than was hypothesized. For example, PAS might not be as effective in every context. This is in line with the proposition of Egloff (2015) as a response to PASTOR, who states that PAS does not necessarily have positive consequences. Similar to that the adaptiveness of any ER strategy depends on context, this is an important factor to consider with PAS. Specifically, cognitive reappraisal, which includes but is not limited to PAS, is found to be less successful during sadness regulation in high emotional intensity situations. Here, individuals prefer distraction as an ER strategy. Moreover, cognitive reappraisal is more adaptive in low intensity situations (Sheppes, Catran & Meiran, 2009). To recap, cognitive reappraisal is a strategy in which one reinterprets emotion-eliciting situations, changing the meaning and emotional impact of the situation (Gross & John, 2003). More importantly, PAS is the generalized tendency to appraise aversive stimuli in a non-negative way. Positive reappraisal, which is cognitive reappraisal focused on positive interpretation of (potentially) negative stimuli, is considered one of the key tenets of PAS (Kalisch, Tüscher & Müller, 2015). Another contextual factor found to influence adaptiveness of cognitive reappraisal, is controllability of the situation. When facing uncontrollable stress or situations with little control, cognitive reappraisal is considered an adaptive ER strategy. However, when individuals feel that they have control, it is maladaptive to use this strategy. Adaptiveness was measured in the lab as depressive symptoms before and after having watched a sad film clip (Troy, Shallcross & Mauss, 2013).

Affect was not taken into consideration in this study, but affect is strongly associated with depressive symptoms (Houben et al., 2015), it is expected that this is associated with affect as well. Further research is needed to investigate this. The presented evidence shows that it may be important to take into consideration context when studying the association or the nature of the relationship between PAS and affect, since there is not always a positive outcome related to use of PAS. The positive association between weekly PAS and NA variability, and mean PAS and NA mean, might be influenced by contextual factors that were not taken into consideration in the recent study. For future research this is something to bear in mind, and to further elaborate on.

Another example underlying the complicatedness of the association between PAS and affect is that they are characterized on different timescales. In PASTOR, PAS is believed to be relatively stable, reflecting how a person typically reacts or behaves. As opposed to this PAS style, it can also be assessed how much someone's PAS is used in a given week. This PAS "mode" takes into account changes across time and situations. In the recent study, one PAS questionnaire (PASSp) a month is included and asks about the two preceding weeks. This is considered a state-like measure. However, as it relies on information about usage during the previous two weeks rather than asking out all situations on a beep level, as is done with the EMA questionnaires (approximately every two hours), it might still be prone to recall bias. A difference between state and the more stable trait reappraisal and NA was found by Silva and colleagues (2018). State cognitive reappraisal was associated with higher NA concurrently, while trait cognitive reappraisal was associated with low NA. In other words, individuals with higher reappraisal skill reported lower NA levels on average, while they used more reappraisal when NA was high. It must be pointed out that this is not NA mean, but NA and state reappraisal were measured per beep, and thus compared per beep instead of averaging NA over a week. The authors suggest that reappraisal may not be immediately effective, but frequent use decreases NA. Indeed, it was found that the positive association between state cognitive reappraisal and NA was moderated by trait cognitive reappraisal. This demonstrates that different processes underly trait and state PAS as defined here. In the recent study, PAS measured situations that happened over the past two weeks and was then linked to affect variables averaged over the weeks, instead of being measured in EMA.

Nevertheless, it is a state-like measure. Future studies should focus on how affect relates to PAS on different timescales, measuring PAS in EMA, as well as on broader timescales.

The unexpected positive association between PAS and NA mean and variability is partly in line with the finding that higher levels of depression are associated with frequent and ineffective cognitive reappraisal use (Ford et al., 2017). However, the present study did not measure whether PAS was applied successfully. If appliance was not successful, this could be associated with more PAS use and worse affect. Further research is needed to investigate whether frequent ineffective PAS use is related to higher levels of NA mean and NA variability. Altogether, the presented literature taken together with the present results demonstrates the complexity of the characteristics of the association between PAS and affect.

Stressor exposure

Another potential explanation for not finding significant associations is that stressor exposure is not included in the analysis. Considering the definition of PAS is based on the appraisal of (potentially) adverse events, it would be expected that stressor exposure is an influential factor. Stress is linked to poorer affect reporting (Gartland, O'Connor, Lawton, & Ferguson, 2014; Krieger, Hermann, Zimmermann, & grosse Holforth, 2015). In theory, it would be expected that for people with high PAS this would not make a difference. Although, if the link between PAS and affect is not as straightforward as was expected, which is suggested by the results, including stressor exposure could provide complementary information about the link between the three. Troy (2015) found that during low levels of stress, cognitive reappraisal ability is not associated with depressive symptoms, but at high stress levels there is a negative association between cognitive reappraisal ability and depressive symptoms. Implying that stress is related to the association between cognitive reappraisal and mental well-being. Furthermore, more exposure to stressors is associated with increased cognitive reappraisal ability, probably because there are more opportunities to practice cognitive reappraisal. (Zeier, Meine & Wessa, 2021) In the recent study, daily hassles had an average impact of 2.43 (SD: 1.14), out of 5. Indicating stressor exposure had impact on participants' life's.

In the recent study, pleasantness is measured per beep and only for the most relevant event since the last beep. How relevant or how stressful it has been for a person is not included. Even though an event that is pleasant can simultaneously be stressful. One individual can have a low PAS, but experienced high exposure, whereas another person who has a low PAS, experienced low exposure. Including stressor exposure, and what kind of stressors, can have additional value in understanding the association found, and can answer the question whether stressor exposure plays a role in the association between PAS and NA variability within participants. Future studies should assess stressor exposure (e.g., in the form of daily hassles), to substantiate whether this interacts with the relationship between PAS and affect. If more stressor exposure is related to the positive association between PAS and NA variability, this may indicate that PAS is not the most effective strategy to use, or that PAS is not being used effectively. This is in line with that more stressor exposure is related to poorer affect measured (Gartland et al., 2014, Krieger et al., 2015). However, if less stressor exposure is related to the positive association between PAS and NA variability, this suggests that there were less opportunities to practice PAS (Zeier et al., 2021). In the situations PAS could be used, this might have been less effective, hence, increased NA variability. It should be taken into account that there is a difference within types of daily hassles, some are more detrimental for mental health than others (Almeida, 2005).

Neuroticism

The post-hoc results examining neuroticism show that neuroticism is positively correlated with NA mean and NA variability, in line with previous findings (Jacobs et al., 2011). This verifies that the NA variables reflect emotional instability. This finding is consistent with neuroticism being a vulnerability marker for psychopathology, considering individuals with higher NA variability are more vulnerable than individuals with more stable affect patterns (Ebner-Priemer, Eid, Kleindienst, Stabenow, & Trull, 2009). Furthermore, both affect measures were positively associated with each other, as expected (Jacobs et al., 2011).

Methodological differences

Depression

The hypotheses, in specific for reactivity, are largely based on evidence coming from the MDD population, or related to depression symptoms (Peeters et al., 2003; Gruber et al., 2013; Van Roekel et al., 2015; Brose

et al., 2020). This is because a large part of available literature is on MDD, as mentioned in "reactivity" in the introduction of the present paper. Strikingly, a difference is found between how depressive symptoms are associated with affect measures in the general population and in people with MDD (Gruber et al., 2013; Houben et al., 2015), proving that this process can be different and one should be careful in making assumptions. In the present study, three participants were assessed with a current MDD episode, this was not used as an exclusion criterium because the sample is a healthy, enriched, sample to increase vulnerability for stress. Additionally, depression symptoms were assessed with the GHQ and SCL-90 questionnaires but not included in the analysis. This is not enough to make any statements on whether associations in this sample are influenced by this difference. The recent findings regarding reactivity, although not consistent with previous findings on participants with MDD, are comparable to the literature on healthy participants. In other words, reactivity is not associated with mental well-being in healthy participants (Thompson et al., 2012; Nelson et al., 2020; Heininga et al., 2019). This emphasizes the differences in emotion regulation between patients with MDD and the healthy (though enriched) population. Future studies should take this difference into account.

PAS as measure

EMA is designed to be ecologically valid, PAS is measured with a questionnaire asking out the past two weeks. It is found that questionnaire measurements only to a small extent relate to actual behavior (Back, Schmukle, & Egloff, 2009). EMA has high ecological validity, however, if PAS does not relate to actual behavior as much, this can influence the associations found between affect and PAS. Considering this difference in level, measuring PAS in the EMA beep during the day can give insight in whether there is a concurrent relationship between affect and PAS. However, this would not measure PAS as defined by Kalisch and colleagues (2015), namely as a generalized tendency.

ERQ vs PAS

Furthermore, the present study used the PASSp questionnaire, which is developed to assess beneficial cognitive processes which people use to generate positive appraisal contents (Veer et al., 2021). This is a relatively new questionnaire in the field and most evidence until now is based on cognitive reappraisal, generally measured using the ERQ questionnaire (e.g., in Eftekhari et al., 2009). This questionnaire focuses on one's tendency to use cognitive reappraisal for emotion regulation. Even though cognitive reappraisal is a key factor of PAS, the PASSp questionnaire is composed of a combination of cognitive and conscious components of ER strategies (perspective taking, positive reappraisal, refocusing on planning, acceptance, positive refocusing, cognitive distancing, and humor). Therefore, the PASSp comprises a broader set of appraisal variations, and focuses on specific ways what one did to change appraisal in contrast to only whether one changed what they were thinking and the way they were thinking about the situation. While both questionnaires measure related processes, these dissimilarities could underly the differences in associations found with what was expected.

Limitations

Several limitations regarding the methodological design should be noted. First of all the moments PAS and affect were measured do not completely coincide in time. In theory the questionnaires are filled in during the EMA week, but in practice participants can choose when to fill in the questionnaire because the link that is sent has unlimited availability. To prevent a gap too large, the weeks in which the PAS questionnaire and EMA start dates differ more than 14 days from each other, are excluded from the analysis (n=1). Nevertheless, some participants filled out PAS during the first day of EMA, others a couple of days after EMA, which leads to variability. Considering the PAS questionnaire covers the previous two weeks, for some participants the EMA week coincides with the questionnaire whereas other participants have no overlap, or limited. Additionally, there is a discrepancy in time both measures cover PAS covers the past two weeks and EMA is measured on beep level, covering 6 days.

Another limitation is that the generalizability of the results is limited by the sample. This sample included a small age width of healthy students who experienced at least three stressful events. This was chosen for because stress is a major problem among students. Even though a sample like this increases the chance of finding within-person fluctuations, as is found in NA variability within participants. It is important to be aware that no statements can be done for the entire population. Evidence suggests that affect levels change over time, it decreases over age, and becomes more stable (Röcke, Li & Smith, 2009) Future studies should

investigate whether the findings of the present study apply in the entire population, people of all ages, and different backgrounds.

Furthermore, the results could not be explained by current episodes that were assessed with help of the MINI during the baseline battery. Even though the MINI was only conducted during the baseline measures, no follow-up of persistence or development of symptoms was done. For instance, if someone developed a depressive episode during the study, this was not controlled for. Likewise, no distinction is made in the analysis in what kind of episode is present. However, symptom development was checked with the SCL-90 and the GHQ. Future research can look whether current episodes or symptoms, and classes of episodes, interact with daily life affect and PAS by including episodes or symptoms concurrently with PAS, and thus monitoring episodes.

Due to PE occurring more often, there are a considerably less weeks with reactivity on NE than on PE, this is a methodological limitation and can influence the power of reactivity in relation to NE. This finding is in line with previous literature (Walker, Skowronski, & Thompson, 2003). People tend to look for positive experiences, but avoid negative experiences. At least 5 events should have occurred within the week to calculate the reactivity score, 273 NE were excluded for that reason. For NA reactivity on NE 61 weeks and for PA reactivity on NE 63 weeks were calculated, compared to 188 for NA reactivity on PE and 189 for PA reactivity on PE. The difference in number of weeks in the linear mixed model is quite large, leading to a less robust result for NE, but also difference in fit.

Lastly, the study, in particular EMA, was very intensive and sometimes experienced as a burden, this limitation is apparent in many EMA studies. Participants were not always as motivated and often reported that they were annoyed by the beeps during the later weeks. It is found that compliance is not associated with study duration (Vachon, Viechtbauer, Rintala & Myin-Germeys, 2019) but the burden might have interfered with motivation to answer beeps seriously, or if the burden was too big with participants' life's. Regardless of whether this would influence the results (there is no indication it does), it is an ethical consideration to make. Further research is needed on whether this type of intensive study interferes with the results and with the well-being of a participant.

Future studies

Future research could investigate whether there is an association between PAS and affect reactivity considering activity-related stress. In the present study, only event related stress was used, which involves the (un)pleasantness of the most important event since the last beep. Activity related stress measures the pleasantness and competence a participant believes to have of the activity the participant was doing right before the beep. This way, the event is rated at that moment, reflecting momentary feelings, and is about minor disturbances rather than the most important event that happened since the last beep. Including both types of stress provides a broader image of types of reactivity that can have a relation with PAS.

Another mechanism future studies should look into is whether the significant positive association between NA variability and PAS within can be explained by inertia (autocorrelation). Variability can also mean recovery of NA, with inertia you can calculate the persistence of NA. Autocorrelation is the consistency within NA, looking at moment-to-moment affect dynamics, thus including a temporal factor (Koval, 2014). Dejonckheere and colleagues (2019) show that calculating variability had the most value, however, because an effect between variability and PAS was found, studying inertia can give more insight in the characteristics of the association found.

Lastly, the present study investigated the association between PAS and affect. Based on previous research, it was expected that a higher PAS score would mean a lower NA mean and variability. However, it cannot be concluded whether increase in NA variability is a cause or a consequence of higher PAS, only association. Further research on this is required for better understanding the relationship. This can be executed by creating a mathematical model to investigate what predicts what.

Conclusion

In conclusion, the findings of the present longitudinal study highlight that the association between PAS and affect rely on different processes. While PAS and NA variability rely on weekly-varying processes, PAS and NA mean are more stable over time. Moreover, the present research advances understanding that the relationship between PAS and affect is more complex than anticipated. In future work, the apparent complicatedness of the relationship should be taken into account and the nuances should be carefully handled.

References

Almeida, D. M. (2005). Resilience and vulnerability to daily stressors assessed via diary methods. *Current Directions in Psychological Science*, **14**(2), 64–68. https://doi.org/10.1111/j.0963-7214.2005.00336.x

Back, M. D. , Schmukle, S. C. , & Egloff, B. (2009). Predicting actual behavior from the explicit and implicit self-concept of personality. *Journal of Personality and Social Psychology*, 97, 533–548. https://doi.org/ 10.1037/a0016229

Bastiaansen, J. A., Bennik, E. C., Marsman, J. B. C., Ormel, J., Aleman, A., & Oldehinkel, A. J. (2018). Prefrontal cortex activation during a cognitive reappraisal task is associated with real-life negative affect reactivity. *PloS one*, 13(8), e0202888. https://doi.org/10.1371/journal.pone.0202888

Brans, K., Koval, P., Verduyn, P., Lim, Y. L., & Kuppens, P. (2013). The regulation of negative and positive affect in daily life. *Emotion (Washington, D.C.)*, *13*(5), 926–939. https://doi.org/10.1037/a0032400

Brose, A., Blanke, E. S., Schmiedek, F., Kramer, A. C., Schmidt, A., & Neubauer, A. B. (2021). Change in mental health symptoms during the COVID-19 pandemic: The role of appraisals and daily life experiences. *Journal of personality*, 89(3), 468–482. https://doi.org/10.1111/jopy.12592

Bylsma, L. M., Morris, B. H., & Rottenberg, J. (2008). A meta-analysis of emotional reactivity in major depressive disorder. *Clinical psychology review*, 28(4), 676-691. https://doi.org/10.1016/j.cpr.2007.10.001

Carver, C.S. (1997). You want to measure coping but your protocol's too long: Consider the Brief COPE. *International Journal of Behavioral Medicine*, 4, 92-100.

Cochrane, R., & Robertson, A. (1973). The life events inventory: A measure of the relative severity of psycho-social stressors. *Journal of Psychosomatic Research*, 17, 135–139.

Costa, P.T., & McCrae, R.R. (1992). Revise NEO Personality Inventory (NEO PI-R) and NEO Five- Factor Inventory (NEO-FFI). Professional manual, Psychological Assessment Resources.

Crego, A., Carrillo-Diaz, M., Armfield, J. M., & Romero, M. (2016). Stress and Academic Performance in Dental Students: The Role of Coping Strategies and Examination-Related Self-Efficacy. *Journal of dental education*, *80*(2), 165–172. https://doi.org/10.1002/j.0022-0337.2016.80.2.tb06072.x

Crowe, E., Daly, M., Delaney, L., Carroll, S., & Malone, K. M. (2019). The intra-day dynamics of affect, self-esteem, tiredness, and suicidality in Major Depression. *Psychiatry research*, *279*, 98–108. https://doi.org/10.1016/j.psychres.2018.02.032

Dalal, Dev & Zickar, Michael. (2011). Some Common Myths About Centering Predictor Variables in Moderated Multiple Regression and Polynomial Regression. *Organizational Research Methods*. 15. 339-362. https://doi.org/10.1177/1094428111430540.

Dejonckheere, E., Mestdagh, M., Houben, M., Rutten, I., Sels, L., Kuppens, P., & Tuerlinckx, F. (2019). Complex affect dynamics add limited information to the prediction of psychological well-being. *Nature human behaviour*, 3(5), 478-491. https://doi.org/10.1038/s41562-019-0555-0

Ebner-Priemer, U. W., Eid, M., Kleindienst, N., Stabenow, S., & Trull, T. J. (2009). Analytic strategies for understanding affective (in) stability and other dynamic processes in psychopathology. *Journal of abnormal psychology*, 118(1), 195. https://doi.org/ 10.1037/a0014868

Eftekhari, A., Zoellner, L. A., & Vigil, S. A. (2009). Patterns of emotion regulation and psychopathology. *Anxiety, stress, and coping*, *22*(5), 571–586. https://doi.org/10.1080/10615800802179860

Egloff, B. (2015). Does a positive appraisal style work in all stressful situations and for all individuals?. *Behavioral and Brain Sciences*, 38. https://doi.org/ 10.1017/S0140525X14001514

Ford, B. Q., Karnilowicz, H. R., & Mauss, I. B. (2017). Understanding reappraisal as a multicomponent process: The psychological health benefits of attempting to use reappraisal depend on reappraisal success. *Emotion*, 17(6), 905–911. https://doi.org/10.1037/emo00 00310

Fox, J. (Ed.). (2008), Applied Regression Analysis and Generalized Linear Models 2nd Edition. Thousand Oaks, CA: SAGE.

Friedman, A. K., Walsh, J. J., Juarez, B., Ku, S. M., Chaudhury, D., Wang, J., Li, X., Dietz, D. M., Pan, N., Vialou, V. F., Neve, R. L., Yue, Z. & Han, M. H. (2014) Enhancing depression mechanisms in midbrain dopamine neurons achieves homeostatic resilience. *Science* 344, 313–319. https://doi.org/10.1126/science.1249240

Frost, J. (2019). *Guidelines for Removing and Handling Outliers in Data*. Retrieved from https://statisticsbyjim.com/basics/remove-outliers/

Gale, C. R., Hagenaars, S. P., Davies, G., Hill, W. D., Liewald, D. C., Cullen, B., & Harris, S. E. (2016). Pleiotropy between neuroticism and physical and mental health: findings from 108 038 men and women in UK Biobank. *Translational psychiatry*, 6(4), e791-e791. https://doi.org/ 10.1038/tp.2016.56

Garland, E., Gaylord, S., & Park, J. (2009). The role of mindfulness in positive reappraisal. Explore (New York, N.Y.), 5(1), 37–44. https://doi.org/10.1016/j.explore.2008.10.001

Garnefski, N., Kraaij, V., & Spinhoven, P. (2001). Negative life events, cognitive emotion regulation and depression. *Personality and Individual Differences*, 30, 1311–1327. https://doi.org/10.1016/S0191-8869(00)00113-6

Gartland, N., O'Connor, D. B., Lawton, R., & Ferguson, E. (2014). Investigating the effects of conscientiousness on daily stress, affect and physical symptom processes: A daily diary study. *British Journal of Health Psychology*, 19(2), 311-328. https://doi.org/ 10.1111/bjhp.12077

Gawali, S. (2021, May 2). *Shape of data: Skewness and Kurtosis.* Retrieved from: https://www.analyticsvidhya.com/blog/2021/05/shape-of-data-skewness-and-kurtosis/

Geschwind, N., Peeters, F., Jacobs, N., Delespaul, P., Derom, C., Thiery, E., van Os, J., & Wichers, M. (2010). Meeting risk with resilience: high daily life reward experience preserves mental health. *Acta Psychiatrica Scandinavica*, 122(2), 129-138. https://doi.org/ 10.1111/j.1600-0447.2009.01525.x

Goldberg, D.P. (1972). The Detection of Psychiatric Illness by Questionnaire. Oxford University Press: London.

Graham J. W. (2009). Missing data analysis: making it work in the real world. *Annual review of psychology*, 60, 549–576. https://doi.org/10.1146/annurev.psych.58.110405.085530

Gross, J. J. & Munoz, R. F. (1995). Emotion regulation and mental health. *Clinical Psychology: Science and Practice*, 2, 151-164. https://doi.org/10.1111/j.1468-2850.1995.tb00036.x

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology, 85*(2), 348–362. https://doi.org/10.1037/0022-3514.85.2.348

Gross, James J. (2013). Emotion regulation: Taking stock and moving forward. *Emotion*, 13, 359-365. https://doi.org/10.1037/a0032135

Gruber, J., Kogan, A., Quoidbach, J., & Mauss, I. B. (2013). Happiness is best kept stable: Positive emotion variability is associated with poorer psychological health. *Emotion*, *13*, 1–6. doi:10.1037/a0030262

Gunaydin, G., Selcuk, E., & Ong, A. D. (2016). Trait Reappraisal Predicts Affective Reactivity to Daily Positive and Negative Events. *Frontiers in psychology*, *7*, 1000. https://doi.org/10.3389/fpsyg.2016.01000

Heininga, V.E., Dejonckheere, E., Houben, M., Obbels, J., Sienaert, P., Leroy, B., ... & Kuppens, P. The dynamical signature of anhedonia in major depressive disorder: positive emotion dynamics, reactivity, and recovery. *BMC Psychiatry* **19,** 59 (2019). https://doi.org/10.1186/s12888-018-1983-5

Hettema, J. M., Neale, M. C., Myers, J. M., Prescott, C. A., & Kendler, K. S. (2006). A population-based twin study of the relationship between neuroticism and internalizing disorders. *American Journal of Psychiatry*, 163(5), 857–864. https://doi.org/10.1176/appi.ajp.163.5.857

Houben, M., van den Noortgate, W., Kuppens, P. The relation between short-term emotion dynamics and psychological well-being: A meta-analysis. *Psychological Bulletin*, Vol 141(4), Jul 2015, 901-930. https://doi.org/ 10.1037/a0038822

Jacobs, N., Van Os, J., Derom, C., Thiery, E., Delespaul, P., & Wichers, M. (2011). Neuroticism explained? From a non-informative vulnerability marker to informative person–context interactions in the realm of daily life. *British Journal of Clinical Psychology*, 50(1), 19-32. https://doi.org/ 10.1348/014466510X491397

Jaso, B. A., Kraus, N. I., & Heller, A. S. (2021). Identification of careless responding in ecological momentary assessment research: From posthoc analyses to real-time data monitoring. *Psychological Methods*. Advance online publication. https://doi.org/10.1037/met0000312

John, O. P., & Gross, J. J. (2004). Healthy and unhealthy emotion regulation: Personality processes, individual differences, and life span development. *Journal of personality*, 72(6), 1301-1334. https://doi.org/10.1111/j.1467-6494.2004.00298.x

Jylha, P., & Isometsa, E. (2006). The relationship of neuroticism and extraversion to symptoms of anxiety and depression in the general population. *Depression and Anxiety*, 23(5), 281–289. https://doi.org/10.1002/da.20167

Kalisch, R., Köber, G., Binder, H., Ahrens, K. F., Basten, U., Chmitorz, A., Choi, K.W., Fiebach, C.J., Goldbach, N., Neumann, R.J., Kampa, M., Kollman, B., Lieb, K., Plichta, M.M., Reif, A., Schick, A., Sebastian, A., Walter, H., Wessa, M., … & Engen, H. (2021). The frequent stressor and mental health monitoring-paradigm: a proposal for the operationalization and measurement of resilience and the identification of resilience processes in longitudinal observational studies. *Frontiers in Psychology*, 3377. https://doi.org/10.3389/fpsyg.2021.710493

Kalisch, R., Müller, M. B., & Tüscher, O. (2015). A conceptual framework for the neurobiological study of resilience. *The Behavioral and brain sciences*, *38*, e92. https://doi.org/10.1017/S0140525X1400082X

Kessler R. C. (1997). The effects of stressful life events on depression. *Annual review of psychology*, 48, 191–214. https://doi.org/10.1146/annurev.psych.48.1.191

Koeter, M.W.J., & Ormel, J. (1991). General Health Questionnaire, Nederlandse bewerking: Handleiding. Lisse: Swets, Test Services.

Koval, P. (2014). Understanding emotional inertia: Processes underlying the autocorrelation of negative affect. https://lirias.kuleuven.be/1787695?limo=0

Koval, P., Pe, M., Meers, K., & Kuppens, P. (2013). Affect Dynamics in Relation to Depressive Symptoms: Variable, Unstable or Inert?. *Emotion* (Washington, D.C.), 13. https://doi.org/10.1037/a0033579.

Krieger, T., Hermann, H., Zimmermann, J., & grosse Holtforth, M. (2015). Associations of self-compassion and global self-esteem with positive and negative affect and stress reactivity in daily life: Findings from a smart phone study. *Personality and individual differences*, 87, 288-292. https://doi.org/ 10.1016/j.paid.2015.08.009

Leary, M. R., & Hoyle, R. H. (Eds.). (2009). Neuroticism. Handbook of individual differences in social behavior (pp 134). New York: Guilford Press.

Nelson, J., Klumparendt, A., Doebler, P., & Ehring, T. (2020). Everyday emotional dynamics in major depression. *Emotion*, 20(2), 179. https://doi.org/10.1037/emo0000541

Pavani, J. B., Le Vigouroux, S., Kop, J. L., Congard, A., & Dauvier, B. (2016). Affect and affect regulation strategies reciprocally influence each other in daily life: The case of positive reappraisal, problem-focused coping, appreciation and rumination. *Journal of Happiness Studies*, 17(5), 2077-2095. https://doi.org/10.1007/s10902-015-9686-9

Peeters, F., Nicolson, N. A., Berkhof, J., Delespaul, P., & deVries, M. (2003). Effects of daily events on mood states in major depressive disorder. *Journal of Abnormal Psychology, 112*(2), 203–211. https://doi.org/10.1037/0021-843X.112.2.203

Petri-Romao, P., Engen, H., Rupanova, A., Tuescher, O., Basten, U., Kalisch, R. (2021, september). *Development and validation of self-report assessment of positive appraisal style, Positive Appraisal Style Scales* [Poster]. Resilience Symposium.

R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Reichardt, C. S. (2010). Standard deviation. *The Corsini Encyclopedia of Psychology*, 1-1. https://doi.org/10.1002/9781118660584.ese2278

van Roekel, E., Bennik, E. C., Bastiaansen, J. A., Verhagen, M., Ormel, J., Engels, R. C., & Oldehinkel, A. J. (2016). Depressive Symptoms and the Experience of Pleasure in Daily Life: An Exploration of Associations in Early and Late Adolescence. *Journal of abnormal child psychology*, 44(5), 999–1009. https://doi.org/10.1007/s10802-015-0090-z

Röcke, C., Li, S.-C., & Smith, J. (2009). Intraindividual variability in positive and negative affect over 45 days: Do older adults fluctuate less than young adults? *Psychology and Aging*, 24(4), 863–878. https://doi.org/10.1037/a0016276

Russo, S. J., Murrough, J. W., Han, M.-H., Charney, D. S. & Nestler, E. J. (2012) Neurobiology of resilience. *Nature Neuroscience* 15(11):1475–84. https://doi.org/10.1038/nn.3234

Sheehan, D.V., Lecrubier, Y., Sheehan, K.H., Amorim, P., Janavs, J., Weiller, E., Hergueta, T., Baker, R., Dunbar, G.C. (1998). The Mini-International Neuropsychiatric Interview (M.I.N.I.): The development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *Journal of Clinical Psychiatry*, 59(20), 22–33.

Sheppes, G., Catran, E., & Meiran, N. (2009). Reappraisal (but not distraction) is going to make you sweat: Physiological evidence for self-control effort. *International Journal of Psychophysiology*, 71(2), 91-96. https://doi.org/ 10.1016/j.ijpsycho.2008.06.006

Silk, M. (2019, November 11). *Mixed Model Diagnostics*. Retrieved from https://dfzljdn9uc3pi.cloudfront.net/2020/9522/1/MixedModelDiagnostics.html

Silva, E., Freire, T., & Faria, S. (2018). Concurrent and Lagged Relations between Emotion Regulation and Affect in Adolescents' Daily Life. *The Spanish Journal of Psychology*, 21, E67. https://doi.org/10.1017/sjp.2018.61

Southwick, S. M., Vythilingam, M., & Charney, D. S. (2005). The psychobiology of depression and resilience to stress: implications for prevention and treatment. *Annual Review Clinical Psychology*, 1, 255-291. https://doi.org/ 10.1146/annurev.clinpsy.1.102803.143948

Sperry, S. H., Walsh, M. A., & Kwapil, T. R. (2020). Emotion dynamics concurrently and prospectively predict mood psychopathology. *Journal of affective disorders*, 261, 67–75. https://doi.org/10.1016/j.jad.2019.09.076

Stetz, M.C., Thomas, M.L., Russo, M.B., Stetz, T.A., Wildzunas, R.M., McDonald, J.J., Wiederhold, B.K., Romano, J.A., (2007). Stress, mental health, and cognition: a brief review of relationships and countermeasures. *Aviation, Space, and Environmental Medicine*, 78(5), B252-B260.

Tabachnick, B. G., & Fidell, L. S. (2013). Using Multivariate Statistics (6th ed.). Boston, MA: Pearson.

Thompson, R. J., Mata, J., Jaeggi, S. M., Buschkuehl, M., Jonides, J., & Gotlib, I. H. (2012). The everyday emotional experience of adults with major depressive disorder: Examining emotional instability, inertia, and reactivity. *Journal of Abnormal Psychology*, 121(4), 819–829. https://doi.org/10.1037/a0027978

Troy, A. S. (2015). Reappraisal and resilience to stress: Context must be considered. *Behavioral and Brain Sciences*, 38. DOI:10.1017/S0140525X1400171X

Troy, A. S., Shallcross, A. J., & Mauss, I. B. (2013). A person-by-situation approach to emotion regulation: Cognitive reappraisal can either help or hurt, depending on the context. *Psychological science*, 24(12), 2505-2514.

Trull, T. J., Lane, S. P., Koval, P., & Ebner-Priemer, U. W. (2015). Affective Dynamics in Psychopathology. *Emotion review : journal of the International Society for Research on Emotion*, *7*(4), 355–361. https://doi.org/10.1177/1754073915590617

Vachon, H., Viechtbauer, W., Rintala, A., & Myin-Germeys, I. (2019). Compliance and retention with the experience sampling method over the continuum of severe mental disorders: meta-analysis and recommendations. *Journal of medical Internet research*, 21(12), e14475. https://doi.org/10.2196/14475

Vargas, T., Conley, R. E., & Mittal, V. A. (2020). Chronic stress, structural exposures and neurobiological mechanisms: A stimulation, discrepancy and deprivation model of psychosis. *International review of neurobiology*, 152, 41–69. https://doi.org/10.1016/bs.irn.2019.11.004

Veer, I. M., Riepenhausen, A., Zerban, M., Wackerhagen, C., Puhlmann, L., Engen, H., Köber, G., Bögemann, S. A., Weermeijer, J., Uścilko, A., Mor, N., Marciniak, M. A., Askelund, A. D., Al-Kamel, A., Ayash, S., Barsuola, G., Bartkute-Norkuniene, V., Battaglia, S., Bobko, Y., … Kalisch, R. (2021). Psycho-social factors associated with mental resilience in the Corona lockdown. *Translational psychiatry*, 11(1), 67. https://doi.org/10.1038/s41398-020-01150-4

Vos, T., Barber, R. M., Bell, B., Bertozzi-Villa, A., Biryukov, S., Bolliger, I., Charlson, F.J., Davis, A., Degenhardt, L., Dicker, D., Duan, L., Erskine, H., Feigin, V., Ferrari, A.J., Fitzmaurice, C., Fleming, T., Graetz, N., Guinovart, C., Haagsma, J., Hansen, G., … & Brugha, T. S. (2015). Global, regional, and national incidence, prevalence, and years lived with disability for 301 acute and chronic diseases and injuries in 188 countries, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. *The Lancet*, 386(9995), 743-800. https://doi.org/ 10.1016/S0140-6736(15)60692-4

Wackerhagen, C., Veer, I., van Leeuwen, J., Bögemann, S., Mor, N., Puhlmann, L., Reppmann, Z., Riepenhausen, A., Uściłko, A., Zerban, M., Yuen, K.S.L., Köber, G., Pooseh, S., Weermeijer, J., Marciniak, M., Arias-Vásquez, A., Binder, H., de Raedt, W., Kleim, B., … & Walter, H. (2022). Study protocol description: Dynamic Modelling of Resilience-Observational Study (DynaM-OBS). https://doi.org/ 10.31234/osf.io/y54b6

Walker, W. R., Skowronski, J. J., & Thompson, C. P. (2003). Life is pleasant—and memory helps to keep it that way!. *Review of general psychology*, 7(2), 203-210. https://doi.org/ 10.1037/1089-2680.7.2.203

Yilmaz, M., Psychogiou, L., Ford, T., & Dunn, B. D. (2021). Examining the relationship between anhedonia symptoms and trait positive appraisal style in adolescents: A longitudinal survey study. *Journal of adolescence*, 91, 71-81. https://doi.org/ 10.1016/j.adolescence.2021.07.007

Appendix A Questionnaires

EMA

Start item
o 'Tijd voor een nieuwe vragenlijst!' (alleen tekst)

Humeur items
o Ik voel me vrolijk.
o Ik voel me geïrriteerd.
o Ik voel me angstig.
o Ik voel me tevreden.
o Ik voel me onzeker.
o Ik voel me ontspannen.
o Ik voel me verdrietig.
o Ik voel me gestrest.
o Ik voel me rusteloos.
o Ik voel me moe.
o Ik heb rust in mijn hoofd.
o Mijn gedachten laten me niet los
o Ik kan me goed concentreren.

Event beoordeling items
o Denk nu aan de belangrijkste gebeurtenis *voor jou* sinds de vorige beep. (alleen tekst)
o Hoe plezierig was deze gebeurtenis? (-3 (heel onplezierig) -2 -1 0 1 2 3 (heel plezierig))
o Dit was een stressvolle gebeurtenis.

End item
o Bedankt voor het invullen! (alleen tekst)

Note: These are the questionnaires used for the present study, which is a selection of the whole EMA procedure used in the DynaM-OBS study. The whole procedure can be found in figure S8 of the study protocol (Wackerhagen et al., 2022, https://osf.io/hcmdk/)

NEO-FFI Neuroticism

	helemaal oneens	oneens	neutraal	eens	helemaal eens
Ik ben niet makkelijk bezorgd.	○	○	○	○	○
Ik voel me vaak de mindere van anderen.	○	○	○	○	○
Wanneer ik onder grote spanning sta, heb ik soms het gevoel dat ik er aan onderdoor ga.	○	○	○	○	○
Ik voel me zelden eenzaam en triest.	○	○	○	○	○
Ik voel me vaak gespannen en zenuwachtig.	○	○	○	○	○
Soms voel me ik volkomen waardeloos.	○	○	○	○	○
Ik voel me zelden angstig of zorgelijk.	○	○	○	○	○
Ik word vaak kwaad om de manier waarop mensen mij behandelen.	○	○	○	○	○
Wanneer dingen misgaan raak ik maar al te vaak ontmoedigd en heb ik zin om het op te geven.	○	○	○	○	○
Ik ben zelden verdrietig of depressief.	○	○	○	○	○
Ik voel me vaak hulpeloos en wil dan graag dat iemand anders mijn problemen oplost.	○	○	○	○	○
Soms schaam ik me zo erg dat ik wel door de grond wil zakken.	○	○	○	○	○

PASSp questionnaire

Iedereen wordt van tijd tot tijd geconfronteerd met negatieve of onaangename ervaringen en iedereen reageert op zijn of haar manier. Voor de volgende vragen word je gevraagd aan te geven wat je gewoonlijk de afgelopen twee weken dacht toen je een negatieve of onaangename gebeurtenis meemaakte. Het kan zijn dat geen van de mogelijke antwoorden op jou van toepassing zijn.					
In de afgelopen twee weken heb ik me op de volgende manier gedragen in ongemakkelijke of moeilijke situaties:	helemaal niet	een beetje	behoorlijk	heel veel	
Ik heb er grapjes over gemaakt	○	○	○	○	
Ik heb de situatie belachelijk gemaakt	○	○	○	○	

	(bijna) nooit	soms	regelmatig	vaak	(bijna) altijd
Ik heb nagedacht over hoe ik de situatie kan veranderen.	○	○	○	○	○
Ik dacht aan prettige dingen die er niets mee te maken hadden.	○	○	○	○	○
Ik bedacht dat ik iets van de situatie kan leren.	○	○	○	○	○
Ik bedacht dat het niet zo erg was in vergelijking met andere dingen.	○	○	○	○	○
Ik bedacht dat ik moest accepteren dat dit is gebeurd.	○	○	○	○	○
Ik probeerde de situatie vanuit een afstandelijk perspectief te bekijken.	○	○	○	○	○
Ik dacht aan iets leuks in plaats van wat er is gebeurd.	○	○	○	○	○
Ik zei tegen mezelf dat er ergere dingen in het leven zijn.	○	○	○	○	○
Ik dacht over een plan na van wat ik het beste kan doen.	○	○	○	○	○
Ik probeerde afstand te nemen van de situatie en mijn emoties.	○	○	○	○	○
Ik bedacht dat ik de situatie moest accepteren.	○	○	○	○	○
Ik bedacht dat ik een sterker persoon kan worden als gevolg van wat er is gebeurd.	○	○	○	○	○

Appendix B Data cleaning

The data was cleaned via the following steps. First, data was only included when both EMA and PAS data were present per participant per week. Subsequently, it was confirmed that no data contained values outside the possible ranges. Beeps with a time delay larger than 10 minutes between the notification and the start of the questionnaire were (5 beeps) removed because it could indicate that participants answer the beep at a convenient time, leading to a bias (e.g., not answering during stressful moments). Similarly, beeps with more than 30 minutes between the start and end of the questionnaire were removed (61 beeps). A large answering delay results in unreliable data and indicates that participants got distracted while it is important to answer the notification based on what you feel at the moment of receival. Moreover, beeps that were answered in less than 43 seconds were removed (5 beeps) to exclude careless responding (Jaso, Kraus & Heller, 2021). Careless responding was defined as an answering time of less than one second per item on average. Additionally, weeks of participants that answered less than 20 out of 60 beeps in a week were excluded from the dataset (24 weeks). This cleaning step was performed because low compliance is considered unreliable and data quality is affected by this. It is found that low compliance rates can have a detrimental effect on statistical power (Graham, 2009). For the same reason, participants with less than three PASSp questionnaires and/or less than three EMA weeks in the dataset were excluded from the data analysis (N=5). Finally, even though the study design intended that PASSp was answered during each EMA week, in reality, the participants could fill out the questionnaires at any given moment because the link sent to them was permanently available. Thus, if the PASSp and the first day of the EMA week of a participant were performed with a delay longer than 14 days, the weeks were removed from the dataset (1 week) because there is no overlap between the measures. As a result of these cleaning steps, a remainder of 203 weeks from 42 participants is included in the analyses, consisting of 9292 beeps in total.

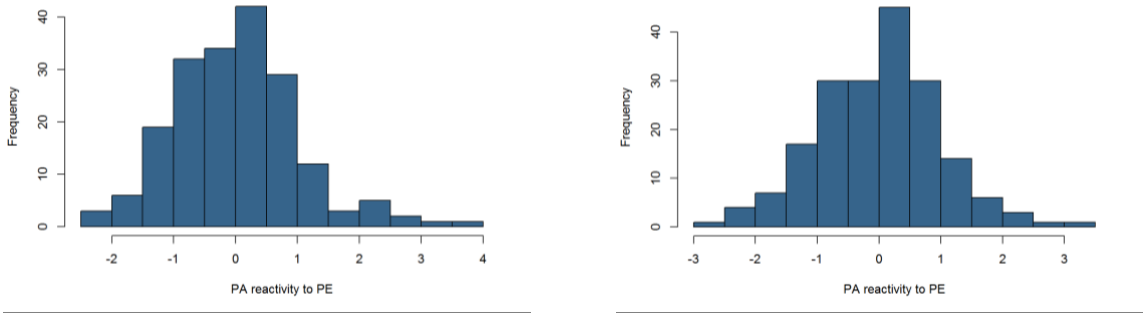
Appendix C Assumptions, normality

Linearity was graphically checked with scatterplots. To check for homoscedasticity residuals against fitted values plots were examined. This check is not necessary for ungrouped data. However, analysis is weakened if this assumption is not met (Tabachnick & Fidell, 2013). For this reason, and to get insight in the data, homoscedasticity was graphically checked but not corrected for.

For each variable, Quantile-Quantile (q-q) plots were used to investigate normality. In a q-q plot quantiles of the sample data were plotted to the statistical population. To transform data that did not meet the assumption of normality, the skewness of the residual's distribution was first calculated with the moments package (Komsta & Novometsky, 2015). If the intensity of asymmetry lower than minus 0.5 or higher than 0.5, the data was considered moderately skewed, if this number was lower than minus 1 or higher than 1, the data was considered strongly skewed. Negative values indicate a left skewed distribution and were transformed via an absolute log transformation to improve model fit (Gawali, 2021). An example of the distribution of a variable before and after the transformation is shown in figure C1, illustrating PA-PE.

Figure C1

Example of transformed variable, PA-PE



Note. Graph on the left shows the skewed distribution before log transformation. The right graph shows the distribution after log transformation, now approximately normal.

The q-q plots showed that the residuals of half of the variables were not skewed. However, NA mean, PA variability, and PA-PE were positively skewed. This was confirmed by the calculated skewness. Additionally, NA-NE was positively skewed. To decrease skewness, a log transformation was performed on those variables. As confirmed by the skewness intensity (table C2, on the next page), the log transformation improved normality of all variables. Therefore, statistical results were interpreted only for the transformed variables.

Table C2

Skewness per variable before and after log transformation.

	PA mean	NA mean	PA variability	NA variability	PA-PE	NA-PE	PA-NE	NA-NE
Regular variable	-0.22	**0.87**	**0.83**	0.40	**0.69**	-0.19	0.41	**0.78**
Transformed variable		0.49	**0.60**		0.13			-0.33

Note. A negative value represents a left skewed distribution and a positive value right skewness. Values higher than 0.5 indicate skewness, values between 0 and ± 0.5 are considered approximately normal, skewed values are presented in bold font.

Appendix D References R packages

R packages

In order of package: plyr, dplyr, DataCombine, tidyr, tibble, esmpack, psych, DT, nlme, viridis, lattice, stargazer, lmerTest, broom.mixed, forcats, ggplot2, table1, ggtext, moments, lme4, corrplot

Hadley Wickham (2011). The Split-Apply-Combine Strategy for Data Analysis. Journal of Statistical Software, 40(1), 1-29. URL http://www.jstatsoft.org/v40/i01/.

Hadley Wickham, Romain François, Lionel Henry and Kirill Müller (2018). dplyr: A Grammar of Data Manipulation. R package version 0.7.6. https://CRAN.R-project.org/package=dplyr

Christopher Gandrud (2016). DataCombine: Tools for Easily Combining and Cleaning Data Sets. R package version 0.2.21. https://CRAN.R-project.org/package=DataCombine

Hadley Wickham (2021). tidyr: Tidy Messy Data. R package version 1.1.4. https://CRAN.R-project.org/package=tidyr

Kirill Müller and Hadley Wickham (2021). tibble: Simple Data Frames. R package version 3.1.5. https://CRAN.R-project.org/package=tibble

Wolfgang Viechtbauer and Mihail Constantin (2021). esmpack: Functions that Facilitate Preparation and Management of ESM/EMA Data. R package version 0.1-17.

Revelle, W. (2021) psych: Procedures for Personality and Psychological Research, Northwestern University, Evanston, Illinois, USA, https://CRAN.R-project.org/package=psych Version = 2.1.9.

Yihui Xie, Joe Cheng and Xianying Tan (2021). DT: A Wrapper of the JavaScript Library 'DataTables'. R package version 0.20. https://CRAN.R-project.org/package=DT

Pinheiro J, Bates D, DebRoy S, Sarkar D, R Core Team (2020). _nlme: Linear and Nonlinear Mixed Effects Models_. R package version 3.1-148, <URL: https://CRAN.R-project.org/package=nlme>.

Simon Garnier, Noam Ross, Robert Rudis, Antônio P. Camargo, Marco Sciaini, and Cédric Scherer (2021). Rvision - Colorblind-Friendly Color Maps for R. R package version 0.6.2.

Sarkar, Deepayan (2008) Lattice: Multivariate Data Visualization with R. Springer, New York. ISBN 978-0-387-75968-5

Hlavac, Marek (2018). stargazer: Well-Formatted Regression and Summary Statistics Tables. R package version 5.2.1. https://CRAN.R-project.org/package=stargazer

Kuznetsova A, Brockhoff PB, Christensen RHB (2017). "lmerTest Package: Tests in Linear Mixed Effects Models." _Journal of Statistical Software_, *82*(13), 1-26. doi: 10.18637/jss.v082.i13 (URL: https://doi.org/10.18637/jss.v082.i13).

Ben Bolker and David Robinson (2021). broom.mixed: Tidying Methods for Mixed Models. R package version 0.2.7. https://CRAN.R-project.org/package=broom.mixed

Hadley Wickham (2021). forcats: Tools for Working with Categorical Variables (Factors). R package version 0.5.1. https://CRAN.R-project.org/package=forcats

H. Wickham. ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag New York, 2016.

Benjamin Rich (2021). table1: Tables of Descriptive Statistics in HTML. R package version 1.4.2. https://CRAN.R-project.org/package=table1

Claus O. Wilke (2020). ggtext: Improved Text Rendering Support for 'ggplot2'. R package version 0.1.1. https://CRAN.R-project.org/package=ggtext

Lukasz Komsta and Frederick Novomestky (2015). moments: Moments, cumulants, skewness, kurtosis and related tests. R package version 0.14. https://CRAN.R-project.org/package=moments

Bates, D., Maechler, M., Bolker, B., Walker, S. (2015). Fitting Linear Mixed-Effects Models Using lme4. Journal of Statistical Software, 67(1), 1-48. doi:10.18637/jss.v067.i01.

[Taiyun Wei and Viliam Simko (2021). R package 'corrplot': Visualization of a Correlation Matrix (Version 0.92). Available from https://github.com/taiyun/corrplot]